Spatial Dynamic Media System
Amalgam of form and image through use of a 3D light-point matrix to deliver a content-driven zone in real-time

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(Doctor of Philosophy)

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School of Architecture and Design
Design and Social Context Portfolio
RMIT University, Melbourne, Australia
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Spatial Dynamic Media System
Amalgam of form and image through use of a 3D light-point matrix to deliver a content-driven zone in real-time

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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Declaration

I hereby declare that the following PhD by Project except where due acknowledgement has made, is my own work and has not been submitted previously, in whole or in part, to qualify for any other academic award. The content of this thesis is the result of work that has been carried out since the official commencement date of approved research program. Any editorial work, paid or unpaid, carried out by a third party is acknowledged.

[Signature]

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26.08.2007
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Abstract

This body of work is the culmination of a three year investigation into a development of a system acting as an extension of existing media facades that allowed me to test the representation of information and ideas as ‘form’ within space that is constantly generated and regenerated as a result of fresh input. The research draws from different fields of architecture, computer science, electro engineering, communication theory and present technologies. The hypothesis of my PhD is that this real time reconfiguration of space using light offers a variety of new perceptions ranging from information sharing to public art never experienced previously. During my research, I have established an extensive body of evidence that points to a growing scholarship around the details and impacts of media façade technological developments and the content displayed on them. In the thesis I define the boundaries of these technology shifts and enhanced content combinations hitherto limited to 2 dimensions. I consider the technical and media implications of extending conventional 2D screens which are limited currently to architectural cladding into a 3D matrix thereby altering spatial perception through the content animating the 3D matrix.
Chapter Layout: **spatial dynamic media system** - Amalgam of form and image to deliver a content-driven zone in real-time through use of a 3D light-point matrix

### PhD by Project

**Research background:** Media and architecture

**Defining my research question:**

**The historical, technological and media content backgrounds of media in architecture:**

**A discussion of works by others in research domain:**

**Possible significance of spatial dynamic media system for architecture:**

**ANOTATED BIBLIOGRAPHY with historical account, technical and content overview, accessed literature for theoretical framework and project based research**

**Structure and methodology of research:**

**Evaluation of research and project work - Technology and media content:**

**Discussion of my contribution to the field of enquiry:**

**Reflection of project work:**

**Evaluation of research and project work - Technology and media content:**

**Reflection of research and project work:**

**GUIDE TO RESEARCH IN 3 YEARS WORK:**

**ABSTRACT Research - Distillation of 3 years work**

**ABSTRACT Project work**

**CHAPTER 4 Project work - Technology:**

- Designing an appropriate technology as an evolution of media facade technology into a fully spatial representation of content

- Applying prototype system in an architectural context to test its functions

- The issue of media content follows the research into a technology which I use as the vehicle for an investigation of dynamic 3D media content

- Writing software 'applets' for a third party to adapt system to their own input

**CHAPTER 4 Project work - Media content:**

**CHAPTER 5 Reflection of research - outcome of research and conclusion**

**CHAPTER 1 Research background**

**CHAPTER 2 Introduction**

**CHAPTER 3 Embedding media in architecture: cultural and technical implications**

**CHAPTER 4 Project work - Technology**

**CHAPTER 4 Project work - Media content**
**Spatial Dynamic Media System**

Amalgam of form and image through use of a 3D light-point matrix to deliver a content-driven zone in real-time

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CHAPTER 6 Appendix

Appendix 1 – Plans

Appendix 2 – Tables
The core project within my PhD research has been the development of a system as an extension of existing media facades that allows me to test the representation of information and ideas as ‘form’ within space that is constantly generated and regenerated as a result of fresh input. The hypothesis of my PhD is that this real time reconfiguration of space using light offers a variety of new perceptions ranging from information sharing to public art never experienced previously. During my research, I have established an extensive body of evidence that points to a growing scholarship around the details and impacts of media façade technological developments and the content displayed on them. In the thesis I define the boundaries of these technology shifts and enhanced content combinations limited to 2 dimensions. In my research I consider the technical and media implications of extending conventional 2D screens which are limited currently to architectural cladding into a 3D matrix thereby causing an alteration to spatial perception through the content animating the 3D matrix. The central research-question is:

_When weaving architecture and electronically applied and managed imagery together, are their respective properties successfully interchanged to the extent that they mutually create a new architectural zone, one that is in constant flux, generated and regenerated through ever changing content?_

The research has been organised in two volumes. Volume One discusses the background and set a theoretical framework and Volume Two presents the project work done in the research.
In Volume One the thesis has been organised into 4 chapters. The background chapter outlines my experience with media and architecture; what questions and motivations have come out of these experiences when working in these fields. The background chapter also summarizes the central hypothesis and the research I have done to define the core research question.

In the next chapter, the introduction chapter an annotated literature review reinforcing the boundaries set in the previous chapter. After providing an annotated bibliography I now want to illustrate the steps made to further investigate the core-research question, the questions raised from the literature review and how the proposition can be proven. Here a description of the structure of the research outlines the methodology of the research.

In this regard, my research will look at the history of media and architecture in order to gain an understanding of the development of media facades. Thus I will analyse the development of different technologies along the way to provide an understanding of existing media facades, where chapter three provides the theoretical framework for my research. Here I discuss the cultural motivation for embedding media within architecture, and introduce the two main interests contained within the research question - designing an appropriate technology [...] weaving architecture and electronically applied and managed imagery together [...] as an evolution of media façade technology into a fully spatial representation of content. The discussion of the highly charged issue of content will follow the research of technology; after providing a system which would be the vehicle for investigating the possibilities of dynamic 3D content [...] a new architectural zone, one that is in constant flux,
generated and regenerated through ever changing content?]

The investigation of these two topics then leads to a theoretical concept of what a system could potentially look like, one which allows the display of information in dynamic 3D. I position my research against work by others in order to at least part-fill the gaps in this field with regard to the relevance to architecture. Chapter 3 concludes by discussing the significance of such a system for architecture and outlines the characteristics of the system. Chapter 4 concludes with a discussion of results from the research with an evaluation of the research outcome and an indication of where the research could go from here.

With Volume One providing a theoretical framework for my research, the hypothesis is then tested by a series of four projects in Volume Two. I have undertaken these four projects to develop my research hypothesis, and how this knowledge can applied through a series of experiments in developing systems.

Two Projects are dedicated to the design of a technology that fulfils the requirements of the research question and applies this system to an architectural context. The third and the fourth projects discuss content. In project three, the content is provided by the author and in project four the author functions as the curator of various content scenarios through providing a toolset composed of different codes used to influence the generation of form.

What has been the motivation in doing these projects?

As stated in the theoretical framework in Chapter 3, the research question asked for two main aspects. The development of an appropriate
technology [...] weaving architecture and electronically applied and managed imagery together [...] and the provision of a system which would be the vehicle for investigating the possibilities of dynamic 3D content [...] a new architectural zone, one that is in constant flux, generated and regenerated through ever changing content?]. The selection and motivation of the projects is consequently driven by the core-research question.

Therefore I have developed as a first step a prototype system which, with the use of a 3D light-point matrix, alters space. The experiments undertaken to develop such a prototype are described in Project 1: Realisation of system in regards to an industrial design product. The prototype system has then been applied in an architectural context, in Project 2: Applying system to answer if the prototype can fulfill its function as a media façade to become an architectural component. These two projects are dedicated to the design of a technology that fulfils the requirements of the technical part of the research question.

Projects three and four are experimental series dealing with the question of content. In the following the system was tested by applying ‘designed’ content to it in Project 3: Effect and use – providing content. Lastly, in Project 4: Effect and use – working as curator for different contents, I have experimented with writing software ‘applets’ for a third party to adapt to their own input for display purposes.

Technologies to actually display content onto media facades exist, but they must be adapted from a 2D surface into a 3D zone, by allowing the content to be spatial and the space to be dynamic.
Timeline diagram: Spatial Dynamic Media System - Amalgam of form and image through use of a 3D light-point matrix to deliver a content-driven zone in real-time
I commenced my doctoral research by project in July 2004. The topic and direction I have taken (research by project) was precipitated by a combination of a longstanding interest in media and architecture and a profession frustration in the lack of a media facade system which would not only clad architecture. In fact, my research question emerged as a fusion of my interest and my experience previous to my research.

Prior to undertaking my research I worked at the German architecture firm Kauffmann, Theilig & Partner based in Stuttgart, Germany from October 2003 – July 2004. During my employment there I was worked on two projects, both of which had media in architecture as a main component in their design. Both projects were car booths for Mercedes-Benz, where at one for the Auto Salon Geneva 2004 in Geneva Switzerland (March 2004) I was project architect responsible for the design of the media façade. The job as a project architect included all design decisions of the façade, meetings with clients and consultants to discuss the façade and its realization. On the other booth, at the Auto Show China 2004 in Beijing (July 2004), I worked as project manager for the entire project. There my job included the complete design of the booth, cost management, liaising with the client and consultants and construction supervision. Both projects had million Euro budgets and a timeframe of 4 – 6 months from first design sketch to completion. These booths are usually built within a few weeks or even days, in the case of the booth in Geneva three weeks, and six days for the booth in Beijing. The duration of the car shows is around a week, with some major ones running for up to two weeks. Car booths for Mercedes-Benz allowed the architects of Kauffmann, Theilig & Partner to create mainly experimental architecture where corporate identity of the company is augmented with the architecture of the booth. The main aspects of these shows given by the client Mercedes-Benz is the representation of

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1 Cost figures and communication strategies of Mercedes-Benz are confidential, during my work for Mercedes-Benz I had access to these data, but have not been allowed to publish or discuss any of these data in greater detail with a third person
their products with all means and methods of communication. Mercedes-Benz had decided for the communication strategy in the next shows to use large display systems or other forms of media systems. Therefore the two booths I was working on had media and architecture as a main feature and new options in how these media technologies could be integrated in the architecture and be used for communication were the main challenge.

Having rented the Media system Barco MiPix20 for three automobile trade fairs, Mercedes-Benz (as the client) wanted to continue using the MiPix20 for the Auto Salon Geneva 2004. The Barco MiPix20 are 40x40mm square blocks containing 4 RGB LEDs that are controlled remotely and are able to display any content one could have on any other screens available.

Kauffmann, Theilig & Partner had already designed two shows where they used the Barco MiPix20. At the first show, the Internationale Automobil Ausstellung (IAA) in Frankfurt, Germany (July 2003) the Barco MiPix20 was used to create horizontal lamellae as a media board where low resolution texts could been displayed.

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ii I am using the term lamellae for a either horizontal or vertical element made out of timber and acrylic which has inhabited the Barco MiPix20LEDs. The lamella can be seen in picture Fig. 2 as a horizontal element and in picture Fig. 3 as a vertical element.
A similar solution was chosen at the second show where the Barco MiPix20 was used for the Northern American International Automobile Show (NAIAS) in Detroit, USA (January 2004). Here the lamellae have been arranged in a vertically.

The idea for the third show, when using the Barco MiPix20 media system, was to create a solid surface created by the Barco MiPix20 and not having lamellae.
The Barco MiPix20 was used as a façade material for the VIP café of the booth. People sitting at first floor level in the café were able to overlook the booth and be seen by the visitors walking on the booth and looking at the façade. Both the movie clip played on the façade and the people in the café should be then recognisable for the visitor on the booth and create a play of moving image and moving person on the façade. The diagrams below show the concept in three steps:

Fig. 5: First design principle, done during the design to illustrate the concept to the client

Fig. 6: Illustration of how the Barco MiPix 20 are arranged in previous booths

Fig. 7: Façade as a wall with openings for view to allow a screen with openings.

The form of the VIP café had similarities to a human hand with four fingers reaching out towards the booth to create different zones for different exhibits or cars, such as the new world premiere cars at the centre in front of the café supported by an additional screen and smaller sections for Formula One and the AMG car series. The hand-like
The floor plan was established when I started working on the project. Based on the sketches above I started to design façade openings which would be possible using the Barco MiPix20 system. The first design was based on an image of one of the client’s cars which was altered by heavily rasterising it in Photoshop to achieve different circle shaped apertures.

Fig. 8: The image which I used to explain the façade development to the client

Fig. 9: The same image rasterised in Photoshop as a first step towards the layout of the façade

Fig. 10: Two different options of how the image could be rasterised and the apertures could be achieved. Black indicates openings in the façade.
The façade proposal was accepted by the client and based on this model the façade was developed to cover the whole front of the VIP Café. At this stage a first introduction of the MiPix20 system has been made by the communication agency Atelier Markgraph, Frankfurt, which had worked with Kauffmann, Theilig and Partner on the two previous booths where the MiPix20 system has been used. Atelier Markgraph was the only contact point for information for myself and Martin Schroth, the project leader of the who worked with me and four 3rd year interior design students doing their internship in the office on this project.
When presenting this layout to the client, we were told there was a limitation on how many MiPix20 elements were available. Mercedes-Benz had rented in total 124,000 MiPix20 elements and did not want to pay for any more. Therefore, more openings in the façade had become necessary in order to reduce the number of pixels needed, as well as to alter the distance between each pixel, which could easily be achieved thanks to the MiPix20 fixing system.

The next step in the design process was still based on designing a façade with round openings, but during a first 1:1 scale mock-up we discovered the round opening could not be perceived when the MiPix20 were switched on. It was not possible to define round openings with a square light element. Therefore a change of the openings from circular to square was necessary.

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**Fig. 14:** A PDF document I received from the communication agency which explained how the MiPix20 is fixed to the metal support grill

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**Fig. 15:** Second design stage with circular openings (blue) which could not be built due to the grid arrangement of the MiPix20
When presenting this design to the client we were advised that due to technical requirements the MiPix20s had to be arranged in a chain containing up to 25 MiPix20. The chain could be either arranged in a line or in a coil shaped form. This was necessary for the communication between the control unit and a single MiPix20. One had to define the arrangement of each MiPix20 at the beginning to give the control unit an address for each MiPix20 in order to deliver the right colour information, so a complete picture could be generated.

Based on this new knowledge the existing façade layout was redesigned again utilising the previous experience to inform it.
At that stage the number of control units required for each coil was limited as well and the budget did not allow the rental of more control units. Therefore, the design had to change again to match the existing number of control units. This became the fifth design for the façade.
Fig. 22: Model of media façade stage 5, all previous design stages were also tested on a model to define where openings should be in regards to internal functions of the VIP cafe.

The last obstacle to be encountered was that the length of the cables from control unit to the first MiPix20 had a limitation, but thankfully this did not affect the design in a critical way.

Fig. 23: The MiPix20 prime-cable extension kit allowed a maximum distance of 10 metres from the control unit to the first MiPix20.

At this stage the original design idea of having circular openings as presented to the client at the beginning of the design process had totally changed. The director of the office was not convinced with the design of design stage 5 any longer, and based on all the technical experiences a new design concept was developed. The design was again based on an image to show the façades function as a carrier for still and moving images. The image was rasterised again, but this time to accommodate the lower resolution of the façade as a result of not having enough MiPix20 units.
Over the next two weeks I worked together with Martin Schroth on the façade. We presented six further design stages in internal presentation and at the end to the client in order to demonstrate a final development of the media façade based on a technical understanding of the constraints of the MiPix20 and design considerations.
These two options were tested in 1:1 scale mock-ups to test if small openings, as seen in Fig. 26, and bigger opening such as seen in Fig. 27 were viable. After completing design stage 6 and design stage 7 further design principals called ‘Stone’s Throw’ were developed.

Fig. 28: Design stage 8 named ‘Stone’s throw’

Fig. 29: The ‘Stone’s throw’ idea was continued in Design stage 9; the openings were seen as too big in this stage

Fig. 30: Design stage 10; did not combine small and big openings well enough
The façade in design stage 11 was also clad with an etching foil with openings at the bigger windows to express the openings more clearly.

Fig. 31: Design stage 11 had achieved all qualities required and was accepted by the client.

Fig. 32: Openings in the façade corresponded to openings in the etching foil to express the windows.

Fig. 33: Final model presented to the client, each design stage had been applied on a model to test where openings in the façade were required.

To summarize the design of the façade: the main problem was a lack of technical understanding when using LED display systems such as the Barco MiPix20. Trained as an architect I was responsible for the design of the façade only three weeks after handing in my final year project and had previously not used media facades to the extent
of actually building one. The system had many constraints I was not aware of and which partly shifted the design to its final outcome. The design process was mainly driven by offering a design solution and then being advised by a consultant that this option is impossible.

The interesting aspect of the façade was the use of the Barco MiPix20 as a common façade cladding system with windows for the visual contact for its users. The idea of including windows in a media facade was mainly neglected when looking at other examples where big screens have been attached to building facades as seen, for example, in Times Square in New York. Here façades were mainly covered with media facades which did not allow natural illumination for the users of the building. Furthermore, even having achieved a media façade with windows the space as such did not change when the content changed, the façade of the VIP café stayed on the level of a television with windows. This raised the question of content of media facades but unfortunately I was not able to influence the displayed content, which was supervised by the communication agency Atelier Markgraph, Frankfurt, Germany. Political issues between the architecture and communication agencies enforced a very strict separation between architecture, with the design of the booth, and communication, with the design of the content of the booth.

The booth is explained using floor plans Level 0 and Level 1, Section and a façade section. The plans that show the set up of the booth can be found at Chapter 6 Appendix in Appendix 1 - Plans.1 The following images show the set up of the media façade, from different positions. They are also under copyright with Kauffmann, Theilig & Partner, Stuttgart, Germany.2

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1 Copyright Kauffmann, Theilig & Partner, Stuttgart.
2 More images in a larger format have been included for reference in Chapter 6 Appendix: Appendix 3 – Images.
**Fig. 35:** Main elevation of media façade of the VIP café within booth opening hours, with different content

**Fig. 36:** Main elevation of media façade of the VIP café within booth opening hours

**Fig. 37:** View of the VIP Café from the top

**Fig. 38:** Detailed view of façade and the play between people in the café and the content displayed on the façade
Following the car booth in Geneva I was commissioned by Kauffmann, Theilig & Partner to work as a design director and senior project manager for the Auto Show China 2004 in Beijing in July 2004. The job had to be completed in even less time than the booth in Geneva, with four months between starting with the job and the end of the exhibition. All working drawings had to be finished eight weeks before construction started in China so parts built in Germany could be shipped to China in time. The
extremely short timeline for the project was also reflected in the time available from starting the job to the first and only meeting with the client, who came from Hong Kong, where the Mercedes-Benz China headquarters was located, to Stuttgart. The design process gave me three days to come up with a conceptual idea, plans and to build a model and prepare a presentation. The project team included another architect, Maria Milan, working on the costs and project management and again four interior design students doing their internship in the office. Here two brands of DaimlerChrysler were to be exhibited - Mercedes-Benz and the high-end luxury brand Maybach, this being Maybach’s first appearance on the Chinese market \(^1\). Several Mercedes-Benz internal decisions had made the exhibition in Beijing 2004 to an important event, therefore the exhibition was the second biggest booth in square meterage that Mercedes-Benz had built and a complete exhibition hall had been rented for the exhibition. In the following section I will explain how I designed the booth and the concept that lay behind the design. The design idea for this booth was similar to a museum where visitors walked from one exhibition area to another and were able to see in each area a different exhibit, in this case a different car group. The reason for this spatial arrangement was the great number of visitors at exhibitions in China which required a constant flow of visitors’ constraint to one direction. The visitors were guided through a ramp system from floor level +/- 0.00 to a height of + 4.09 m.

This allowed the visitor to experience the booth from different height levels and experience different vistas of the booth and the exhibited cars.

\(^1\) The China Daily newspaper has published an article in 14.05.2004 on their homepage: http://www.chinadaily.com.cn/english/doc/2004-05/14/content_330722.htm where Peter Honegg, president of Mercedes-Benz China Limited state the debut of Maybach at the Beijing International Auto Show 2004.
The ramp system also allowed the visitor to view the new Mercedes-Benz SLR from all four sides and from different heights. The design allowed the public to see the cars not only from one to three different sides but from all four. Seeing the car from different heights allowed the visitors to perceive the car from all angles.

Maybach required the cars to be seen when entering the booth, but they were required to be seen as an individual brand within the DaimlerChrysler group. Therefore the Maybach display was located underneath the ramp system, using materials and quality appropriate to the Maybach corporate identity. The concept of different height levels was also drawn from traditional Chinese gardens where one is able to experience the garden’s layout from different heights and therefore view different vistas. This would allow the visitor to get an overview of the selection of cars on display and also an overview of the architecture as a build landscape.

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1 The principles of Chinese Gardens at this time had been researched with Keswick, Maggie – *The Chinese Garden*, (Frances Lincoln Publishers, 2003)
The balustrade of the ramp system ought to have been executed with the previously used Barco MiPix 20 system, but due to the very limited budget this idea could not be realised. Instead of Barco MiPix 20, conventional fluorescent light tubes were used. These tubes were combined with a dimming system that allowed the control of each light according to a predefined content. Therefore with the use of light the visitors’ attention could be focused on certain areas of the booth by increasing the brightness and combining this with sound effects. Furthermore the light effects of the media façade were adjusted with the video clips showing on the main screen at the centre of the booth in front of the main stage. After gaining experience in the field of media facades and being previously trained as an electrician, the use of fluorescent light tubes did not offer any difficulties in designing a media façade. The communication and the content of the façade were discussed with the communication agency Atelier Markgraph to guarantee that architecture and communication would fit together and augment each other. The combination of media, architecture and communication in Beijing created a positive outcome which helped to improve the appearance of the booth.
The design of this booth did not present any new challenges in designing media facades. The control of the fluorescent light tubes was simpler than that of the Barco MiPix20 system. In cooperation with the communication agency Atelier Markgraph a concept for the content of the media façade was developed. Here, pre-existing advertisement clips and newly produced Chinese clips were combined with the design principles of the architecture. Due to its programmed content the media façade was able to place the focus on different parts of the booth by changing the brightness of the lights and other effects. The use of different a medium, fluorescent light tubes, raised the interest on other built examples using the same technology such as the Kunsthaus Graz by Peter Cook and Colin Fournier/Spacelab. Here a further engagement with media architecture happened and I broadened my interest in how this technology could be used in architecture.

The booth is explained using floor plans Level 0 and Level 1, Section and a façade section. The following images show the set up of the booth, from different positions. They are all under copyright with Kauffmann, Theilig & Partner, Stuttgart, Germany.

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i The plans that show the set up of the booth can be found at Chapter 6 Appendix in Appendix 1 - Plans. Copyright for all plans are with Kauffmann, Theilig & Partner, Stuttgart, Germany.

ii More images in a larger format have been included for reference in Chapter 6 Appendix: Appendix 3 – Images.
Fig. 46: Elevation from entrance exhibition to the main stage of the exhibition

Fig. 47: Vista from first ramp towards Maybach booth located underneath the highest point of the booth

Fig. 48: View from ramp to main stage

Fig. 49: Elevation entrance area Maybach
Prior to this exhibition I lived and studied for 4 month of the end of 2002 at the Tokyo Institute of Technology, Japan. During this time I lived in close proximity to Shibuya crossing and passed this concentrated location of media and architecture daily. I began to be aware of the limitations of how media is used in architecture and the potential uses of media technology in architecture at this time.

Fig. 16: Street scene Shibuya crossing, a location I passed by twice a day on my way to university

An extended discussion of the history of Shibuya and the use of media and architecture will be presented at a later stage of my report. Shibuya, and media facades in Tokyo in general, have been an inspiration for the film *Blade Runner* by Ridley Scott (1982). A movie which, although based in a dystopian Los Angeles, uses Tokyo as its main reference, where “overlooking the city is the ‘Japanese Simulacrum’, the huge advertisement which alternates a seductive Japanese face and Coca-Cola sign.”

The importance of Shibuya in the discussion of media and architecture have been also stated by Anthony Townsend in *Digitally Mediated Urban Space: New Lessons for Design* where he states: “No discussion of digitally mediated urban space could be complete without including Shibuya Crossing in Tokyo,...”

Prior to my architecture degree, I completed a three and a half year training course as an electrician and I worked for a year afterwards as an electrician. An understanding of electrical technology was provided in the training course. I was taught to develop electronic circuits, analyse electronic components such as LEDs and screen
technologies, which helped me in working on the booth in Beijing with developing the media façade.

Summarizing my research background to this stage, following motivations for my research have come out of these experiences.

Even having, in the case of the two booths, a big budget and a prestige client the outcome for architecture are not satisfying. The media facades I were involved in designing were no more than large televisions which clad architecture, and further developments in media facades will only generate better images by developing better screens but do not improve the experience of the space as such. The content of these facades as well do not improve space, because they cannot do more then simply change the image on the screen. I have had the same experience living in Shibuya when walking there through space clad with media facades.

Both experiences raised many questions and in turn provided motivations for my research which I will discuss when defining my research question.
Defining my research question

Introduction

What if a building or a space could be constantly generated and regenerated?

Cedric Price

What are the interests of my research and how do I position my research in an architectural context?

My experience as an architect on the Auto Salon Geneva 2004 and the Auto Show China Beijing 2004 is relevant to my research. In both Geneva and Beijing my main interest and task was the design and development of the facades. Both projects involved architectural components shared by other buildings and projects, such as the space people use, the room program, and circulation through space and so on. But the specific focus of my research is the façade of both projects, and to be precise the media façade used in both projects. The scope of my literature review and the focus of my contribution to this field of knowledge is therefore the further development of media facades and placing them in context to current interests in architecture.

Having worked on projects that combine media with architecture in practice and after living in Shibuya, Tokyo for six months, the following observations on media facades were made that frame my research interest and lead me to my research question:

The work with 2D screens such as large display systems or LED media facades, ie. the Barco MiPix20 system that was used at the Auto Salon Geneva 2004, raised an interest in investigating the possibilities for architecture when applying these systems. Due to being widely available to architects and designers, “large projection screens are becoming more and more ubiquitous in urban spaces”, so Ava Fatah gen. Schiek. Indicators for this are the further development of these products, their use in fields outside of architecture and the falling cost of LEDs screens, LCD screens, etc. Reed Business Information, a company providing information for businesses, states in an article published 17 August 2004 that the

“Prices dropped 10%-20% over the past 12 months and will decline at a similar percentage over the next year for most LEDs. The exception will
be white LEDs. Tags for these devices will fall, but at a smaller rate of decline because there are fewer suppliers and less capacity than for blue, green and yellow LEDs.”

The article quotes Jovani Torres, regional U.S. product marketing manager for Agilent’s optoelectronics division, who notes: “… that 10 years ago a 5 mm AlInGap\(^\text{ii}\) chip cost about 75 cents. Today it costs about 10 cents.” So if “architecture and media technologies [are] melting into each other, and buildings are turning into becoming media infrastructure”\(^4\), architectural facades will not face significant cost constraints in the future when using these LED based technologies, which furthermore does not add more further costs due to high energy consumption\(^\text{iii}\).

Other fields, for example Telecommunication, have adopted display technologies to the extent that most new-release mobile phones come with a colour display screen capable of displaying images and movies in high resolution. By 2004, 68% of all mobile phones shipped worldwide used colour displays, with the remaining 32% being monochrome. By 2008, colour displays will be virtually ubiquitous in new mobile phones, with a 96% penetration, according to ZDNet an Information platform for businesses.\(^4\) Media technology such as LCD or LED screens exists and can be applied in architecture and “large-scale video screens in urban settings suggest new possibilities and challenges for city authorities and regulators, architects, advertisers and broadcasters as well as for cultural curators and producers”\(^5\), says Anthony Auerbach in Interpreting urban screens when discussing the question of defining the role of cultural input in urban media. He further argues: “While this potential [of the screens] remains largely untested, it is clear that urban screens establish new sites for the negotiation between commercial, public and cultural interest.”\(^6\)

But this technology is applied, such as in Tokyo, it mainly featured media façade systems that covered and cladded buildings. The application did not help to actually define space. Stephen Perrella has discussed this when using the example of Times Square in New York, where he said:

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\(^{i}\) Source: [http://www.purchasing.com/article/CA444978.html](http://www.purchasing.com/article/CA444978.html)
\(^{ii}\) AlInGap stands for Aluminium indium gallium phosphide which produces red, orange and yellow LEDs.
\(^{iii}\) I discuss the energy consumption of LEDs in Volume Two in the project work : Project 1 further, where the energy consumption of LED based systems gets analysed
\(^{iv}\) Source: [http://www.zdnet.com/](http://www.zdnet.com/)
“... if we could strip away all the electronic signs in Times Square, we could find a cacophony of material surfaces, each working to maximize the potential readability of the sign. It is this sort of drive, motivated by economic concerns, that differentiates surfaces, and that will propel the surface into a sign, and the sign into a surface.”

For Perrella, it is not in the interest of architecture to function only as a carrier for messages or images, driven by economic concerns. The issue of integration of screens into buildings is a concern for Ava Fatah, and she suggests “that in order to achieve integration on the urban level, the displayed content and output technologies need to be embedded in the architecture of the building and become part of the emergent space and perhaps space-defining elements themselves.”

The concern of Perrella that screens “propel the surface into a sign” and the requirement of Fatah that screens could “perhaps [be] space-defining elements themselves” have led me to the conclusion that screens do not necessarily define space more than any other material, stay on the level of an animated surface. In an interview with John Armitage, Paul Virilio argues that “the prima materia of the architect is not matter, bricks, stones and concrete, but space”, and when these screens clad 3D objects they define space but the content displayed on the screens themselves do not create space in themselves’. What the screens restrict themselves to is present an ever-renewing content.

With the development of new technologies during the twentieth century, including video, television and the internet, the visual changeable medium with images, movies and visual representation have risen to prominence globally. One could argue that these inventions contribute to a view of postmodernity being dominated by images. Furthermore one could argue that architecture has been similarly influenced by this domination, by images which have influenced the way architecture is now thought of. Images now belong within the accepted vocabulary of discussing the quality of facades.

Another important question arises once the screens have been attached to a façade or building. What gets displayed on the façade?

The question of content has been raised by Stephen Perrella when he talks about the dimension of signs that have been motivated by economic considerations. The maximisation of the sign and, therefore, the maximisation of the screen are closely connected with the content. The content in the case of Times Square and many other
places is mainly based on advertising, and Ava Fatah gen. Schiek states that: “…most screens serve mainly commercial purposes, showing objects in different scale and proportions without taking into consideration the surrounding environment”.10 Commercial applications and the role of media do not form part of the discussion in my research in terms of the further development of media facades beyond their current appearance. However my research will investigate different forms of content to see if content could do more than simply alter the 2D appearance of the screen. Pre-recorded content, such as films, advertisement or others are only one obvious form of displayed content. While contemporary technologies, such as sensors, cameras and GPS, enable a façade to display more, they also allow for the creation of an interactive façade which can react immediately, or ‘live’, to events happening both close to or remote to the physical environment of the façade itself. When looking into content such discussions could drive my research, but in this thesis I have restricted my enquiry to computer codes which demonstrate what my proposed system could do and prove propositions I have made when talking about the significance of my system to the field of architecture.

When considering the content and the possibility for the façade to react live, there are the obvious differences between images and architecture: architecture creates, “after being erected, a static image that will not change over a period of time and is not yet in the position to fulfill the postmodern need for a ‘persistent new’ and react to different steams and trends.” 11 Wilhelm Klauser describes this need for a ‘persistent new’ when he speaks of buildings in Tokyo having a function similar to that of clothes. Fashionable for a season or a fashion stream they need to be extraordinary to manifest their existence. This dichotomy between being static or being dynamic has provoked some architects to create a shift in architecture when using different methods to make space more dynamic, to mention Greg Lynn as one example. The methods used vary from designer to designer - one, such as Greg Lynn tried to animate space via a fluid form while others, such as UN Studio sought to translate the movement of the user into the form principles of the building. Movement, fluidity, dynamic, etc. occur here as key words in architecture at present. The possibility for images displayed on a media façade reacting live according to the content thus creating a ‘moving image’, as touched on earlier, has been a major drive for my research.
How these future observations form into a valid research question?

There is a manifest interest in contemporary architecture to embed electronic technology where appropriate and in my research I am focusing on the technology of displaying images on a façade using LED-based display systems. This technology exists, but so far most examples of built space where media has been embedded into architecture have provided frustratingly limited results. Most built examples, such as the buildings with media facades in Times Square, New York are dominated by the image, leaving broader architectural concerns and opportunities behind with the chosen images mainly picked according to economic priorities.

Six propositions listed below summarise research interest:

- Firstly, an interest in extending the possibilities of existing media facades beyond their present appearance as a 2D screen applied to a building.
- Secondly, testing the proposition that there will be an increase of media in architecture, as predicted by Ava Fatah. Testing this hypothesis through a series of projects a development of media facades seems appropriate.
- Thirdly, rapidly accessed emerges of technology demonstrated by the example of mobile phones. Could architecture therefore be similarly influenced by the development of these display technologies?
- With existing technologies restricted so far to 2D screens and display systems my fourth proposition is to investigate into the possible evolution of screen technologies into a fully spatial representation of content.
- My fifth proposition is that the media content displayed on the media facades system could influence the alteration of space if an evolution of media façades would allow a fully spatial representation and not only an alteration of an image through content as in a 2D screen.
- Lastly, does a media façade, developed with these considerations in mind, offer a way of realising keywords such as ‘movement’, ‘fluidity’,
‘dynamism’, ‘interactivity’ thereby adding a new dimension to the current discussion in architecture?

With these observations in mind, my central research question has emerged as:

*When weaving architecture and electronically applied and managed imagery together, are their respective properties successfully interchanged to the extent that they mutually create a new architectural zone, one that is in constant flux, generated and regenerated through ever changing content?*


6 Auerbach, op.cit.


CHAPTER 3 Embedding media in architecture: cultural and technical implications

[1.1] Introduction

The historic, technologic and media content background of media in architecture

After providing an annotated bibliography demonstrating a scholarly depth and breadth of all relevant subject matter expertise, I will now illustrate firstly the steps made to further investigate the central research question, secondly the questions raised from the literature review and thirdly how the proposition can be tested. I am interested in the further development of existing media façades through a system that allows a modification of a zone, in the form of a 3D light point matrix, through an "alloplastic mode of operation" in form of a media content. This zone should have its origins in the developments of displaying image through electronic media, all with the previously outlined research background of applying media at two car shows and the experience of living in Tokyo and questioning different aspects of current applications.

To begin my cultural and technical investigation in media facades, I will research the cultural motivations for embedding media in architecture. Two questions can be raised. Where was the first building to be “decorated” with a screen? What can be learned from the early stages of the history of media facades?

To answer the first question, the winner of an international competition for the Centre Pompidou in Paris in 1971 by the partnership of Renzo Piano, Richard Rogers and Gianfranco Franchini, was in its original design, an antecedent for a use of media in architecture. The original design intentions, later relegated to a level of simple metaphorical statements, anticipated experimental forms of electronic communication more than three decades ago. Electronic communication was intended to happen through large television screens attached to the building so the building would have

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Luigi Prestinenza Puglisi discusses in greater detail this shift of Centre Pompidou from an antecedent of electronic communication to a building with metaphoric statements due to cost constraints in his book Hyperarchitecture – Spaces in the Electronic Age.
been, as Piano stated, “the largest TV screen in France”. The building therefore marks a shift to when electronically-driven display elements were introduced into architecture. Thus the Centre Pompidou can be identified as the first historical evidence of the type of relationship between media and architecture that my research seeks to explore. Today’s use of LED screens provides the main difference from the way buildings previously have communicated through their façades.

Another early example of media and architecture, but never realised, are some of the buildings shown in the movie *Blade Runner*, a for my research influential 1982 science fiction film directed by Ridley Scott, adapted from the novel ‘*Do Androids Dream of Electric Sheep?*’ by Philip K. Dick.

In *Blade Runner* the main characters of the movie often pass by a giant screen attached to a building. Although the film did not delve deeply into architecture as such, being based in a dystopian Los Angeles located in time as November 2019, it had picked up the idea of large media screens on the façades of buildings. Being a building model in a movie set it did not have to deal with financial constraints as in the case of Centre Pompidou where the large media screen was omitted for financial and technological reasons.

An example which does exist, however, is the Tower of Winds in Yokohama, Japan, built in 1986 designed by Toyo Ito. During the day the Tower of Winds stands as a 21m tall opaque tower, its surface cladded with acrylic reflective plates and enclosing it in a perforated aluminum cylinder with an ellipsoidal base. A series of three different lights were installed within the cylinder, in the air space between the perforated aluminum plates and the external surface to illuminate the tower at night. The three light types used are 1280 mini-lamps, 12 neon rings, vertically and evenly spaced around the tower and 30 flood lights situated on the ground and directed upwards, to illuminate the tower.
26 of them situated inside the tower. The Tower’s main function is accommodating water tank facilities and ventilating an underground shopping centre attached to the nearby Yokohama train station.

These two examples, Centre Pompidou and the media façade in Blade Runner, were not realized or relegated to a level of simple metaphorical statements. I would argue that both projects were too ambitious for their time and therefore could not be realized with the technology available at the time they were designed.

The Tower of Winds, on the other hand, could be realized because Toyo Ito used techniques in his media façade which already existed and had found use in earlier architecture. Thus the three discussed examples shows that designers and developers of media façades have considered the use of technologies which existed elsewhere, such preexisting technologies included television screens on the façade of Centre Pompidou as well as other pre-used technologies such as lights, neon rings, among others.

I am interested in researching further development of media façades guided by my central research question.

When weaving architecture and electronically applied and managed imagery together, are their respective properties successfully interchanged to the extent that they mutually create a new architectural zone, one that is in constant flux, generated and regenerated through ever changing content?

In this chapter I focus on materials and electronic components not commonly used as building materials in architecture.

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i  Source for the amount of lights: http://www.shu.ac.uk/schools/cs/cri/adrc/research2/pixelraiders/pixelcdrom/papers/paphohl.html (accessed in October 2006)

ii  The first recorded flat light-emitting diode display LED television screen prototype was developed by James P. Mitchell in 1977 and first presented at an Engineering Exposition in Anaheim May 1978. The LED flat panel TV display received special recognition by NASA, General Motors Corporation, and area universities including The University of California, Irvine, Robert M. Saunders Prof. of Engineering and IEEE President 1977. Additionally, technology business representatives from the U.S. and overseas witnessed operation of the monochromatic LED flat panel television display. The prototype remains operational. A LCD (liquid crystal display) matrix design was also presented in the accompanying scientific paper, as future television display methods using a similar scanning design method. The early display prototype was red monochromatic. Low-cost efficient blue LEDs did not emerge until the early 1990s, completing the RGB color triad. High-brightness colors gradually emerged in the 1990s enabling new designs for outdoor signage and huge video displays for billboards and stadiums.

iii  Ito used three different light types, which are listed in earlier in the text.
Therefore the question that this historic analysis of media façades raise is what kind of media façade development can be conceived within current constraints and what are the first steps towards realising such a system? My historical research has also demonstrated that a shift in how a building might alter the appearance of the façade through its interaction through its media façade is enabled due to a shift in technology. Display technologies that might create something like ‘the largest TV screen in France’ are now already available through the manufacture of not only cheaper and bigger display systems such as a television or computer screens, but also through the invention of new technologies to display any kind of image. Three currently available mediums, illuminating façade (fluorescent tube), LEDs and TV screens, will be explained with their history in Chapter 3 to demonstrate the progress of media technology since the design and erection of the Centre Pompidou.

Firstly my research will investigate the development of fluorescent tubes as one possible option of communicating via the building façade. Secondly the technology of LEDs will be explained in a general way to provide the reader with an understanding of how this technology works. LEDs will be discussed in greater detail when the research is tested in Chapter 5 Project 1 as a system primarily based on LED technology. Lastly, large visual display screens used as a method for displaying media content is introduced. Here three different technologies (High Definition Television, Plasma Display and LCD Panel) will be considered and compared. With this deeper understanding of the principle competing technologies available and used in contemporary architectural applications, the focus will shift back to the application of these technologies in architecture.

The focus of my research is firstly on a concentrated use of media technology in urban spaces. This chapter looks again into the history of the illumination of buildings in different areas by means of two examples. Both examples examine the history of media and architecture in an urban context, and look for the motivations of embedding media in architecture as well as providing an evidence of the shift in how applications of the media and architecture have been applied, by applying state of the art technologies.

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i Piano, Renzo quoted in Puglisi, Luigi Prestinenza – Hyperarchitecture - Spaces in the Electronic Age; The IT Revolution Series (Basel: Birkhaeuser – publisher for architecture, 1999), p.6

ii The development of Television from a CRT (Cathode Ray Tube) to LCD panel and LED technology is explained in greater detail in different books listed at the end of the thesis, where past technologies are explained as well as technologies that could become standard in the near future, such as OLED (Organic Light Emitting Diode).
first example analyses Times Square, New York and its history and how the space has developed to its present state appearance as well as the kind of technologies that play a major role in its appearance. The second example is Shibuya Crossing, Tokyo, when focusing on the development of the space and the shift of appearance through a shift in technology.

As the shift of appearance has been driven by a shift of technology, my research asks at this point what kind of technological development could push this shift of appearance of media façades further.

Having the shift driven via technological developments discussed by the means of two examples, the before mentioned mediums of fluorescent tube, LED and TV screen are now extended in several methods of media façades and classified in seven different groups by Alexander Wahl. The groups mainly used are introduced by the means of built examples, being display façades, illuminated façade and mechanical façades. These systems have been chosen because they represent three technical categories and allow a comparison between them due to representing developments which are either mechanical or electronic in nature, and if they are electronic presenting either a monochrome image or a coloured image.

The display façade is explored through two different technologies, with the main difference between the two systems being that they either use bigger LED tiles with an approximate 500*500mm size, or smaller single elements where a small number of LEDs are grouped in one element. Both components are explained using my different research projects and information from the manufacturer’s homepage.

The technology of façades with fluorescent tubes will be described to a greater extent in Chapter 3 which discusses the shift of appearance through a shift of technology; the chapter therefore concentrates on a building that represents fluorescent tubes façades at present - the Kunsthaus in Graz by Peter Cook and Colin Fournier/Spacelab.

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i The classification into seven groups have been based on a study by Alexander Wahl, lecturer at the Bauhaus University in Weimar, published on http://www.alexanderwahl.de/dateien/medienfassaden/medienfassaden.html (accessed March 2005) and previous explained in my research on page 39

ii I am using the term ‘illuminated façade’ to group all façades with fluorescent of light bulb based technology. The origin for this word is the Latin word lumen meaning light and its English relative illuminate for bright or beaming.

iii Kunsthaus Graz was built as part of the European Capital of Culture celebrations in 2003. Its exhibition program specializes in contemporary art of the last four decades. The museum was built at the same time.
Mechanical façades and their requirements are explained and also compared with electronic façades such as the ones described earlier to highlight the differences between electronically and manually altering the façade and its appearance. Two examples are introduced when I consider the mechanical façade – one from the Institut du Monde Arabe in Paris by Jean Nouvel and the other a project by the kinetic architecture group located at Michigan Institute of Technology (MIT).

The question emerging from this study in Chapter 3 is the following: If existing technologies of media façades have pushed back architecture and left space as a pure "carrier of a sign", how did space become the main issue when applying media facades?

The summary of how technology in media and architecture has shifted since the days of its first antecedents, through looking into three mediums, fluorescent tube, LED and TV screen was discussed in my research till this stage. Furthermore my research focussed on how this shift has been documented with alterations of appearances of buildings in two locations of major concentration, Times Square, New York and Shibuya, Tokyo.

My research continues with an analysis of the, as discussed previously, characteristics of all seven classified groups of media facades according to Alexander Wahl. The discussion media façades’ characteristics shifts the focus from hardware to software, when considering what kinds of media content have been applied to media facades.

Firstly my research looks back at the characteristics of the precursors of media in architecture, again the Centre Pompidou. Puglisi described in his before-mentioned

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i The Institut du Monde Arabe (IMA) was established during 1980 in Paris, when 18 Arab countries concluded an agreement with France to establish the Institute to disseminate information about the Arab world and set in motion detailed research to cover Arabic and the Arab world’s cultural and spiritual values.

ii The Massachusetts Institute of Technology (MIT) is a private, coeducational research university located in Cambridge, Massachusetts. MIT has five schools and one college, containing 32 academic departments, with a strong emphasis in theoretical, applied, and interdisciplinary scientific and technological research.

iii Perrella, Stephen – Hypersurface Theory: Architecture>Culture, (Great Britain: Wiley-Academy, 2001) p.139

iv I am using the term ‘hardware’ for all physical parts of a media façade. This includes all 7 introduced groups classified earlier. The term ‘software’ should then be used for the content delivered when using the hardware.
book three phenomena that for him marked an electronic age - immateriality, sensoriality and multimediality. Puglisi here speaks of the attributes of an immaterialised architecture\textsuperscript{ii}, in the sense of visible systems, as they had been positioned by Archigram and ”metabolists” from the Sixties onwards.

A second categorisation is the technical enhancements of media facades. Anthony Townsend captured the technical constraints of digitally mediated urban space when he grouped present technologies into four groups based on their functional application in urban environments - Display and expression, Communications, Positioning and Documentation.

In relation to the third categorisation that I am considering when analysing the characteristics of media facades, Toyo Ito discussed the characteristics of architecture in the electronic age and sees modern man existing at the same time in two different planes – one, the body in which he lives and the other, the virtual body in which his senses, stimulated by modern technology. Therefore architecture for him must be a ”media suit”\textsuperscript{iii} able to function in its nature and its information environment.

As a fourth and last point Paola Gregory offers further attributes matching the philosophical concept for our time which then has been divided by Gregory in four further phenomena\textsuperscript{iv}, which brings for her space to:

- “the co-presence of ‘technologies of intelligence’ capable of increasing memory (with databases, hyperdocuments, the Web)
- imagination (with visual interactive simulations)
- perception (with computerized images and the widespread tele-listing and television)
- reaction (with words, images, music, etc.)”\textsuperscript{v}

\textsuperscript{i} I am refering here to Puglisi, Luigi Prestinenza – Hyperarchitecture - Spaces in the Electronic Age; The IT Revolution Series (Basel: Birkhaeuser – publisher for architecture, 1999), pp. 7
\textsuperscript{ii} See book reference above, Page 10
\textsuperscript{iii} Ito uses the term 'media suit' in the article Architecture in Electronic Age is Figuration of Vortex of Information published online at: \url{http://www.designboom.com/eng/interview/ito_statement.html} (accessed March 2007)
\textsuperscript{iv} Gregory, Paola – New Scapes, Territories of Complexity; The IT Revolution Series (Basel: Birkhaeuser – publisher for architecture, 2003), p. 76
Having outlined these characteristics, the research then focuses on how these characteristics influence media content.

My research has thus far has outlined what hardware developments have been made since the design of Centre Pompidou and the common characteristics of all media facades. Now two paths of categorizing media content into discrete forms should be investigated further. For Joachim Sauter, professor at the University of Arts in Berlin and founding member of the communication agency ART+COM, “a media façade can be either autoactive, reactive or interactive”. In addition the façades could be designed, according to Sauter, to allow participation. These three and four terms respectively presented by Sauter are analysed by means of examples. Further investigations were made into the evaluations of the previous chapters where three discrete forms of media content have been filtered out of the characteristics of media facades. These three forms of pre-recorded, life content and interactive content are explained in greater detail with an example of possible media content and application of each of the three discrete forms on media facades.

In researching a system that explores the ideas inherent in a new conception of the relation between media or information and the built or constructed surface, the question of media content should focus on media façades built of LED, LCD, large screen or similar applications, keeping these systems, such as screens, in mind when considering how media content has been applied on them. But “If a screen is still a screen” as the quote from Manovich says, what kind of a system would allow media content to be more than just a generator of what is happening in the ‘window into another space’ yet be a generator of space itself? This has been the key driver for me: going beyond 2D display.

Having analysed the nature of the material available for creating a media façade and the characteristics of the media content that could be displayed, the research aims to fill in a

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I am refering to an articla by Joachim Sauter, published at [www.netzspannung.de](http://www.netzspannung.de) (accessed February 2007), this artical has been firstly published as Sauter, Joachim – Das vierte Format; Die Fassade als mediale Haut der Architektur, Fleischmann, Monika; Renhard, Ulrike (Eds), Digitale Transformationen. Medienkunst als Schnittstelle von Kunst, Wissenschaft, Wirtschaft und Gesellschaft, (Heidelberg: whois verlags und vertriebsgesellschaft, 2004).
gap by offering a material that could overcome the dichotomy between the 3D complexity of built space and 2D representation of applied image. The material should not be another media skin over the cover of an existing building but should help to "mediatize" the meaning of architecture, so Gregory in Territories of Complexity and help to shift the traditional meaning of architecture as a solid body towards a transfer to the fluidity and immateriality of electronic media.

A new material which could overcome the dichotomy between the 3D complexity of built space and 2D representation of applied image will weave together 3D and 2D with the creation of a system that requires three discrete considerations in order that such a system achieves its full potential and allows an alteration of space through form and image. Firstly I will to discuss how forms are received, secondly I will investigate the potential of existing media technologies beyond their typical application and lastly I will to discuss the mode of representation.

Firstly, how are forms received and can they be defined with the use of light? The illumination of the city gives the beholder a notion of space at night time, where one can locate the city and its buildings in relation to one’s own position - something one could not do if there had not been any light in forms and therefore the ability to define space with the use of light. I refer here to works or events such as the light cathedral (Lichterdom) designed by Albert Speer for the annual Reichsparteitag (NS party conference) in Nuremberg in 1934 to proof the possibility of defining space with light.

Secondly, I want to investigate the potential of existing media technologies beyond their typical application in architecture. Currently the typical application of a screen only offers the display of apparently 3D images and forms – but these ‘3D forms’ are never actually 3D, they only become 3D when one ‘moves’ them with a computer mouse. The reason for this limitation is the fundamentally two dimensioned nature of the display. Extended beyond their typical 2D application, my proposed zone built with a 3D grid of lights points, each with different X, Y, Z coordinates with LEDs placed at each intersection of the 3D grid. This zone will be formed by a number of ‘LED sticks’, attached at an angle normal to the built existing façade, with each of these sticks containing an array of LEDs placed in certain distances from each other. An equal resolution could be achieved in all three axes; images displayed in the X, Y, and Z planes and more importantly as 3D objects. Through their ‘non-physical’ existence, this ‘zone’
allows a modification of space, shape, image, form and impressions within its spatial boundaries, which can be changed as a function of time.

Thirdly, I will discuss three modes of representation which are used to display media content on screen: the pre-recorded content – such as a movie or a TV show; the live content – such as a live broadcasted sports event, and; the ‘living content’ – media content that is altered and defined by its environment in real-time. What do I mean by this? Sensors such as sound, temperature, movement sensors, and other devices that detect or respond to a physical or chemical stimulus, are able to capture what happens in our environment and translate the complexity of private and public into electronic data. This data could then function as a digital information injection for the zone in order to define the zone’s movement and its form in real-time.

My research summarizes a history of media in architecture and shows that a shift in technology has facilitated a shift in appearance. This shift so far has pushed the development of a 2D element capable of displaying media content in an improved form, but had reached its limits in how it defines space. My research has identified two main aspects through having a media façade as a medial skin and as an interactive membrane between architecture and public space. One aspect is that a façade could be an integrated component of a building and not simply an element added later onto buildings such as seen in Times Square. The other aspect deals with an adequate narrative of the façade, namely with the media content shown.

Irrespective of how good the integration might be and what kind of media content could be displayed, this media content displayed on a screen-based format does not allow an alteration of space and the space stays static. Here my research considers a system that offers an option of form and image being amalgamated, and the potential significance for architecture if such a system existed.

An answer can be found to the question of what material could overcome the dichotomy between the 3D complexity of built space and 2D representation of image.
In 1971 the competition for the Centre Pompidou (the original name for the competition was Plateau Beaubourg Centre Paris) was announced by the French president Georges Pompidou. A total of 681 projects were entered by architects from all over the world. The brief asked for a cultural centre incorporating a museum and a creative centre that would be modern and evolve continually.

Regarding to Luigi Puglisi,

“A jury was called to examine the designs whose members included Willi Sandemberg, a renowned museum expert; Oscar Niemeyer, a Brazilian architect; and Phillip Johnson, an American architect and curator of different exhibitions held in the MoMA, New York. The jury was chaired by Jean Prouvé, a French engineer, inventor and experimenter with new material and technologies”.

Fig. 1: Centre Pompidou, main plaza in front of building

Fig. 2: Centre Pompidou viewed from a distance in an urban context
The partnership of Renzo Piano, Richard Rogers and Gianfranco Franchini won the competition with their idea of opening a large gathering space that was to create an open-ended mega structure that would address the city which stands out from within. Furthermore, the main façade included a giant screen displaying electronic messages about events at the centre or cultural and political news.

For Puglisi, “six years passed between the competition and the inauguration, by which time the energetic figure of Pompidou had disappeared. Plans for the mobile floors were set aside, as they would double the costs, and even the large screen on the façade was abandoned.” These numerous changes made during the construction process had the effect of annulling the initial aims of the designers and relegating these aims to the level of simple metaphorical statements, such as the coloured pipes on the outside representing communication with the building’s environment.

When did this shift to communication occur in architecture? In *Hyper Architecture – Spaces in the Electronic Age*, Luigi Pestinenza Puglisi argues that the Centre Pompidou is an antecedent for a shift of space to a communicative space. For him, the building and the space in front of the building marked the start of something new. Why does this building define a new way of space communicating with its surroundings and that being different to how space communicated in the past?

The winning design was:

“a transparent machine structured on slabs that could be raised and lowered to offer maximum flexibility; supported by long girders that minimised the needs for pillars; all the systems were projected outwards and realized in full view so that they could be easily maintained and replaced when needed. Lastly, the main façade included a giant screen displaying electronic messages about events in the centre or cultural and political news.”

Communication was its theme, and a three dimensional load-bearing wall was to constantly provide news and information on Paris shows, events, exhibitions, among other information. Centre Pompidou truly realised the concept of the building itself becoming a media format through communication using its façade - initially, mobile floors and large screens on the façade were considered, but abandoned due to cost.
issues. Piano commented that the Centre Pompidou “would have been the largest TV screen in France, without having a production structure behind it.”

The façades of the Centre Pompidou as now built show media functions through their performance as “exposing media” that display the systems that are necessary to run the museum (water, gas, electricity, circulation ….) on the outside. It resembles an x-rayed image, communicating through its transparency. These features are those that remained after numerous changes were made during the construction process and all but annulled the initial aims. Communication, through exposing mediums, still became part of the building’s defining characteristic even through the screen was abandoned.

The thoughts by Puglisi also have been in the following section important for my research.

For Puglisi the building entered a ‘new age’ marked by electronics and characterised by four attributes:

- Non-Firmitas
- Immateriality
- Sensoriality
- Multimedia

These attributes and not the Centre’s imposing utility systems, by its pipes, iron, glass and various mechanical systems, saw the start for Puglisi into a ‘new age’. But what do these four attributes mean?

For Puglisi, “Firmitas, namely attention to the values of weight and structure, is replaced by lightness, indeterminateness, transformability, the involvement of the user.”

Here, Puglisi talked about, a prevention of one of three classical goals of architecture traced back to the Vitruvian triad has taken place. Goals still followed in the first half of the 20th century, where the logic of the “machine for living” had its parallels in the characteristics of cars, steamships or aeroplanes, were replaced with the aesthetic of electronics and characterised by the next three attributes listed by Puglisi: immateriality, sensoriality, multimediability.

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i  I am referring here to four points Puglisi discusses in his book Puglisi, Luigi Prestinenza – Hyperarchitecture - Spaces in the Electronic Age; The IT Revolution Series (Basel: Birkhaeuser – publisher for architecture, 1999), pp. 7

ii  I am referring here to the work of Le Corbusier published in Le Corbusier – Toward a new architecture, (Dover Publication, 1986).
“Immateriality is primarily expressed by transparency”\(^7\). With buildings covered in a transparent skin of glass the immaterial has consequently become predominant in architecture: walls lose their consistency, objects are dematerialized, the media content takes over the container. This allows the third attribute: “Sensoriality is the capacity of a structure to interact with the outside world”\(^8\). An immaterialist skin creates a 2D screen on which action happens on the inside, i.e. human movements, light, colours, structures, to name a few are displayed on it, which then leads to the last attribute:

“Multimediality represents the choice to transform the building into an organism capable of conveying messages using various media, integrating them into the building fabric. The building becomes a screen that irradiates lights, colours and sounds and, at the same time, communicates information.”\(^9\)

This approach has been carried throughout the built building of Centre Pompidou by conveying messages using various media such as its transparency, allowing the structure to interact with the outside world; such that the street side would display traffic related data while the plaza would present entertainment and information to the pedestrians. The building also acts as a screen that emits light, colours and sound.

The building has been turned inside out, that is, these machine infrastructures were placed in front of its glass skin. It creates an exterior mapping of its architectural components, such as steel which can be seen exposed vertically and held by a series of diagonal bracings.

There are attachments of tubing on the exterior that can be identified by their distinctive colouring:

- Blue = air (air conditioning)
- Green = fluids (water circuits)
- Yellow = electricity
- Red = circulation (elevators), security (fire apparatus)

With this tubing the interactivity of the façade has been relegated to a level of simple metaphoric statements. But it shows the potential of a media façade: a media façade should stimulate the beholder through the use of communication methods to communicate with its environment. This potential for communication gives architecture another dimension than the purely decorative, with the use of ornaments, colour and material, among others.
For Puglisi;

“The Centre Pompidou, at least in its original design – anticipates, but without being subject to the same strong commercial pressures, Times Square and experimental forms of electronic communication introduced above all in Japan and the United States.”

[1.2.2]

Blade Runner

*Blade Runner* is an influential 1982 science fiction film directed by Ridley Scott from a screenplay written by Hampton Fancher and David Peoples, adapted from the novel ‘*Do Androids Dream of Electric Sheep?*’ by Philip K. Dick. The plot and characterisations of ‘*Do Androids Dream of Electric Sheep?*’ are different from its movie adaptation, *Blade Runner*, in a number of ways. For this research the key difference is the alteration of where in the novel 3D televisions entertain humans, but in the movie this has been altered to large screens attached to buildings. Here the film as such becomes a precursor for media in architecture. The film depicts a dystopian Los Angeles in November 2019 in which genetically manufactured beings called replicants, physically identical to adult humans, are used for dangerous and degrading work in Earth’s ”off-world colonies”. In different scenes in the movie the main character travels via a flying object or transporter through this dystopian Los Angeles.

The building of particular interest to this research is covered with a giant television screen. Without having a clear possibility to analyze the size of the screen, one can assume from the size of the surrounding buildings that the screen must be several storeys high. The image sequence below shows the building in two different scenes with two different contents, and in one what seems to be a sunrise or sunset (*Fig. 3*) and a night scene (*Fig. 4 and Fig. 5*). Due to the same camera angle and the same surrounding buildings, when comparing *Fig. 3* and *Fig. 4* the building on the left is the same in both scenes and one can assume that it is the same building. Furthermore in the second picture series one can see two further screens, which appear to be of a smaller size,

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1. The film has been discussed in its architecturale context by essays such as, Burns, Alex – *Will Androids dream of electric sheep?*, www.disinfo.com/archive/pages/article/id1109/pg1/index.html, (accessed April 2005). or Benjamin, Andrew – *At home with the Replicants*, www.basilisk.com/A/A_Benjamin_BRunner_110.html, (accessed April 2005), amongst others.
displaying “Off Worlds” in the centre, and of a size similar to the main one, a screen displaying “PAN AM” on the top left of the image. The screen used in the media façade has clearly visible separations in smaller fields, having five fields horizontal and 4 fields vertical. I can only speculate on the motivation for this separation but one can assume that it seems more realistic to separate the screen into smaller fields and give the impression that large televisions have been assembled to create an even bigger one. This assumption is mainly based on the fact that large LED screens were not yet invented in the beginning of the 1980s when the film was made. Of course economical concerns were not a factor for a built model used in a film, which allowed the producers to achieve what the designers of Centre Pompidou could not: creating a giant television screen on a façade.

![Fig. 3: Blade Runner Scene from Movie, 1982 with the media façade on the left side of the image](image)

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The first recorded flat light-emitting diode display LED television screen prototype was developed by James P. Mitchell in 1977 and first presented at an Engineering Exposition in Anaheim May 1978. The LED flat panel TV display received special recognition by NASA, General Motors Corporation, and area universities including The University of California, Irvine, Robert M. Saunders Prof. of Engineering and IEEE President 1977. Additionally, technology business representatives from the U.S. and overseas witnessed operation of the monochromatic LED flat panel television display. The prototype remains operational. A LCD (liquid crystal display) matrix design was also presented in the accompanying scientific paper, as future television display methods using a similar scanning design method. The early display prototype was red monochromatic. Low-cost efficient blue LEDs did not emerge until the early 1990s, completing the RGB color triad. High-brightness colours gradually emerged in the 1990s enabling new designs for outdoor signage and huge video displays for billboards and stadiums.
The 1986 completed Tower of Winds in Yokohama, Japan, designed by the Japanese architect Toyo Ito, is another precursor for media and architecture, and according to Hohlwelt, a homepage \textsuperscript{11} as even one of the earliest form of interactive architectures. During the day the Tower of Winds is a 21m tall opaque object, grey and blending in with department stores, banks and office buildings, its surface clad with acrylic reflective plates and englobed in a perforated aluminum cylinder with an ellipsoidal base. But as the sun goes down, it becomes a sensual device recording the transitory state of the city around it. A series of three different lights were installed within the cylinder, in the air space between the perforated aluminum plates and the external surface. The three light types used are 1280 mini-lamps and 12 neon rings, vertically and evenly spaced around the tower, and 30 flood lights situated on the ground and directed upwards to illuminate the tower, 26 of them situated inside the tower.\textsuperscript{1} The tower has as its main function two

\textsuperscript{1} Source for the amount of lights: http://www.shu.ac.uk/schools/cs/cri/adrc/research2/pixelraiders/pixelcdrom/papers/paphohl.html (accessed October 2006)
tasks; inhabiting water tank facilities and providing ventilation for an underground shopping center attached to the nearby Yokohama train station, both transforming a mundane chimney into an elegant column.

The light system, conceived by Toyo Ito himself in collaboration with the TL Yamagiwa Laboratory, is controlled by two computers placed at the foot of the Tower which regulate the intensity, direction and typology of the light sources, depending on the hours and some environment parameters. The lamps are programmed in a way that the neon rings light up to approximately mark the hour; the light of reflectors on the ground changes intensity and luminous flux depending on the wind’s direction and speed; the mini-lamps light up tracing in real-time different designs as an interpretation of the surrounding environment. Sometimes all lights light up synchronously, producing a bright show which represents the musicality of surroundings; a wonderful example of ambient architecture able to interpret through light the sound produced by the environment.  

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The communication of the tower has been described in further detail in:  
For Ito the Tower of Winds “loses its presence after sunset and metamorphoses into a phenomenon of light. I refer to this metamorphosis from opaque substance into a transparent object of light as ‘fictional’.” Furthermore when being asked about the direction of architecture regarding ideas of fluidity and interdisciplinary metaphors and inspirations he states that he “…hates to see the space in architecture freeze and continue to exist for a long time.”

The three examples discussed above were selected from the early beginnings of embedding media in architecture. One of them, the Tower of Winds, was completed using technologies available at the time of its construction and design. But two of them, Centre Pompidou and the architecture in the movie Blade Runner, were not completed or not meant to be built at all, but they nevertheless have established a path for thinking of how media, in these examples television screens, could become a part of architecture and then one must wait until this technology is widely available to design and build projects like them. I believe that the media facades in both unrealis projects document a process of the creative imagination where systems can be envisaged, but not built at that time. Centre Pompidou and Blade Runner were visionary because they were designed at a time where electronic components capable of displaying media content were in their early stage of development. Nonetheless, the designers of both projects were thinking of possibilities of how to include technologically advanced elements. They used available technologies and when looking at these technologies imagined ways to alter such existing technologies to create something different with them. The questions this chapter asks are, what kind of media façade development exists at present and what kind of steps could be taken to turn an existing technology into something new? To create a system which could be envisaged at present and how could the first steps towards such a system be made?

The following chapter will look into the technological shift that happened in the decades since Centre Pompidou and the other buildings presented were built or conceived, in the case of Blade Runner. The focus here should be on technologies used or meant to be used in the projects described above, when discussing fluorescent tubes, LED technology and large display screens.
Cost difficulties that Piano, Rogers and Franchini faced in realising the original proposal for the media elements on the façade of the Centre Pompidou, would be obsolete today. Technology for media screens has improved and the technology required in the 1970s is now more affordable. More so if the Centre Pompidou screen was built, the technology for displaying information such as computer screens or televisions would have been outdated by now and would have most likely been exhibited on the inside rather than the outside of a museum as a state of the art technology.

If one thinks about the changes to computer monitors from 1971 to the present, it becomes obvious what kind of changes display technology underwent. The shift from the monochrome CRT computer displays using a green ‘P1’ phosphor screen, better known as “green screens”, to analogue RGB monitors, to LCD screens has happened within the last 30 years.

Media technology is therefore very closely connected with developments in industries such as companies producing fluorescent tubes or LED producing firms as well as businesses producing TV and computer screens.

These three mediums, illuminant (fluorescent tube), LED and TV screen will be explained in their history to demonstrate the progress of media technology since the days Centre Pompidou was designed and built. This research is not intended to contribute to the field of knowledge in electronics; therefore explanations of the three mediums remain on a general and not a technical level. The focus is more on a brief history to introduce the three mediums and then to discuss their use within an architectural media façade.

Illuminates (fluorescent tube) are a type of lamp that uses electricity to excite mercury vapor in argon or neon gas, resulting in a plasma that produces short-wave ultraviolet light. This light then causes a phosphor to fluoresce, producing visible light.

The earliest ancestor of the fluorescent lamp is probably the device by Heinrich Geissler who obtained in 1856 a bluish glow from a gas sealed in a tube, excited with an
At the 1893 World's Fair, the World Columbian Exposition in Chicago, Illinois displayed Nikola Tesla's fluorescent lights. In 1894, D. McFarlane Moore created the Moore lamp, a commercial gas discharge lamp meant to compete with the incandescent light bulb of Thomas Edison. The gases used were nitrogen and carbon dioxide emitting respectively pink and white light. In 1901, Peter Cooper Hewitt demonstrated the mercury-vapor lamp, which emitted light of a blue-green colour, and thus was unfit for most practical purposes. It was, however, very close to the modern design. This lamp had some applications in photography where colour was not yet an issue, thanks to its much higher efficiency than incandescent lamps. Edmund Germer and coworkers proposed in 1926 to increase the operating pressure within the tube and to coat the tube with fluorescent powder which converts ultraviolet light emitted by a rare gas into more uniformly white-colored light. Germer is today recognized as the inventor of fluorescent lamp. General Electric later bought Germer's patent and under the direction of George Inman brought the fluorescent lamp to wide commercial use in 1938.

Fluorescent tubes are a very old medium and widely used in households, offices and to illuminate advertisements in an urban environment. My research does not look any

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1 The research about the history of fluorescent tubes has been based on readings in resources such as Gossner, Stephan – *Grundlagen der Elektronik – Halbleiter, Bauelemente und Schaltungen (Schulbuch)*, (Shaker Verlag GmbH, 1992), Horowitz, Paul and Hill, Winfield – *The Arts of electronics*, (Cambridge University Press, 1997) and Lurch, E. Norman – *Fundamentals of electronics*, (John Wiley and Sons, Inc., 1971), amongst others
further into the function of a fluorescent tube, but discusses the main aspects that made them difficult to use in the past. Firstly they only allowed images in one colour (e.g. white, red, blue, to name a few colors). Moreover they could not be dimmed; being digital they could be switched on or off, but only could display two possible states, on or off, and could not be switched to analogue which allows for example 10% on or 70% on. The development of an electrical device plugged in before the tube made it possible to dim the light and therefore nowadays allows a gradient from 100% to 0%.

The book Smart Materials and Technologies by Addington and Schodeck describes: “An LED (light emitting diodes) is a semiconductor that luminesces when a current passes through it.” 13 This effect is a form of electroluminescence. The color of the emitted light depends on the chemical composition of the semiconducting material used, and can be near-ultraviolet, visible or infrared. Rubin Braunstein of the Radio Corporation of America first reported on infrared emission from GaAs (Gallium Arsenide) and other semiconductor alloys in 1955. Nick Holonyak Jr. of the General Electric Company developed the first practical visible-spectrum LED in 1962. Addington and Schodeck continue with:

“The use of LEDs for task lightning, signage, outdoor lightning, façade illumination, traffic lights, mood lighting, large panel displays and other applications is far cry from 1980s when LEDs were primarily used as indicator lights, letting us know that our oven was on, or that our car alarm has been activated.”14

For the purpose of displaying objects in colour, e.g. illuminating a light box, clusters of these LEDs can be used. Some exist as ready made objects purchasable from different manufacturers that produce LED display panels.
There are two types of LED panels: conventional, using discrete LEDs, and Surface Mounted Device (SMD) panels. Most outdoor screens and some indoor screens are built around discrete LEDs, also known as individually mounted LEDs. A cluster of red, green, and blue diodes is driven together to form a full-color pixel, usually square in shape. These pixels are spaced evenly apart and are measured from center to center for absolute pixel resolution. The one of the largest LED display in the world is approximately 427 meter long and is located in Las Vegas, Nevada covering the Fremont Street Experience.\textsuperscript{1}

Most screens on the market are built using SMD (Surface mounted device) technology. An SMD pixel consists of red, green, and blue diodes mounted on a chipset, which is

\textsuperscript{1} Informations provided by the Touristinformation of the city of Las Vegas on their homepage: [www.vegas.com/attractions/off_the_strip/fremontstreet.html](http://www.vegas.com/attractions/off_the_strip/fremontstreet.html) (accessed June 2007)
then mounted on the driver PC board. The individual diodes are of a size of a pinhead and are set very close together. The difference is that minimum viewing distance is reduced by 25% from the discrete diode screen with the same resolution.

Indoor use generally requires a screen that is based on SMD technology and has a minimum brightness of 600 candelas per square meter. This will usually be more than sufficient for corporate and retail applications, but under high ambient-brightness conditions, higher brightness may be required for visibility. Fashion and auto shows are two examples of high-brightness stage lighting that may require higher LED brightness. This has been the case in the auto shows the author has worked on.

This system works when LEDs are mounted together in smaller elements such as the BARCO MiPix 20 or in large display systems, due to both being based on the technical principles of LED technology.

Lastly, an introduction to TV screens should be made with a focus on the development of large screen display systems. Here a differentiation has to be made between large LED display panels and LCD screens. The LED display panel has been explained when talking about LEDs in general so the main focus will be on the other large display screens.

One of the first display systems was the common television used in households and other places. When it was first established some 75 years ago it was black and white but through further developments the analogue television soon advanced to colour - here the development followed a similar path to the before mentioned computer screens.

Even though it has proven its worth in the domestic field and was the norm through the second half of the 20th century, the CRT (cathode ray tube) component of the standard television was too heavy and bulky, especially for a big screen. Hence a technology was founded to cater for the need of a large display screen that is light in weight and still allows great viewing.

At present these large display systems are available:

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For further information about the topic of the history of TV screens please refer to literature such as: Winston, Brian – *Media Technology and Society, A History: From the Telegraph to the Internet*, (London: Routledge, 1998) or Smith, Anthony – *Television an International History*, (Oxford University Press 1995).
High-definition television (HDTV) means broadcast of television signals with a higher resolution than traditional formats, such as NTS and PAL, allow. HDTV is broadcast digitally, and hence its introduction corresponds with the introduction of digital television (DTV).

Flat screen plasma displays are not a new idea: the basic technology has been around for more than 40 years. However, modern computers are the thing that makes the complex displays of today's flat screen plasma TVs possible.

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For further information about HDTV please refer to an article written by Martyn Williams in May 2007 publicised on: http://www.pcworld.com/article/id,132289-c,hdtv/article.html (accessed May 2007)

For the history of flat screens plasma display please refer to the homepage of Donald Bitzer at North Carolina State University. Bitzer has co-invented the flat plasma display in 1964. See: http://renoir.csc.ncsu.edu/Faculty/Bitzer/ (accessed May 2007)
In a flat screen plasma TV the computer at its heart lights, in the correct sequence and at the correct time, thousands or millions of tiny fluorescent spots ("pixels"). The lighting is created with electricity, and each pixel is red, green or blue. By combining pixels of these colours and varying their intensities, from which any colour can be made, the flat screen plasma TV reproduces the entire colour spectrum. The largest plasma display in the world was shown at the CES (Consumer Electronics Show) in Las Vegas in 2006. It measured 103” (1080p) and was made by Matsushita Electronics Industries (better known as Panasonic).

A plasma screen has two glass sheets (1/16”), with ‘spacers’ between them which create individual cells. Transparent electrodes are coated inside the front and back of each glass, and the back glass is called the "address electrodes”. Each cell is coated with phosphor filled with mixtures of neon and xenon gases; therefore the entire structure is sealed so no gas is let out. The image is created by an electric charge added to the front and back electrodes, and through that a voltage differential is created. The plasma state is made when energy is added to the gas mixture. Once it changes into plasma state, it releases its ultraviolet energy which stimulates the phosphor coated inside each cell and hence emits a visible light. Each pixel is made of three cells (placed side by side), and each cell contains a phosphor coated red, green, or blue.

LCD stands for “liquid crystal display”. Liquid crystal flat screen displays are everywhere in modern life, not just in TVs. LCDs are critical to many items of everyday life: wristwatches, stereos, car displays, hand calculators, instant-read thermometers and computer displays. LCDs in these items may not seem the same as flat screen TVs, but the exact same technology is used in all types of LCDs.

In March 2005, Samsung announced the largest LCD panel, the 82” HDTV TFT Panel. The viewing angle of 180° TFT-LCD is applied through Samsung’s proprietary S-PVA technology. 12.44 million thin-film transistors used to achieve full HD image quality of 6.22 million pixels. An LCD panel is a “transmissive display”; it relies on a

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i  For further information please refer to an article by David Richards publicised in January 2007 where he talks about the presentation of the Plasma display by Panson in the CES in Las Vegas; See:  http://www.smarthouse.com.au/CES/C7U4N7V9 (accessed May 2007)

separate light source to allow light to pass through to the eye. The light source is the “back light”, a very thin lamp that sits directly behind the LCD panel. The light from the backlighting then passes through a polarizing filter; it filters and aligns the light waves in a single direction. Then the polarized light passes through the actual LCD panel and the liquid crystals portion of the panel either allows or blocks the polarized light to pass through depending on how the liquid crystals are aligned at the time of the light passing through. The panel is made of tiny individual cells that are each controlled by a tiny transistor to supply current. One pixel is equal to 3 cells (side by side to each other). Each cell is made of red, green and blue, for example a 800 x 600 resolution LCD panel has 48,000 pixels and a total of 1,440,000 individual cells. Once light passes through the liquid crystal layer of the final polarizing filter it then passes through a colour filter so that each cell will then represent one of the 3 primary colours of the light.

Fig. 13: LCD Pane, as example for a transmissive display
[1.3.2]
Evidence of this shift by the means of two locations

Times Square is well known for its extensive use of media.¹ Anthony Townsend calls Times Square, “perhaps the quintessential example of a digital urban environment.” Its history gives a good overview in how media has been used and how development in media technology has been adopted at Times Square.

At the end of the 19th century, New York City had expanded up to 42nd street and the area was becoming the centre of the city's social scene. In 1904, the New York Times built the Times Tower on 43rd street just off Broadway to replace their premises downtown. The square facing the building was called the Longacre square, but was soon renamed Times Square. The name is now used for the area between 40th and 53rd street and 6th and 9th avenue. The inauguration of the Times' new headquarters was celebrated with a fireworks display, starting a New Year's Eve tradition which continues today. The first famous ball-lowering from the 1 Times Square's rooftop pole was held on New Year's Eve 1907.

At the start of the First World War, Times Square was the centre of the Theatre district and attracted a large number of visitors. This made the square an ideal place for billboards. In 1917 the first large electric display billboard was installed. Eleven years later, the first running electric sign was switch on for the first time, to announce Herbert Hoover's victory in the Presidential elections. The billboards have become such a tourist attraction for the area that the zone now requires the buildings to be covered with billboards. In the thirties, the Great Depression led to a sharp decline in theatre attendance. Many businesses had to close down, and they were quickly replaced by strip tease venues and peep shows.²

¹ The importance of Times Square as an area with a high use of media facades has been argued by Townsend, Anthony– Digitally mediated urban space: New lesions for design; Praxis Issue 6 Journal of writing and Building, Praxis inc, Cambridge, MA 2004. Here he chose Times Square as one of three locations to discuss mediated urban spaces.

² The Times Square Alliance, founded in 1992, works to improve and promote Times Square, their homepage: http://www.timessquarenyc.org/index.html (accessed March 2006) has been helpful in writing about Times Square in this section of my research such as literature in particular: Boyer, M. Christine – The Double Erasure of Times Square, Iain Borden, Joe
The history of the area gives us an understanding of its development to its present form. As the 1933 movie musical 42nd Street proclaimed, 42nd Street was a “naughty, bawdy, gaudy, sporty place already well in decline when it lent its iconic title to the film that opened at the Strand Theatre, five blocks away.” Even so, 42nd Street was still the most intensely imagined and glamorous street in the world – it was the hub of the entire theatre world for thousands who dreamed of becoming an actor or dancer.

“But already at the time the movie was playing, Times Square/42nd Street was changing - a sordid undercurrent of crime, pornography and prostitution took over its terrain. The last legitimate stage production on 42nd Street closed in 1937, and most of that street’s theatres became movie houses shortly after the Brand Organization bought them in 1933. Of the thirteen fabled theatres that once adorned 42nd Street – all built between 1899 and 1920 – only five survive.”

But these theatres were the first to shape the face of Time Square with their use of artificial lights, a common decorative element that was also later used for cinemas. Examples of such can still be seen at both the Astor Cinema in St. Kilda, Melbourne or the Regent Theatre in the Melbourne city centre.

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For many years Times Square meant to New Yorkers six to seven crimes a day. The theatres transformed into cinemas, and together with the porn shops kept the garish illumination, which is indeed a characteristic symbol of porn shops or cinemas - the very bright illumination on the outside to attract passers by, with a darker interior. The area continued to attract visitors though and after the Second World War, and the district was booming again. At the end of the sixties the area started to go downhill and by the mid-seventies tourists avoided Times Square, which had become a seedy, crime-ridden and drug-infested place. In the 1980s redevelopment proposals were submitted, with little result. Political factors like the Zero Tolerance guidelines for the police and building regulations changed the face of Times Square in the mid-eighties. M. Christine Boyer argues that;

“We could claim that New York City real estate values, and the midtown zoning district that operated between 1982 and 1987 and allowed taller and bulkier skyscrapers from Times Square to Columbus Circle along the Broadway spine, killed Times Square and turned it into a corporate office park.”  

18
But the lighting, which is regulated by guidelines that call for a requisite number of "LUTSes" (Light Units in Times Square), kept the illuminated impression of the area. It went even so far that a 1987 ordinance mandated the amount of illuminated signage and the degree of brilliance that new buildings must carry. The first LUTS appeared on the giant jukebox exterior of the Holiday Inn Crowned Plaza Hotel on Broadway and 48th street in 1989.

From there on Times Square as a quintessential public space of an American city was transformed into a stimulated theme park for commercial entertainment, where each of the thirty-four refurbished structures that line the street between Broadway and Eight Avenue must now be wrapped and layered with spectacular signage – some animated and some lighted, but all legible from a distance, and all with outstanding visual impact. To quote Robert A.M. Stern;

“A chart of coordinated colors has been developed; diversity in styles, scales, and materials encouraged; and a mélange of restaurant and retail types expected.”

The New York Times architectural critic reports:

In short the plan is devised to reinforce the street’s existing characteristics. The layered accretion of forms over the past century. The mix of styles and scales. The lack of visual coordination... Above all, the street will be unified by the prominence given to signs: video screens, painted billboards, theatre marquees, faded murals from the past, LED strips, holograms – an uninterrupted commercial interruption.

Times Square/42nd Street is an urban territory shaped by global capitalism, or that it substitutes signs of the real for the real. A set of façades as illuminated and shiny as the
area of Times Square/42nd Street, existing in the memory as an entertainment area with a slightly sleazy touch, has now been “Disneyfied” and saved, and therefore consumable by the whole family. This so-called “Disneyfication” began in the 1990s when the Walt Disney Company opened a Disney store on Times Square, attracting more family-friendly businesses to the area.

By the late 1990s Times Square was again a symbol for the vibrancy of Manhattan — it is the only zone in the city where tenants are required to display big, bright signs. The NASDAQ sign is a flashier example, costing over $37 million to build; at 37 feet high it is the largest LED sign in the world. With all the residents living in New York and an estimated 26 million annual visitors each year, Times Square has changed greatly since its inauguration 100 years ago not only in its use and in its visitors but also in its appearance. According to analysts at the Times Square Business Improvement District, “there are now 38 large-format LED screens in Times Square, installed at a cost of over $140 million. These signs have added over $75 million in taxable property value.”

“From the first electronic billboard to the largest LED screen the space has always been a reflector of display technology.

“No discussion of digitally mediated urban space could be complete without including Shibuya Crossing in Tokyo.” This statement by Anthony Townsend shows the importance and the influence of Shibuya crossing, not only as an inspiration for futuristic visions such as Ridley Scott’s Blade Runner. Shibuya is a suburb in Tokyo located approximately 3 kilometres south of Shinjuku, another major centre within Tokyo, and is a similar gigantic commercial area focused on a huge train station. Shibuya Station is one of the busiest stops along the Yamanote rail loop, one of the major train lines around the centre of the city. Like Shinjuku Station, it is a major transfer point for commuters between the suburbs and the city, as well as a popular destination for thousands and thousands of workers, students, shoppers, and others who disembark there every day and enter the surrounding neighbourhood. As is typical of large train station-centered commercial districts in Japan, including Shinjuku, the spatial structure of Shibuya includes various specialized subdistricts: i.e. an area of department stores and other retailing; an area of banks and office buildings; several specialised areas of restaurants, coffee shops, and other eating and drinking places; a
large night time entertainment zone (and some smaller ones); and a quiet district of love hotels. ¹

The subdistrict of Shibuya given to retailing is especially large and, if the rate of expansion of its leading stores is any indicator, extremely profitable. Two major department store chains dominate the trade. One is the huge Tokyu chain, which also owns the train line leaving Shibuya towards Yokohama and indeed built the train station that is included in the department store, and the other chain is Seibu. In addition to the flagstaff stores, which themselves are opulent multi-level consumer showcases, they have, between them, at least 15 giant branch stores within a few blocks.

Two general characteristics distinguish Shibuya, one demographic and the other cultural. ² The key demographic point is that a disproportionate fraction of the district’s users are young. The second distinguishing point is that Shibuya is extraordinarily trendy. Its young shoppers come to see and be seen, being attentive to the minutest detail of fashion and in step with whatever is hot, and sometimes it seems no matter what the cost.

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¹ For a further detailed analysis see Cybriwsky, Roman – Tokyo - The Shogun’s City at the Twenty-first Century, (Chichester, England: John Wiley & Sons, 1998), pp. 162-168 from where this data has been taken.

² The information for the two general characteristics was also taken from the book mentioned above.

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**Fig. 19:** Shibuya crossing in 1958

**Fig. 20:** Shibuya crossing in 1962
Fig. 21: Shibuya crossing undated picture

Fig. 22: Shibuya crossing in 1977

Fig. 23: Shibuya crossing in 1978

Fig. 24: Shibuya crossing in 1978
The images above illustrate the development of the area and the department stores and demonstrate how the advertisements for those stores have shifted over time with the development of technology, from fluorescent tubes from the 1950s to 1980s to large displays and LED screens at present. But more than any other place, Shibuya at present has formed a new type of urban space that thrives by melding together, according to Anthony Townsend, “display and expression, wireless communications, and automated positioning.” So the shift in appearance through a shift in technology has been extended from the technology used on the façade to an introduction of technology to define a media content, including mobile phones for wireless communication and GPS for an automated positioning. Townsend continues in his article that

“according to recent surveys, Shibuya Crossing has the highest mobile phone density in the world. Of the more than 200,000 people who pass through the intersection each day, some 80 percent carry a mobile phone. Each time the light changes, some 1,200 mobile phone users swarm across the plaza.”

GPS comes into place; because Japanese cities lack Western-style sequential street address systems, Tokyo’s citizens tend to rely heavily on maps to give direction. This
practice according to Townsend has driven a wave of technological innovations starting with the fax machine, which was a consumer hit in Japan long before the U.S., as it offered a superior method for sharing maps and has resulted in a wide array of based-mapping services that rely on GPS receivers embedded in mobile phones. In Shibuya we will, according to Townsend, see the first signs of how interactive urban spaces are shaped by individuals and groups who provide their own infrastructure for interacting with, navigating, and recording the urban environment. The development of Shibuya into an interactive urban space had its beginning in Centre Pompidou as an antecendent for a shift of space to a communicative space.

The text and images for both examples show a shift in appearance of both places, and even though the motivations for this shift were different it was driven by advancements in technology. Thus, what kind of technical development could further push this shift of appearance?

As an outcome of the above explained developments, several forms of media façades can be built and communication can be delivered in different methods. All of them have been used in various examples in architecture. I want to divide these methods into 7 different groups separated into technical categories based on research made by Alexander Wahl:

- Projection façades, where a façade is used as a projection screen, with the projector on another building.
- Back projection façades, with a projector behind a translucent projection surface.
- Window raster animation uses existing window grids on buildings and each window functions as one pixel. Low resolution messages or early computer game atmospheres are possible.

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Passive media façade is primarily a transparent façade, where the communication is created through different visible layers behind and the users/people in the building.

Display façades, having a mainly LED medium displaying items on the façade. The façade functions as a big screen and available systems are produced by several companies such as Barco, SmartSlab, Versatile, among other products.

Illuminated façades, where neon tubes are dimmable and allow the display of low resolution black and white moving images.

Mechanical façades have mechanical driven elements that change the appearance of the façade.

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[1.4.2]

Introduction of three categories by the means of built examples

The last three types of media façades in the above list are described in greater detail:

- Display façades
- Illuminated façades
- Mechanical façades

Why these three types of media façade? A detailed study of resources, based on the examples Wahl offered in his essay, of all seven types of media façade, has shown that only Wahl’s last three bullet points, the ones I want to discuss further, have potential to be developed toward the aims of my research. These systems represent three technical categories and have been chosen because they are either the most commonly used or the most advanced systems or, in the case of the mechanical façade, show differences in appearance between a mechanically and electronically altered façade. Each façade type should be introduced by built examples.

Firstly I want to talk about display façade systems, introduce the product and show built examples. Display façades are built with the use of different systems by different producers. Here I want to explain two products which can be used to design a display façade and these products should stand here as representatives for all other systems.
The two selected products have been built by various manufacturing companies, but for demonstration reasons two different manufacturing companies will be chosen as an example but without a personal preference.

The main difference between the two introduced systems by these two manufacturers are that they are either a bigger tile of approximately 500*500mm in size or are smaller single elements where a small number of LEDs are grouped in one element.

The systems are:

- Large display systems such as Versa TILE Staging Panel¹, ILite 6XP by Barco² or SmartSlab³
- MiPix 20 by Barco⁴, Versa PIXEL by Elementlabs⁵

The possibility of having openings, such as doors or windows in a façade are very much limited when using a screen element with the size of 500*500mm or greater. Therefore these elements are mainly used for large displays. Even with resolution not as good as LCD screens the advantage, due to being able of connecting more then one element with others, is the size the screen can reach when working as a screen with more then one element. LCD screens are available only up to a certain size and have a frame around the screen, a phenomenon that is commonly known from flat screen computer monitors. When one connects more then one of the LCD screens to create a bigger image the frames always divide the image.

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¹ For further information about product please refer to producer’s homepage:

² For further information about product please refer to producer’s homepage:

³ For further information about product please refer to producer’s homepage:
http://www.smartslab.co.uk/ (accessed November 2006)

⁴ For further information about product please refer to producer’s homepage:

⁵ For further information about product please refer to producer’s homepage:
Fig. 27: Versa TIE Staging Panels as a single element

Fig. 28: Versa TIE Panel in use in different applications

Fig. 29: ILite 6XP by Barco as a single element

Fig. 30: ILite 6XP in use in a car show
Fig. 31: SmartSlab Tile as a single element

Fig. 32: SmartSlab in use, proposed
Guggenheim museum Tokyo by Zaha Hadid

The pictures above show all three products as an element and in use. The first two products, Versa TILE Staging panel and ILite 6XP are used mainly indoors, but they also exist as outdoor options although with limitations. Different from the SmartSlab product, and described on the homepage as the “world’s toughest video display for walls, floors, billboards and buildings”, its honeycomb structure allows it to be used directly as a building component for an interior or exterior wall, ceiling or floor. It is “inspired by the naturally efficient optics of the fly’s eye; the display uses hexagonal pixels (hexels) to effect a perceived image of 18% finer resolution than a regular square ‘pixel’.”

Fig. 33: SmartSlab resolution improvement through ‘hexels’

http://www.smartslab.co.uk/ (accessed November 2006)
When it comes to luminance and diffusion, the producer classifies

“SmartSlab [as] a high brightness display with a full viewing angle that can be seen in daylight and artificial lighting conditions. It is available in either standard (1000Cd/m²) or high brightness (5000Cd/m²) versions”27

This statement is of great interest for the spatial dynamic media system, when raising the question of visibility and readability during daylight. The smaller single elements where a small number of LEDs are grouped in one element are mainly in systems such as MiPix 20 by Barco or Versa PIXEL by Elementlabs. Both these systems allow the possibility of openings for windows, doors and other openings. A built example of a media façade designed by the author tests the difficulties when using Barco MiPix and the quest for possible openings.

The author was responsible for the design of the media façade for the Mercedes-Benz car booth at the Geneva Automobile Salon 2004 whilst working for German architects Kauffmann Theilig and Partner in Stuttgart. Mercedes-Benz had rented 124,000 Barco MiPix 20 for three shows, two previous shows at the IAA (International Automobile Exhibition) Frankfurt, Germany 2003 and the NAIAS 2004 (North American International Auto Show) Detroit, USA. These elements were used and arranged in either horizontal or vertical lamellae (See Fig. 34 and Fig. 35).

![Fig. 34: IAA Frankfurt Mercedes-Benz, 2003 an example where Barco MiPix 20 elements has been used](image-url)
The aim for the Automobile Salon Geneva 2004 was to create a façade for the VIP café with openings; a ”TV screen” where moving image and moving people interacted with each other. The design of the façade was driven by the technical requirements of the product. Here it was not possible to place openings in any location of the façade. This was because of the way the façade was controlled by the hardware and software, where it was necessary for the computer to know the location of each pixel to give it the right colour information to produce an image. The arrangement of the pixels had to be made in a coil form with a length of four strings with of 11*11 pixels per string. Openings could be achieved when removing the pixels at the end of each string, but not in the middle of beginning of a string. Furthermore the cable length from pixel to pixel was of importance as well as the length of the cable from the controlling hardware to the first pixel in a coil. These requirements lead to the result shown in the images below.
Regarding information on the homepage of Elementlabs the product Versa PIXEL does not have such strict constraints. Here the length of the connecting cables and the positioning of the single pixels can be done independently from a coil arrangement, which allows more flexibility and a bigger range of façade design. The manufacturer states on the homepage that “its distributed architecture gives designers complete freedom over pixel shape and placement – including intricate 3-D arrangements.”

The picture below with its random openings and its curved surface could give an idea of how the product could be used in an architectural context. Due to being only recently developed, no further images are at present available.

A diagram provided by SmartSlab on their homepage when comparing different systems with each other and also compares the previously mentioned system with bigger tiles or smaller elements according to different criteria. These details have not been tested by the author but due to its publication on the web one can assume that the publisher has not made claims that can’t be legally justified. Please find the table attached at Chapter 6 Appendix: Appendix 2 – Tables.

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The possibilities offered by façades with fluorescent tubes should be explained with an example that stands as the most advanced use of this technology. The project I want to introduce is the Kunsthauß Graz, in Austria, by Peter Cook and Colin Fournier/Spacelab. The Kunsthauß Graz, a museum for international exhibitions of modern and contemporary art, was built as part of the European Capital of Culture celebrations in 2003 and is the result of an international competition initiated by the city of Graz, Austria. The museum site is embedded in the historic cityscape of Graz. In November 2001 construction started and was finished by the end of 2003. The design team was a partnership of three offices: spacelab (Peter Cook and Colin Fournier's office), Architektur Consult and the structural engineering firm Bollinger + Grohmann.

After the overall planning for the Kunsthauß project had reached an advanced stage, an idea was brought forth by the client to transform the entry façade into a virtual art space, an ever-changing media display. They contacted realities:united, a Berlin-based architecture and media design collective. Consideration was given to this particular firm because of their previous success with large scale media façades.

For the Kunsthauß project, realities:united explored a concept that they titled “BIX”, short for Big Pixel. This was a completely new idea, one that would incorporate sophisticated computer software and electrical circuitry with basic fluorescent bulbs to achieve large display, low resolution motion graphics.

Beneath blue acrylic panels facing the river and city centre realities:united deployed a matrix of 930 circular fluorescent light tubes covering an area approximately 20m high and 40m across. By being able to individually adjust each bulb’s brightness at an infinite variability with 18 frames per second, each lamp acts as a pixel in the same way a pixel behaves in a computer or television screen. This allows low resolution images, films
and animations to be generated over the whole eastern façade; visible at a considerable distance all over the surrounding city.

*Fig. 40: Kunsthaus Graz, 2003* rendering of media facade

*Fig. 41: Kunsthaus Graz, 2003*

The design process of the façade is explained on the BIX homepage as follows:

“Each of the matrix’s individual pixels is a conventional fluorescent lamp with 40W and a diameter of 40 cm. The decision to use this industrial module exemplifies the asymmetrical design character of the BIX concept. For the development central design features of conventional large displays had been abandoned in order to obtain a number of substantial advantages in exchange.

As a result the "resolution" of the matrix is extremely low. There are only 930 pixels – these are mere 0.2% of the pixels in a conventional TV screen. And they are "black and white" only.

On one hand, this low image resolution imposes strong limitations. In exchange, however, this "deal" enables both the modular structure and the huge size of the installation to be highly integrated into the architecture. The BIX installation is practically covering the entire façade facing the riverside. Using conventional big screen display
technology the surface area which could have been covered with the same budget would have been nearly a hundred times smaller.”

Continuing on their homepage they discuss the aesthetics of the project:

“Sharing the same scale the architecture and the media installation together generate new aesthetic results. Not a separately mounted video wall but the Kunsthuis itself radiates characters and images; the link between the aspect of projection and the building as entity achieves an extremely high level of integration. The total area is broken down into 930 independent light sources, like individual spots of pigment "tattooed" onto the skin ...

The light matrix does not constitute a rectangular field with straight sides, but rather an amorphous zone tailored to the complex shape of the building and gradually fading away towards the edges. Thus one has the impression that the blue bubble itself renders the light patterns from within. In the absence of a recognizable boundary, it looks as though the light patterns could dance freely on the outside skin of the building. The complete fusion between architecture and media technology defines a new standard.”

Thirdly, mechanical façades and their requirements will be explained. They will also be compared with electronic façades such as those described earlier to see the differences between an electronic and a mechanical way of altering a façade.
Allowing a façade to be changed and altered in a mechanical way means to move parts with the use of electro engines or hydraulic or pneumatic systems. At this point my research will discuss façade systems driven by electro engines.

A well known example of a façade controlled by electro engines is the façade at the Institut du Monde Arabe in Paris by Jean Nouvel. It was established in 1980 in Paris, when eighteen Arab countries concluded an agreement with France to establish the Institute to disseminate information about the Arab world and set in motion detailed research to cover Arabic and the Arab world’s cultural and spiritual values. The Institute also aims at promoting cooperation and cultural exchanges between France and the Arab world, particularly in the areas of science and technology, thus contributing to the development of relations between the Arab world and Europe.

![Fig. 43: Façade Institut de Monde Arabe, a mechanical media facade](image)

The south façade takes up the historic themes of Arab geometry in the design of the Mashrabiya.

Based on this façade concept in Arabic architecture, Nouvel designed a façade with an intricate structure that holds several motor-controlled apertures that act as a ”brise soleil” to control the light entering the building according to the weather conditions and the season of the year. The mechanism creates interior spaces with filtered light – an effect often used in Islamic architecture with its climate-oriented strategies. In the original concept these diaphragms open and close on every hour. Dennis Sharp describes the façades in his book *Twentieth Century Architecture: a Visual History*, as follows:

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Mashrabiya is the Arabic term given to a type of projecting oriel window enclosed with carved wood latticework, often located on the second storey of a house. A good view of the street can be obtained by the occupants without being seen, offering privacy for women and protection from the hot sun. The detailed, turned wood lattice is open to the air, without the use of glass windows. Resource:
“The huge south-facing garden courtyard wall has been described as a 60m 'Venetian blind', although its appearance is more patently Islamic in decorative terms. It is, however, an ocular device of striking originality, made up of numerous and variously dimensioned metallic diaphragms set in pierced metal borders. These diaphragms operate like a camera lens to control the sun's penetration into the interior of the building. The changes to the irises are dramatically revealed internally while externally a subtle density pattern can be observed. Thus the whole effect is like a giant Islamic pierced screen, giving significance and an audacious brilliance to this remarkable building.”

Still, a buildings’ façade driven by electro engines can lead to problems when one of the engines does not function. Despite being a very old technology it is still somewhat difficult to control electro engines so that they work without problems or stalling and that they will actually stop in a certain position repeatedly, and precisely. In a complex system such as the façade at the Institut du Monde Arabe a failure of one engine within one of the 240 Mashrabiya affects the whole single Mashrabiya.

Hydraulic and pneumatic systems are based on the same principle: to move pistons, with the use of air (pneumatic) or oil (hydraulic). The main difference is the medium. Air can be compressed and can therefore not be used to move heavy weights but does not need a pipe for outgoing air.

Due to being comparable in its principle function a built example will not be introduced, but rather an investigation in kinetic architecture will be explored. The kinetic architecture group located at Massachusetts Institute of Technology (MIT) defines the groups’ role as:

“...to create architectural solutions that can demonstrate responsive and intelligently active behaviours with respect to changing individual, social and environmental needs. Kinetic function is used as a technological design strategy for building types that are efficient in form, lightweight, and inherently flexible with respect to various contexts and a diversity of purposes. Intelligent kinetic systems arise from the isomorphic convergence of three key elements: structural engineering, embedded computation and adaptable architecture. Such systems shall serve as a practical means for inventing entirely new ways
of developing spaces, and the designing and building environments that address dynamic, flexible and constantly changing needs.”

Here one project based on research done at MIT in cooperation with ROART Associates, New York will be presented. For Michael A. Fox from MIT, the project fosters a direct interaction between an architectural-scale installation and pedestrian activity on the street. The 160mm long band of responsive ‘whiskers’ that wrap around a building in New York allows pedestrians to walk up and interact with the installation through their presence. The pistons which one can see in the image below (Fig. 44) move in wave-like rhythm driven by sensors mounted beneath each row, that monitor the presence of a moving person. If motion is detected, the pistons gradually point towards the target creating a ripple through the field. Each element moves in a simple fashion but together more complex patterns evolve. The project at once engages individual interactivity and at the same time actively mirrors the unengaged pedestrian activity as a whole.

ROART wanted to create a kinetic façade fuelled by humans and choreographed by their action; a canvas of everyday life translating the energy, diversity, and individuality of a New York street into an image on the face of a building.

An installation on the 160mm long façade of the Roger Smith Hotel that wraps the corner of 47th Street and Lexington Avenue promotes direct interaction between an awning made up of kinetic metal bars and the pedestrians on the street below.

The designers have been inspired by the collaboration between two great artists, Isamu Noguchi and Buckminster Fuller, who worked at the hotel during the 1930s to invent and model the Demoxion Car; the design group of MIT conceived a mechanical dune, a kinetic wheat field.

For their mechanical canvas the designers of MIT chose panels made up of fifty individual, straight, metal bars. The “bars”, lightweight rods of equal length and

![Fig. 44: Prototype of façade Roger Smith Hotel](image-url)
diameter, move in a wave like rhythm driven by sensors that are mounted beneath each row to monitor the presence of a moving person. If motion is detected the poles start pointing toward the target, creating a ripple through the field of poles. “A sea of bars sensing a sea of people presenting the life of the city on the face of their skyscraper host because in New York, everything happens in the street.” 34 The motion of the rods was also controlled by small electro engines to allow a motion into X-plane and Y-plane.

The three examples have shown different applications of how a façade could be turned into a media façade. While some examples work as an enrichment of space, where through the use of the media façade space becomes altered or reconfigurable, other examples include mainly clad buildings. Stephen Perrella discusses this cladding of a façade to “maximize the potential readability of the sign. It is this sort of drive, motivated by economic concerns, that differentiates surfaces, and that will propel the surface into a sign, and the sign into a surface.”35 This section of my research has narrowed down the field in regards to which technologies offer viable directions for continuing the investigation in developing media facades. Compared with illuminated facades and mechanical facades there are advantage of LED based facades for my research. Illuminated facades and the technology of flourescent tubes have constraints in their size. Moreover the sizes of both the overall units and the individual components can not be significantly modified within the compass of the resources and time available for a postgraduate research project. Therefore the research would have to be limited to existing sizes and product ranges of fluorescent tubes. Mechanical facades have the previously discussed difficulty to control electro engines. My research will concentrate therefore from this point on LED technology when considering a technology for a further development of media facades.

Thus the question arising from research outlined in this chapter is; the present technology of media facades has often trapped architecture and space in being a pure carrier of a sign, but how can space again become the main issue when applying media façades?
After having introduced different media façades, specifically the three mentioned previously, I will analyse their common characteristics prior to discussing the role of media content on all of these media façades.

The characteristics described by Luigi Pestinenza Puglisi, when declaring the Centre Pompidou as the ‘antecedent of a new space’, were discussed earlier in the chapter [1.2] in the section on the precedents for media and architecture. Let us return to them and reflect if these characteristics could work as a requirement for media façades in general or if they are restricted as principles for the beginning of mediated spaces and could be only used when discussing Centre Pompidou.

Puglisi described the three phenomena that marked an age of electronics with the following statements:

- “Immateriality is primarily expressed by transparency”
- “Sensoriality is the capacity of a structure to interact with the outside world”
- “Multimediality represents the choice to transform the building into an organism capable of conveying messages using various media, integrating them into the building fabric. The building becomes a screen that irradiates lights, colours and sounds and, at the same time, communicates information.”

Puglisi is here referring to attributes of an immaterialised architecture, in the sense of the idea of visible systems, as it has been positioned by Archigram and “metabolists” from the sixties onwards. For them it was necessary to devaluate the traditional problems of architectural composition: they denied that the design of the façade, the rooms, the components or the details might, in themselves, in any way be central; instead, they underlined the links and relations between spaces, functions and activities in a society based on flow, many of which are immaterial, says Puglisi in his book. In the field of architecture the theme of immateriality has been picked up by, amongst others, architects such as Toyo Ito and Rem Koolhaas. Ito’s Sendai Mediatheque is an example where the glass wrapping the building and dividing the inside from the outside
works like a skin. “By skin he [Ito] means a sensitive epidermis to interact with urban space, absorbing lights, sounds, flows and returning images and vital tensions to the outside.”

When talking about sensoriality, Puglisi quotes an observation of Rogers that implies the installation of “sensitive systems which flex like the muscles in the body, minimizing the mass, shifting the forces with the help of a nervous system based on electronic impulses, sensing environmental change and recording individual requirements.”

For Puglisi, this explains the organisation of the Centre Pompidou as a complex system of coordinated activities and, in overall terms, as a machine that manages information on more than one level, relating to multiple activities and using several techniques.

“Multimediality represents the choice to transform the building into an organism capable of conveying messages using various media, integrating them into the building fabric. The building becomes a screen that irradiates lights, colours and sounds and, at the same time, communicates information.”

Here again parallels between the ideas in a design such as Ito’s Sendai Mediatheque and Puglisi’s principles for Multimediality can be seen and are further discussed in Chapter [1.5.3]

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[1.5.2] Technical enhancements

Anthony Townsend in his article about digitally mediated urban space captured the technical constraints of digitally mediated urban space when he grouped current technologies into four groups “based on their functional application in urban environments:

- Display and expression
- Communications
- Positioning
- Documentation”

Display and expression has been discussed in this chapter, focusing on new technologies for display and expression. Without the technological developments described earlier when talking about a shift of appearance through a shift in technology, together with the falling costs of purchasing the technology such as LED screens or large display screens, urban space could not be mediated through visual display to the degree that it is presently.

For Townsend, communication plays a role that has been to date mainly neglected by architecture. For him wireless communications are “defining the very nature of twenty-first century urban streetscapes”, however, wireless networks remain largely outside the realm of architectural and spatial design, despite their powerful impacts on the movement and space requirements of society. As mentioned in my methodology I want to exclude discussing communication, but I am aware of the importance of the role of communication in the discussion of media and architecture. The role of communication has been raised earlier by Puglisi when talking about Centre Pompidou.

The role of a mobile phone or other electronic devices as a tool to communicate with a building or with space has hardly been explored by architects. There have been attempts to integrate electronics in buildings, such as the “T-Com-Haus” in April 2005 where in cooperation between German Telecom, Siemens, Neckermann and WeberHaus a digital house was presented to the public in Berlin. The design of the house is rather ordinary; the main interest was to explore the use of different communication systems to be in connection and control of your private space even when being physically remote.

Positioning of individuals with GPS (Global Positioning Systems) technology has become an item available in phones or cars to name two examples. GPS allows humans to locate and orientate themselves easily in unknown or complex areas, such as driving through metropolitan Tokyo, a city with no street names and addresses in a western sense. But it also means that our surroundings are aware of where we are when being locatable through, for instance, a mobile phone. This kind of information could be used in the computing process to exchange data between surroundings and individuals and be integrated in an architectural design. Proximity-based positioning techniques

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1 An article about the house was published in the German newspaper Siemons, Mark – Frankfurter Allgemeine Zeitung F.A.Z., 13.04.2005, Nr. 85 /p.37
based on the detection of embedded radio frequency identification tags (RFID) are likely to spread even more rapidly.

Finally, “as database technology has merged with computerized cartography to form increasingly sophisticated geographic information systems (GIS), our capability for documentation of urban environments has been greatly magnified.”

We are not only able to collect different data with the help of databases, but this data can be used to form new social networks where people, with the use of databases and the location of their phone via GPS, can extend their spatial knowledge of an area. Townsend provides an example for this the “emerging services like Dogdeball.com [that] provide the ability for social groups to create, store, and retrieve comments and ratings about good places to eat, drink, and shop in major cities like New York through both desktop browsers and internet-enabled mobile phones.”

These four groups of Display and Expression, Communications, Positioning and Documentation frame the technical requirements to start a mediated space. All four groups are not always present, but “they offer compelling evidence of the synergies that are possible when two or more of these technologies are combined to provide new flexibility and capability to human-environmental interactions.”

[1.5.3]
Characterisation of architecture in the electronic age

Puglisi later argues in his book ‘Spaces in the Electronic Age’ that,

“Whereas Futurism is the art of the electric age, namely the car and household electrical appliances, the new architecture is the art of the electronic age, namely, the computer and information sciences.”

What is the architecture of the electronic age and how could it be described? Ito, one of the architects Puglisi refers to in this quote, has an image of architecture in the electronic age, and offers five points as to how he would describe architecture in the

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1. Puglisi refers here to the architecture of Ito, Hadid, Eisenman and Gehry and refers to the influence Mies and Futurism had on them
2. This is also the title of an essay Toyo Ito has written for the University Museum of the University of Tokyo [http://www.um.u-tokyo.ac.jp/publish_db/1997VA/english/virtual/01.html](http://www.um.u-tokyo.ac.jp/publish_db/1997VA/english/virtual/01.html)
electronic age (three of which are relevant here). Firstly, for him architecture in the electronic age is figuration of a vortex of information. Compared to people in the primitive age where the human body is linked with nature, “People today are equipped with an electronic body in which information circulates, and are thus linked to the world through a network of information by means of this other body.” In another article, Ito discusses the dichotomy of the modern man existing at the same time in two different planes – one, the body in which he lives and the other, the virtual body in which his senses, stimulated by modern technology, exists as well. For Ito combining these two bodies is one of the challenges we face at present, and is also the challenge which applies to architecture today. “Contemporary architecture”, for Ito, “must link ourselves with the electronic environment through figuration of information vortices.” The first premise for architecture in the electronic age would be the inclusion of electronic information into architecture, so, as Ito mentioned in his second point, architecture in the electronic age is an extended form of media suit, where architecture no longer provides only a shelter to adjust ourselves to the natural environment. “The contemporary architecture needs to function, in addition, as a means to adjust ourselves to the information environment. It must function as the extended form of skin in relation both to nature and information at once. Architecture today must be a media suite.” Finally in the last point Ito argues that architecture in the electronic age is architecture that designs time. He sees two different processes with the advent of computers into design. Firstly, we can erect a virtual building and experience it in the design process and we can later experience another building as a physical existence and secondly the process of shifting from virtual to physical architecture is continuous. These two types of architecture overlap and proceed simultaneously, so Ito in his article with creating following statement as a result:

(accessed March 2006) where he characterise the nature of architecture in electronic age and refers to the Sendai Mediatheque.

The main types of architecture he refers to in this article is the museum - the article has been written based on ideas for the Sendai Mediatheque, therefore only the first, second and fifth point is relevant for this research, as the two others discuss characteristics of a museum in the age of electronics.

“Eventually, the physical building will emerge. By that time, however, there will be still another virtual space created by the introduction of electronic media. Even after the physical building is completed, its architectural programs may continue to undergo modifications as new media evolve. Thus there will be no end to our spatial experiences as the real and virtual spaces overlap in our experience. Design in architecture will refer not only to traditional hardware design but also to a more flexible software design that includes programs. We will be designing the time just as we design the space.” 48

[1.5.4]
Informational and electronic space

When characterising the co-presence of and/or immersion in new electronic interfaces such as those described in the chapters earlier – in both the direct and indirect sense – then the informational and electronic spaces promote for Paola Gregory “interactivity, connectivity, multi-mediality, and virtuality, [by] creating new dialogic and multisensorial dimensions that extend the very cognitive and perceptive field of architecture” 49

In addition, material attributes matching the philosophical concept of our time have been divided by Gregory into four phenomena:

“In broadening our thought process and communicative capacities, the new electronic and informational spaces bring to the forefront new concepts of operation that promote, on different levels of complexity, the characteristics of cyberspace identified by Lévy i:

- the co-presence of ‘technologies of intelligence’ capable of increasing memory (with databases, hyperdocuments, the Web)
- imagination (with visual interactive simulations)
- perception (with computerized images and the widespread tele-listing and television)

These phenomena are further attributes of a surface defining informal and electronic space in a discussion of contemporary architecture, but also for Gregory:

“Space is in fact no longer an a priori condition, a simple substrata on which to inscribe experience, but rather then an interactive and progressive construction; time is no longer objective, cosmic, measurable, but rather a ‘time acted’ in the dimension of the interaction with a perception based on parameters constantly more instantaneous, unstable and subjective.”

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[1.5.5] How do these characteristics influence media content?

When Puglisi, Gregory, Ito and Townsend outlined the characteristics of media façades they also set a framework for the media content that could be displayed on the façades. The appearance or the media content of media façades are not yet designed, as my research thus far is focused on the hardware, pure electronic or mechanic based components which will begin to act after receiving an input in form of media content. Still the characteristics listed in the Chapter [1.5] will guide the displayed content; therefore my research will categorise them and analyse them how to see if different forms of media content could be designed, if guided by the characteristics of a media façade.

The characteristics of the precursor of media facades explained and discussed in Chapter [1.5.1] had immateriality, sensoriality and multimediality listed by Puglisi as characteristics for a media façade, in this case as the attributes of Centre Pompidou. Immateriality refers to the material and thus is not a reference to possible contents as such, although one could still argue that the movement of people and the arrangement of elements such as walls, columns and other building components happening behind the transparent filter of the façade could be seen as media content – but for this research interest is focused on an electronic input that would allow an alteration of a system from one state to another, for example the change of an image or the movement
of a component. *Sensoriality*, the capacity of a structure to interact, gives one possible form of content, that being an interactive one, where the environment changes its condition in different forms and ways, e.g. weather condition or temperature to name only two which will influence the façade and with a response of the façade again the behaviour or condition of the environment could change with the option of creating a media content loop. *Multimediality* talks about the choice of transforming the building into an organism capable of conveying messages, and again the characteristic of *multimediality* offers more options as to what kind of hardware could convey messages than actually talking about the media content which would run the hardware.

In my Chapter [1.5.2] where Anthony Townsend is quoted as offering display and expression, communication, positioning and documentation as technical characteristics of media façades, these influences on media content are discussed. Display and expression discusses what kind of hardware is available for media façades rather than what will be displayed on the façade. Therefore it can not be seen as a reference for content. Communication could be an umbrella term for all media content but, but due to the wide use of this term, it does not specify further what kind of communication. Positioning on the other hand provides a hint of the possibility of creating an interactive media content. Positioning asks for the location in space of a person or object via GPS i.e. which would create a media content in form of location information that could be displayed. This location information could then possibly influence the behaviour of person or objects. The information could also be displayed live on a screen, for example the information of the person/s or object could be stored and then displayed as pre-recorded media content on the same screen. Documentation would do what has been described with positioning – it allows the collection of data of media content and displays this data as pre-recorded media content.

In the following Chapter [1.5.3] when discussing the characterisation of architecture in the electronic age I quoted Toyo Ito who offered three points which should be analysed to further frame possible media content. He refers to information several times and that architecture should function as a figuration of information. For him, when people live in two different planes – the body one lives in and the virtual stimulated by information – architecture should provide information which could be fulfilled by either a pre-recorded media content or a live/interactive media content. Also, Ito’s statement
that “architecture designs time”\(^i\) does not provide further information about the character of the media content. Paola Gregory has outlined different characteristics as listed in Chapter [1.5.4]. In contrast to the characteristics offered by Ito, Gregory’s characterisation suggests directions of possible contents of media façades. All of these directions offer a media content based on an “interactive and progressive construction”\(^ii\) which will generate and regenerate itself over time. She also lists the conditions for such a construct drawn from thoughts about cyberspace where technologies of intelligence provide enough memory to store and distribute interactive imagination, perception and reaction. Based on these characteristic observations the following chapter will now analyse the forms of media content that exist and can be displayed on media façades in general.

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[1.6] Media façade content
[1.6.1] Introduction

My research has so far discussed what hardware developments have been made since the design of Centre Pompidou and the common characteristics shared by all media façades. The previous chapter discussed at the end if, based on the characteristics of all different forms of embedding media in architecture, this can lead one to an understanding of what kind of media content is displayed on the façade. Two paths of categorising media content into discrete forms should be investigated further. For Joachim Sauter, professor at the University of Arts in Berlin and founding member of communication agency ART+COM, a media façade can be either autoactive, reactive or interactive, and furthermore the façades could be designed to allow participation. These three terms, with a fourth term which will play only a minor role will be analysed in this chapter. Furthermore to these studies in media content and possible forms of content, my research will analyse further what has been evaluated in the previous Chapters [1.5]

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where three discrete forms of media content have been filtered out of the characteristics of media façades:

- Pre-recorded media content; any form of media content where data has been collected and stored and replayed at any other time.
- Live media content; any form of media content which has been recorded and displayed at the same time, without having the option of creating a back loop from display to environment and back again.
- Interactive media content; a simultaneously recorded and displayed content, here with the possibility of creating a loop between environment or user and display. The interactive media content could also be defined as a living media content where media content is related to a number of previous contents and the relationship between them.

In view of the four terms Joachim Sauter has listed, the media contents evaluated out of Chapter [1.5.5] can now be explained in greater detail, and an example provided of what these media contents could be and how the three discrete forms have already been applied on media façades. In researching a system that explores the ideas inherent in a new conception of the relation between media or information and the built or constructed surface, the question of media content should be focused on media façades built from LED, LCD, large screen or similar applications, and have these in mind when considering how media content has been applied to them.

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[1.6.2]
Conditions of utilisation of a media façade

In a paper published in 2004, Joachim Sauter classifies the media content of a media façade into autoactive, reactive and interactive media content, and furthermore, for him the façade could have a participative media content. These classifications should now be introduced as the starting point for a discussion about media content and then further analysed when using results from the evaluations made in Chapter [1.5.5].

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1 Due to being published in German, Joachim Sauters’ argument will be but not be quoted, it will therefore be correct in its meaning but not as a correct English translation.
Autoactive is, for Sauter a media content in the form of a moving image which will be replayed on a dynamic media façade. The material displayed on the media façade could be produced directly by the designer of the façade, as has happened in the case of the BIX Façade of the Kunsthaus Graz or by a community via the internet. The façade of the Kunsthaus in Graz has been explained in greater detail in Chapter [1.4.2] when introducing the building as one of the seven technical categories of media façades. Sauter mentions two more examples in his article; ”Blinkenlights”, realised at a building in Berlin (Haus des Lehrers) in 2001, and the ”Arcade”, a project that worked with the façade of the Bibliotheque National, Paris in 2002. Both examples used, like the Kunsthaus in Graz, fluorescent tubes as a method for displaying a media content on the façade. A similar program as used in Graz has also been applied here and controls the illumination from behind each window of the façade. The façade of both projects, ”Blinkenlights” and “Arcade”, designed by the ChaosComputerClub, were not intended to be a media façade when first built, but have been altered for public art projects. These three examples, ”Blinkenlights”, ”Arcade” and Kunsthaus Graz, are all based in an art context and the media content has been pre-recorded. Autoactive can therefore be described as a method where the appearance of the façade changes itself by itself - ”auto” - through a moving image, such as a movie.

With a reactive façade, the façade is able to react to changes in its environment. Input through sensors allows the façade to “understand” what has happened and gives the façade a command for how to react. An example for such a façade would be the Institut du Monde Arabe in Paris by Jean Nouvel. As explained earlier in Chapter [1.4.2] when discussing mechanical façades, Nouvel based his concept on Arabic architecture and designed a façade with an intricate structure that holds several motor-controlled apertures that act as a ”brise soleil“ to control the light entering the building according to the weather conditions and the season of the year. Still, a reactive façade allows only a reaction or dialogue in one direction; i.e. weather changes offer an alteration of the façade depending on the weather, but the weather will not react in response to changes of the façade. A reaction will only happen in one direction, in the discussed example; weather condition will cause a reaction of the façade. So a reactive façade is capable of receiving information and uses this to alter itself via a number of pre-defined patterns.. While an autoactive façade has its focus on
the moving image, a reactive façade is more fixed on its environment and how the environment provides the façade with input. This reaction or dialogue in one direction varies with an interactive façade - here a reciprocal dialogue exists between façade and environment. Sauter has used as an example for this form of media content, a project commissioned by German Telecom for the Expo 2000 in Hanover, where the user could have a reciprocal dialogue with the façade. This topic will be discussed further in the following Chapter [1.6.3] and has been included to complete Joachim Sauters’ three respectively four terms of contents for a media façade.

Lastly, Sauter offers a participative façade as a form of content. For him participation means the public takes part in the design of a façade. This participation has for Sauter the advantage that the public not only works with the façade and augments it through creative ideas, but furthermore identifies itself with the façade and therefore with the space. He argues that through such façades, possible new communities could arise. Examples that he cites in his article in order to assess that proposition are the previously mentioned projects “Blinkenlights” and “Arcade” of the ChaosComputerClub. In these two projects some novel uses of the screen are for people to call a number and play Ping Pong via mobile phone or display animations sent in by the public. Sending media content to the façade was the main focus in these installations, which linked several participating people worldwide into a new community.

Instead of providing a detailed analysis of the content types, I will focus on the three forms of media content that are mentioned in Chapter [1.6.1].

[1.6.3] Three forms of content

Along with these four different forms offered by Sauter, my research will use the three forms of evaluated and listed in Chapter [1.6.1] for a more detailed analysis. For this research pre-recorded media content can be defined by any form of media content that has been recorded at an earlier point and can be replayed as often as desired. Typical media content in this category would be any movie clip, such as an advertisement, which has been recorded and is available for display as long as required. This form of content is widely present when media and architecture are linked, when
thinking of an example of a digital urban environment where buildings are covered with media, Times Square in New York immediately comes to mind. Anthony Townsend from New York University, in an article published in Praxis Magazine, states Times Square; “... perhaps the quintessential example of a digital urban environment, is at once the most densely and creatively mediated urban space and the most poorly executed one.” Therefore covering of buildings with media elements, such as large-format LED displays and LCD screens, in use at Times Square, does not position architecture in the role as a surface of communication, sensitive, reactive and interactive actions. At Times Square these concerns have not been considered; Times Square was “no accident but rather is the result of a carefully structured set of zoning guidelines put in place by New York’s Department of City Planning in 1998.” The zoning guides allowed no reduction in signage on existing buildings and required large illuminated façade signs for all new development fronting on Seventh Avenue or Broadway. Not surprisingly for Townsend, the result of a decade of this regulation has been an explosion of illuminated signage.

Here the division between the aesthetic culture and academic discourse of architecture as distinct from the operations and machinations of everyday consumer culture can be seen. Stephen Perrella refers to Times Square in his essay Hypersurface Theory: Architecture><Culture;

“...if we could strip away all the electronic signs in Time Square, we could find a cacophony of material surfaces, each working to maximize the potential readability of the sign. It is this sort of drive, motivated by economic concerns, that differentiates surfaces, and that will propel the surface into a sign, and the sign into a surface. This ‘vulgar’ impulse exists outside the discipline of architecture in terms of pure commercialism even though it has been acknowledged in the media architecture trajectory.”

But there are other buildings with façades that would display pre-recorded media content without being a carrier for advertisements. Deborah Snoonian quoted Jan Elder, one of the directors and founder of realities:united, the Berlin firm that created the skin for the Kunsthans in Graz designed by Spacelab.uk/Peter Cook & Colin Fourier, when Elder points out in an interview in the Architectural Record;
“...that the screen’s organic, built in nature and its large, low-resolution ‘pixels’ (i.e. the fluorescent tubes) distinguish it from the digital screens mounted on many other buildings, such as those in Times Square. The firm’s cofounder (Realities:United), Jan Elder, is ‘gloriously incapable’ of projecting most typical television and film sequences, such as ads and movie trailers. Instead, it will display work designed specially for the building and catered to the owners’ or artists’ intentions. ‘If company XYZ is going to sponsor an exhibition, they will not be able to just take the latest company [information] and show it on the façade. It will just not work’, said Elder. ‘There will always be the basic requirement to work with this special BIX format [format that controls the fluorescent tubes on the façade] – and in this way, to work with the special architecture of the building itself.” 57

Jan Elder explains in the interview with Snoonian a solution for the problem of using media facades mainly for advertisement - a façade material that cannot display movies or advertisements produced for example for a TV commercial on the building. When the system used to display pre-recorded media content has its own parameters one must work within these parameters to use it.

Live media content is familiar to both a general and a specific viewer from any kind of mass sporting event such as the Soccer World Cup or the Olympic Games. Frequently events are broadcasted live and in our case, displayed on a media façade. Melbourne’s Federation Square has such a screen which offers such kinds of media content when showing, for example, live images from the Australian Open Tennis or the Grand Prix.

Still screens which show public events are a notable exception most screens currently are used primarily for advertising; in the case of Federation Square the screen functions as a part of a public space and helps to attract a congregation of people. There are of course media facades as a temporary screen in public, for public events such as seen the Tennis Open or other events, but these screens are not part of a building and are installed in public space temporarily. Nevertheless these kind of public screens applied for a non-commercial purposes are the exception. The main reason why screens are not used frequently for non-commercial purposes has been explained by Anthony Townsend. He cites the example of Times Square New York, to demonstrate why screens with a non-commercial media content are the exception. According to analysts
at the Times Square Business Improvement District, there are now 38 large-format LED screens in Times Square, installed at a cost of over $US140 mill.\textsuperscript{58} With a cost of approximately $63,296 AUS per square metre when using a PV 5 SMD LED screen system by Altoona, an Italian large LED screen producer, one can imagine that these kinds of façade add to the building costs and will only be considered if they add to the taxable property value of the building or provide a return of the investment due to advertisement incomes. Cost constraints, similar to what had been the case at Centre Pompidou, when a media façade could not be built in the early 1970s, are the main obstacle in preventing the proliferation of media façade with an artistic or non-commercial purpose.

Still there are exceptions found at Times Square where signage offers more than just the usual commercial messages through advertisements and brand promotion. Anthony Townsend identifies one of them at;

“3 Times Square, where the Reuters Sign presents live news and photos from the news agency feed selected images without human intervention by a sophisticated content management system developed by the interaction design firm RG/A.” \textsuperscript{59}

So even Reuters as a news agency uses the display of news as a method of advertisement for their own services and products. Reuters self advertise by presenting news to the public and selling information and thus they do not offer the screen solely as an information platform for the public good.

Examples which present live media content are the exception: thus my research wants to investigate further the last of the three possible forms of content.

As mentioned earlier, the issue of interactivity deserves closer attention. As a starting point I want to look into different classifications by others and then define the term interactivity for this research and give an example for an interactive space.

Arjen Mulder states in his article ”The object of interactivity” published in NOX / machining architecture that;

\textsuperscript{1} The prices are taken from a spreadsheet of the Italian LED screen producer, ALTOONA, based on October 2004 prices in English pounds and exchanged into Australian Dollar at the exchange rate of \(1 £ = 2.50 A$\) based on the value of the British Pound to the Australian Dollar mid September 2006. Changes to the exchange rate will not be considered in my research.
“We may call any system interactive if it is flexible enough to adapt itself to the use that is being made of it and if, vice versa, it changes its users through the changes the users cause within the system. In other words: when two systems are linked to each other and change each other via this link, we speak of interactivity.”

Sheizaf Rafaeli defines interactivity as “the extent to which communication reflects back on itself, feeds on and responds to the past”. Terry Flew argues that internet communication is highly interactive in this respect since the access to media content and communication online creates archives, databases, and new forms of content, as seen in the example of archived contributions to discussion lists. Flew argues further that,

“It is important to break down the concept of interactivity into two component elements – interconnectivity and interoperability – and to recognize that true interactivity only arises when both are in place. Interconnectivity refers to the capacity to easily connect interactions across different networks, while interoperability refers to the capacity to access all available forms of information and media content using different operating systems.”

Those three definitions by Mulder, Rafaeli and Flew further demonstrate the main differences to the previous discussed media contents, the pre-recorded media content and the live media content. An an interactive system has to either “adapt itself to the use that is being made of it” (Mulder) or “reflect back on itself” (Rafaeli), both discuss employing a database to respond and store this new information to extend its knowledge, very similar to the human learning process. Flew positions the term interactivity more as a mode of communication within a network, when talking about connecting across different networks and the access of information using different operating systems, and he refers here to systems such as Windows, Mac, and Linux. But the example presented below looks more at the definition of Mulder and Rafaeli, where a space is created that has the potential to learn from interactions. My research has identified a recent example of an interactive space or a space altered through interactive media content: “Ada – the intelligent space”, an interactive pavilion

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at the Swiss National Exhibition Expo.02 designed by the Institute of Neuroinformatics, a research institute at the University and ETH Zurich. Ada is an open system based on achievements of neuroscience. Similar to human – and in contrast to the conventional computer – Ada can process erroneous and imprecise information. Ada has the ability to direct her\textsuperscript{1} attention to a person or group of persons and play with them.

Unlike conventional computer systems based on rules, she consists of a neural network modelled on nervous systems. She is able to learn but is also ”unpredictable”, and her way of reacting to her environment is analogous to human emotional behaviour. She can coordinate her individual components and employ them in a goal-directed way.\textsuperscript{ii}

Ada is described on the exhibitor’s home page as follows:

"Ada is a novel artificial organism, a creature in the shape of a space that can perceive and react to its surroundings. At the same time, her form facilitates a novel interaction between humans and machine that goes beyond the possibilities offered by a conventional computer, such as keyboard, mouse or joystick. Ada has sensory organs. She can see, hear and sense touch and contact. While Ada cannot communicate with words, she expresses herself through sounds, light and projections. Ada likewise learns how to synchronise her various components, such as the floor plates, the movable eyes and the light fingers. Ada is able to remember the visitors with whom she has played and whose gestures, movements and sounds she has observed. Like humans, Ada learns from experience: she can store an incident and later build upon it. Ada can furthermore link various pieces of information and draw conclusions from this. Upon observing two individuals standing close together for a long period of time, she concludes that they are a pair."

\textsuperscript{63}

\textsuperscript{i} The designers of Ada and Paul Verschure, a member of the Institute of Neuroinformatics, refer in several articles to Ada as a ’she’; I will follow that and also address the system as female.

\textsuperscript{ii} Short term description taken from an interview with Paul Verschure, interviewed by Marialuisa Palumbo and also published on the exhibitor’s homepage www.ada-ausstellung.ch (accessed February 2006)
There are a number of other projects that deal with interactive spaces and/or intelligent rooms such as MIT's intelligent room project\(^i\) or the intelligent space project pursued at the University of Tokyo.\(^ii\) However, both these projects are rather utilitarian in the interactive technology they apply, whereas as an affective-cognitive space Ada is currently unique.

As an example for interactive space Ada also demonstrates that the media content displayed within the space need not change the experience of space as such. The interactivity is used to display any media but is derived from already existing media content developed in other formats (printed text, photographs, films, recorded music, television) as mentioned in the quote where the exhibitor states that “she expresses herself through sounds, light and projections” rather than being involved in generating space through a content. This is, as mentioned in my research questions, a focus my research wants to concentrate on: to create a zone, through weaving together of architecture and image displayed through electronic technologies, that can be constantly generated and regenerated through content.

The chapters above have either discussed the hardware - different electronic or mechanical systems - or the software - different forms of media content - but the following chapters will go beyond dualistic accounts of whether it is hardware or software to seek a technology that can create a zone, able to be constantly generated and regenerated through one of the three discussed forms of media content - pre-recorded, life or interactive. Or as says Lev Manovich:

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\(^ii\) The intelligent space project get further explained at: [http://dfs.iis.u-tokyo.ac.jp/~leejooho/ismap/](http://dfs.iis.u-tokyo.ac.jp/~leejooho/ismap/) (accessed February 2007)
“Dynamic, real-time, and interactive, a screen is still a screen. Interactivity, simulation, and telepresence: As was the case centuries ago, we are still looking at a flat, rectangular surface, existing in the space of our body and acting as a window into another space. We still have not left the ear of the screen.”  

This quote inspired the final question arising from my research thus far, towards the investigation of the history, technology and media content of media facades. If a screen is still a screen as per the quote from Manovich, what kind of system would allow media content to be more than just a generator of what is happening in the ‘window into another space’ but actually be a generator of space itself?

Architecture can have, as Peter Eisenman explains in an interview with the internet magazine Designboom.com, “in any time [...] 2 roles. It is either reflects society, or in a sense is a precursor.” The investigation into the history of media facades has shown that the selected examples provide precursors for media facade application. In the chapter discussing the history of media facades, I asked the questions what kind of media façade development exists at present and what kind of steps could be made to take an existing technology and alter it to something new, to create a system which could be envisaged at present? How the first steps towards developing such a system could be made?

It can be argued that architectural culture can be legitimately expressed in the appearance through materiality and the surface treatment, when spaces are defined. The developments of hardware such as LED screens among other technologies have shown that a shift from modernist/postmodernist appearance of buildings to an electronic interface can happen. Paola Gregory discusses this shift in her book ‘Territories of complexity’ about Rem Koolhaas’ competition design for the ZKM (Zentrum für Kunst und Medientechnologie) in 1998;

“Koolhaas metaphorically calls the Centre (ZKM) Electronic Bauhaus, in an attempt to emphasize the passage from the second to the third
revolution, where the model of the network – and thus flows – replaces that of a mechanism moved by single center. If earlier rational, light, transport, dynamic constructions expressed the ‘Bildung’ of industrial civilizations, founded on self-transparency, or in other words the ideal of a subject still able to conquer an ‘objective’ vision of the world and history (Vattimo 92), now, in the midst of the electronic era, architecture generates new complexities, showing off the pluralism and polymorphism of a world in movement, ‘ambiguous, incoherent, plastic [that] exalts incorporeal time’ and ‘elects instantaneousness as its own supreme value’ (Baumann 2000).

When investigating technical shifts my research discovered that the shift of appearance was driven by a shift of technology. In media façades, technology, one could argue, is equal to surface material, ie. a screen’s appearance depends on the technology embedded in the screen. If a shift of material and appearance is pushed further the question then becomes what kind of technical development is required to push this shift?

If architecture becomes a surface of communication, sensitive, reactive and interactive defined by contents, what materials then reflect aspects driven by media content and are able to react to these? Or does communication through media content not mean covering the building with media, but more to ”mediatize” the space so media content defines the space?

Times Square and other examples so far represent no more then the covering of buildings with media, but there are other buildings that function, as Gregory terms, “urban transmitters”, who:

“Consider buildings [...] with thin and impalpable façades that precisely show the diaphanous and changing skin of ‘light modernity’: a screen on which plays the changing of actual or virtual reality, picked up and filtered by new trans-apparent screens. Obviously, this does not refer to the revolution of ‘electronic-glass’, nor to the simple superimposition of media skin over the covering of a building. Instead, it refers to

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i The text refers here to Valtimo, Gianni - The Transparent Society, (John Hopkins University Press, 1992)

'mediatizing’ the meaning of architecture, transferring the fluidity and immateriality of electronic media from the technological to the epistemological plane."67

Here Gregory describes the dilemma when reflecting the principles of communicating in architecture onto materiality. For her there exists a dichotomy of, on one hand, an architectural surface as an advertising space as seen at Times Square in a low cultural approach to mediatizing space, and, on the other hand, the approach in the works of Tschumi, Nouvel, Ito, and Herzog & de Meuron amongst others. If present technology of media façades has trapped architecture and space becomes mainly a carrier of a sign, how could space again become the main issue when applying media façades?

A further question is then, what material attributes can display and communicate in a technical standard similar to large-format LED displays and LCD screens and yet do not suffer the risk of being used mainly as a digital billboard? So if a screen is still a screen, what kind of a system would allow media content to be more than just a generator of what is happening in the "window into another space" 68 but actually be a generator of space itself?

My research here raises two questions, both dealing with a shift of architecture that Gregory describes as:

“Shifting the traditional meaning of architecture as a ‘solid body’ towards wavering meanings in which material and non-material, image and reality, are reciprocally conformed, [...]” 69

So architecture would need a material that allows the shift of architecture as a ‘solid body’ towards a material that combines state of the art media technologies as an extention of existing media technology with spatial interests of architecture.

Such a shift of architecture already exists in the number of different 2D screens, such as LED screens, MiPix or SmartSlab. It is possible to define space with them, as much as it is possible to define space with any other 2D elements such as a wall built from materials such as wood, stone, concrete or glass. The important point is, with both groups of materials, the ”animated” materials such as the above mentioned 2D screen, as well as with ”static” materials, space can be defined and then remains static. It can change its appearance, for example, by having a moving image displayed on the screen
or with light, weather or other conditions changing the expression of the wall. But the space itself will not change.

Several characteristics of media façades explained in Chapter [1.5] or media content of media façades as discussed in Chapter [1.6] can partly or completely be embedded in both the “animated” and the “static” systems, but to develop a system which would fulfill the requirements of my research question another material is necessary. Here we could possibly ask for a substance which is immaterial, that has the capacity to interact with the outside world and alter its form as a result of this interaction, a substance which gets stimulated by multimedia inputs, in any form of information.

[1.7.2] New forms of materiality

Would a material that has qualities consisting of where material and non-material, image and reality are reciprocally conformed, or even an immaterial substance, still be considered an “architectural” material? When reflecting on the attributes of material one could conclude that,

“If it is true that architecture is based on its specific materials (patterns of use, concept of space, construction methods and technologies, research into expressive language), then it is just as true that it is also built through the use of ‘other’ materials; materials apparently foreign to architecture, but ones that in reality make up the backbone of a broader and deeper reference connecting architectural considerations to the world and society, to the scientific and philosophical concepts of their own time.”

This quote by Antonino Saggio in the introduction for the book Territories of Complexity by Paola Gregory opens up the quest for a new material which has its origins in the previous developments of media facades.

The book proposal for Info-Aesthetics that Lev Manovich has published on the internet defines the ‘connecting architectural considerations’, “in short, if the shift from modernism to informationalism (the term of Manuel Castells) has been accompanied by a shift from form to information flows,...” One could argue with Manovich that the primary materials media facades currently use to present space is not only
technology, but is more like media content in form of information and the question for architectural considerations if we “can […] still map these information flows to form meaningful to humans.”  My research involves identifying a material which would weave together the 3D complexity of built space and 2D representation of image, where a spatial representation of information is based on electronic display systems.

To define such a material, I will analyse two premises: Firstly how are forms received and can they be built with means other than physical? Secondly how are images produced on a 2D screen to abstract that concept into a 3D method?

How forms are received?

When thinking about how forms can be perceived the sentence of Le Corbusier in *Vers une architecture* comes to mind, where he states;

“Architecture is the masterly, correct and magnificent play of volumes brought together in light. Our eyes are made to see forms in light; light and shade reveal these forms; cubes, cones, spheres and cylinders or pyramids are the great primary forms which light reveals to advantage. The image of these is distinct and tangible within us and without ambiguity. It is for this reason that these are beautiful forms, the most beautiful forms. Everybody is agreed to that, the child, the savage and the metaphysician. It is of the very nature of the plastic arts.”

The architectural principles described in Le Corbusier’s book strongly influenced and shaped the way we design buildings and even think about modern architecture from the 1920s onwards. But soon after being published the expression “volumes in light” became a subject of criticism. Reyner Banham states in his article *Edison, der vergessene Pionier*, that the German expressionist Paul Scheerbart was an early critic of Le Corbusier’s quote. Scheerbart commented:

“But what happened after sun set? Before the invention of artificial lights existed for the masses – let say before 1890 – buildings simply disappeared at night. This doesn’t happen today, not even in the
 twenties. [...] But the fact that they are visible at night, then it is the case, not because they twist the Le Corbusier quote. They are not any longer forms (volumes) in light - they become light in forms.” 75

Even with turning his argument into a “kind of a Dadaistic joke” 76, which covers the radicalism of his statement in a slightly irritating way, Scheerbart “had discovered the aesthetic qualities of glass and how to give that transparent material form at night with the use of artificial light. He had understood that the demand of Adolf Loos for white and pure surfaces wouldn’t be in favour with the masses, and illuminated glass architecture provides the beholder with the colour and the shine at night-time that they lacked during the day.” 77

The fascination for the play of lights in a city can be seen in fields such as the postmodern poster culture with famous prints of the skyline of New York, as well as the difference in property prices for sites with a view of the city skyline. The illumination of the city also gives the beholder a notion of space at night time, where he can locate the city and its buildings in relation to his own position - something he could not do if there hadn’t been any light in forms. The importance of the quote of Scheerbart is represented in the August 2003 New York City blackout when the whole city of New York and parts of Northern America lost electricity due to energy short.i The pictures of New York city taken at this time demonstrate that the city slowly starts to disappear, and thus the argument of Le Corbusier indeed relates only to volumes and thus cities at daytime but not at night.

An example for this phenomenon is the notion of the world in the Middle Ages. This impression has to some extent to do with the way one sees the world when standing in an open space and it seems like the world is flat, and the vision of the sky as a half sphere can be explained due to the movement of the sun, but even more by the sky at night. In absolute darkness with no artificial light whatsoever, which was the case in the Middle Ages, the stars seems nearly to touch the horizon on all ends and due to the enormous amount of stars one gets the impression that they are attached to a dome, which illustrates how with the use of light spatial illusions can be produced.

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i The event has been amongst others publicised by CNN on their homepage, for further information please refer to: http://www.cnn.com/2003/US/08/15/power.outage/ (accessed February 2005)
A modern example of creating a spatial impression with the use of artificial light are the light cathedral (Lichterdom) designed by Albert Speer in 1934 for the annual Reichsparteitag (NS party conference) in Nuremberg. Anti-aircraft artillery spotlights were used to create a light structure visible not only from within the allocated area but also from a very far distance. Here with the availability of strong spotlights to perform such a function, light as a space-defining method could be used.

With the spread of artificial light in society and, consequently, in architecture I want to look at different ways architects or urban planners have made use of light, and also see if light has been used to define space. To do so I have introduced Times Square as a location where the use of light and media have been used excessively, but furthermore I want to take a closer look at another location where light has been a major feature in the urban context and is well known for its use of light. My focus will be on Las Vegas a location where light has been used to a high extent and is an appropriate focus for a research regarding how light can be used, and indeed if light has been used to define space.

Robert Venturi analysed the architecture of Las Vegas in his book Learning from Las Vegas, where he also focused on the use of light in architecture. Everybody is familiar with the extended use of light in Las Vegas, which has been made possible mainly through the erection of the Hoover Dam in the 1930s (Construction began in 1931 and was completed in 1935) where the water of the Colorado River is used to produce an enormous amount of energy for use in the city. The influence of this dam on the city is not the subject of this analysis, however, but rather the use of lights and if they are used for defining space.

Robert Venturi states in his book that “light is not used for defining space” 78. Even though he made this statement in context of the use of light in interior spaces it also contains an attitude for the use of light in the external. His study of ‘The Strip’ in Las Vegas, the well known street where most of the prominent casinos are located, shows that the space-defining objects in that street are the signs on both sides of the street, due to compare the Strip with the piazzas in European cities these “signs inflect toward the highway even more than the buildings” 79 and will therefore stand as space defining objects. In a further explanation of the use of these signs says: “A sign is, contradictorily, for day and night, the same
sign works as polychrome sculpture in the sun; at night it is a source of light. It revolves by day and becomes a play of lights at night” 80

This is a usage difference between light to define space and lights on the Strip whose main function is to illuminate signs for maximum visibility and at night-time to maintain a communicative as well as a spatial function. As mentioned previously, these signs mainly function as advertisements and communication symbols and the dimensions are not ruled by urban contexts, but in their competition with other signs for attention from bypassing cars. Venturi reinforces this competition with other signs when he talks about signs at petrol stations that are like those found elsewhere, “but in Las Vegas they reach three times higher in the air than your local service station to meet the competition of the casinos” 81

The illuminated signs of Las Vegas define space not by their use of light and as well their main purpose is not to define space, but to attract visitors; they therefore differ very much from the idea of defining space with light.

But the before mentioned examples, when discussing Scheerbart, the black-out in New York and the Lichterdom by Speer, assessed that the ability to design space with light exists.

How are images produced?

How do existing media technologies and big screens work in an urban context? The images on such screens are created by a number of RGB LEDs. Each of these LEDs allows the creation of all possible colours by mixing the RGB values to the required colour, and I will discuss the technical aspect of an RGB LED and how it functions at a later stage. When arranging LEDs in combination next to each other they generate an image - this is similar to how images are generated on a computer screen where each individual pixel can be seen when zooming in on the image in programs such as Photoshop.

This allows the display of both images on a screen, but also 3D forms, such as architectural drawings – but these ‘3D forms’ are never actually 3D, they only become 3D when moved with a computer mouse. The reason for this is the 2D nature of the display. The pixels or the LEDs on larger screens are arranged on a 2D surface. But
when arranging them in a 3D grid instead of a 2D grid and placing pixels on each net crossing point the former 2D image can be transformed and distorted into a 3D image. So to realize this 3D image a façade built with a 3D grid with (as yet undefined) coordinates and containing light points at each intersection of the grid has to be designed.

In built reality this façade will be erected by a number of ‘sticks’, attached in a 90 degree angle to the existing façade, and each of these sticks contains an array of LEDs in certain distances to each other along the stick. The distance of the centre of each stick to the LED will be the same as from LED to LED placed on one single stick to create the 3D grid. Therefore an equal resolution can be achieved in all three directions: images can be displayed in an X, Y, and Z plane and more importantly as a 3D object. Through the "non-physical” existence of the façade, it can change its image and its spatial boundaries over time and therefore allow a strong relation between time and space and create new concepts of space, time, and social relationships in an urban environment. The idea of a spatial design via the use of light cells for critical interpretation of space-time/subjectivity, due to not only the surface being shaped in three directions but also it being shaped and changed in a fourth dimension, time. Through having form and image as an addition to each other the image will never be more than a decorative element texturing and ornamenting the form.

With the use of light as an element in defining space, and therefore a façade, plus the dynamic attributes of the medium, a shift of this relation can be achieved. The form is no longer textured by an image - the image will influence the form and the form will influence the image.

Modern RGB LED technology allows one LED to create the whole colour spectrum by mixing RGB colours. Many of these LED’s create an image which will then be, depending on the software and the application of the assembly of LEDs display, a movie or a sequence of pictures. This is nothing new: the change is as a result of the LED pixels being arranged in three dimensions and therefore allowing the image to move in a third dimension. This then allows the look of the surface to reflect the look of the image, or allows the image to change to reflect the surface. Surfaces are consequently able to shift to new attributes, such as:

- **Dynamic relief** – Unlike other 3D objects, but like any physical object, a light animated 3D image can be dynamic: it can move or be
changed in a time frame. The image can be a moving image and influence (by its appearance) the form, and the form on the other hand can also shape the image - interaction between form and image in a spatial dynamic context is therefore possible.

- **Dynamic relief through script or sensor input** – Adding with the use of a script a changeable RGB value to each point, allowing the generation of pictures/moving images, while enabling them to be altered in a third dimension by moving each pixel along this axis to generate a 3D form out of a 2D image.

- **Multilayered surface** – The possibility of overlaying a number of surfaces onto one façade by simultaneously displaying more than one surface on the façade as a 3D object and creating an extra spatial depth - again an aspect not yet explored in architecture.

- **Decay Function** – Achieving a “decay function” of the light surface by writing a script that puts a decay factor on each light point. The light point won’t be switched simply on and off - it will be decayed to create an after-effect of the façade that just existed, an aspect which hasn’t been explored in architecture and opens up a new field in the notion of architecture.

- **Priviledged perspective** – Depending on the position of the viewer an anamorphic image occurs when displaying a curved surface on my system. An anamorphic image is a distorted image that only looks right when viewed from a specific angle or with the use of a device.

- **Movement and speed** – The image can be displayed in actual 3D, not just with 3D drawing programs where the 3D object is placed on a 2D screen. So if the viewer moves, the viewer will see the image in

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\[i\] This is the reason for the use of a grid with equal distances from point to point in three directions, as it is the way we produce digital pictures. When zooming very close to a picture one can see each single pixel. Each pixel contains colour information which when combined with the other pixels creates a complete picture. Here the size of the pixel can differ, but when combined to form one picture they will all be of the same size. With that step a maximum variety is guaranteed and through placing a light source at each grid point, pictures, movies and light effects can be produced.
3D like any other physical object. This can also be achieved through the 3D grid.

- **The design process** – The design process of any object will find its end after a certain period of time, mainly when the object gets built. The introduced system would allow a design process which does not have to stop at one point and would allow a design in real-time.

- **Authorship** – The authorship of space could be divided into two parts, the design of the substructure, the system as such and the space which will be generated within the zone. A shift in the notion of authorship could happen.

Creating these new attributes to surfaces and space generates an implication for architecture. The next chapter will look at these implications and the signification for architecture in dealing with these attributes.

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**Conclusion**

My research has listed four questions through its investigation into the history, technology and media content of media façades. The first question when discussing history, asked what kind of media façade development could be thought of in the present time and in view of current technologies and how could the first steps towards such a system be made? The second question raised, after proving that shift of appearance has been driven by a shift of technology when analysing two locations with a high concentration of media and architecture, Times Square and Shibuya Crossing, is what kind of technical development could push this shift of appearance further? The third question emerged from the study of media façades if present technology of media façades has trapped architecture and left space as mainly a pure carrier of a sign, how can space again become the main issue when applying media façades? Lastly, my research demonstrated that the media content of media façades has no direct influence on space - the media content has only an influence on what Manovich calls a “*window into another space*” on the screen where the media content is displayed. Thus the fourth question is what kind of system would allow media content to be more than just a
generator of what is happening in the “window into another space” but actually be a generator of space itself?

How did the outcome of my research, my introduced system, answer the questions raised during the theoretical background of my research topic and furthermore how does the system answer the core-research question?

My research system is an extension of systems that exist at present. It uses existing technologies such as LEDs and rearranges them from their 2D plane, used for screens, to a 3D matrix to generate a zone. The history of media in architecture has shown that a shift in technology has facilitated a shift in appearance. This shift so far has pushed the development of 2D elements capable of displaying media content in a high definition format, but reached its limits in terms of how it defines space. The future development of screens will see screens created with a higher definition than at present, but while the high definition will help to create a clearer image, it will not improve the spatial impression of a beholder as such. The spatial impressions one can obtain do not change when screen technology changes from black and white to HD television if the screen size stays the same. A system which offers, at this stage, low resolution and no high definition, but a 3D zone, allows space to become the main issue when applying media facades. The media content could then be the generator for a spatial dynamic change of the environment where the beholder can experience change in media content through a change of space. This differs from a 2D screen where the change of media content happens on the screen in the “window into another space”, but not in the actual space the beholder exists.

The system creates a spatial dynamic change of space by using a technology previously used for the display of images and movies. The core-research question required such a system when asking for [...]weaving together architecture and electronically applied and managed imagery...]. A media façade as one component of architecture as a space defining object has been taken and altered in such a way that it has changed from its original 2D plane as a screen to a 3D zone attached to a building. Space is no longer only defined by electronically applied and managed imagery or by an architectural form; space can now be defined by both, because [...]their respective properties (have been) successfully interchanged to the extent that they mutually create a new architectural zone...]. Furthermore the zone can be [...]in constant flux...] in a similar way that the
2D appearance on a screen can be in constant flux, via input such as a movie which changes the displayed image 25 times per second. The zone will be [...generated and regenerated through media content that never stands still] to fulfill the last issue raised in my research question.

Having established a spatial dynamic media system in theory, my research now seeks to position this system in a broader architectural context. Is there an engagement in present architectural literature about a system which would allow an alteration of space in real-time through content? Do projects created by others look in a similar direction and if so how did they achieve a dynamic space which can be generated and regenerated?
A discussion of works by others in my research domain

When describing the steps in the research process that I have taken towards integrating the dichotomy between 3D static form and 2D dynamic image, work done by others is also important in positioning and framing my research, and thus identifying, and focusing on a gap in architectural discourse. I have chosen these specific works done by others because they either explore a similar direction to my own research, or because I see possibilities in developing certain thoughts or concepts already captured by their creators. Within the researched field of media and architecture, its technology and discussion of media content, I wish to investigate the possibility of filling a gap that exists within the discussion of architecture shifting from an "autoplastic mode of operation" to "alloplastic mode of operation" with the use of a 3D light-point matrix. The driving force that alters the mode of operation to make it alloplastic is the injection of media content into my researched system which will allow the zone to be generated and regenerated.

By "autoplastic" and "alloplastic" I refer to an article published by Mark Goulthorpe where he defines "autoplastic" as a "self-determined operative strategy", and "alloplastic" as a "reciprocal environment modification". I wish to argue that the 3D light-point matrix allows an "alloplastic mode of operation" due to being a "reciprocal environment modification" able to be altered in appearance by input from sensors or receptors of noise, temperature, public environment and so on.

In this chapter my research outlines different examples of existing buildings/installations which are used to demonstrate how space, shape, image and form have been transformed in architecture through public participation and in response to changes in the immediately environment. When analysing the following five projects done by others

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\[\text{Footnotes:}\]


\[ii\] Mark Goulthorpe used these two terms ‘autoplastic’ and ‘alloplastic’ in an article discussing the Aegis Hyposurface, drawing these terms from Ferenczi’s analyses of trauma. For this research these terms are borrowed to explain the shift from a determinate, static space to an indeterminate, interactive space.
the focus is on how they achieve a "reciprocal environment modification" and if the modification is achieved by an alteration of form or an alteration of appearance such as changing colours. The projects developed by others which I have used to benchmark the current status and effect in media facades are as follows:

- **The Source** by Greyworld (London, England, 2004) transmits information through moving an array of 3D illuminated spheres, by building an eight storey high kinetic sculpture. Trade activity information on the London stock market is represented by the sculpture’s constantly changing shape.

- The physical movement of the full-size wall surface **Aegis Hyposurface** (dECoi Architects+ Deakin University/Mark Burry et al) comprises two major components: a physical device - the surface as such - and a control system that runs the surface and allows it to react in real-time speed. (Birmingham, England, 1999)

- The **Blur Building** by Diller+Scofidio, the centrepiece of the sixth Swiss national exhibition, looks into how space, generated by mist, could be transformed by an event. The Building exists on a suspended platform shrouded in a cloud: this cloud is created by innumerable tiny drops of lake water sprayed from 31400 jets. The high-pressure spraying technology ensures that the fleeting sculpture will be visible in all weather, rain or shine. A built-in weather station controls fog output in response to shifting climatic conditions such as temperature, humidity, wind direction and wind speed. (Yverdon-les-Bains, Switzerland, 2002)

- The **D-tower** in Doetinchem, Netherlands in 2003 (QS Serafijn & Lars Spuybroek/NOX) is a project that expresses a town’s collective emotions through dynamic change in architecture via the use of colours. The tower abstracts the emotions of the town’s inhabitants via answers to an online questionnaire, determining the intensity of their feelings of love, hate, fear and happiness and each evening transmits the ‘state of the town’ by assuming a correlating colour of the most intensely felt emotion.

- The **Salt Water Pavilion** (Lars Spuybroek/NOX) and **Fresh Water Pavilions** (designed by Kas Oosterhuis Associates with Ilona Lénárd)
create a Hypersurface architecture via projection. A discussion of
Hypersurface Architecture can be found in two publications of the AD
Architectural Design Magazine, edited by Stephen Perrella. For Perrella;
the 2D image projected onto the 3D form produces the Hypersurface, a
principle adapted for both projects. (Neetje Jans in the Netherlands, 1994
– 1997)
The above five examples all create an alloplastic mode of operation, or the “reciprocal
environment modification”, either through an alteration of form or image. None seek an
alteration of space through both form and image. This is the gap in the discussion in
architecture I wish to fill - the development of media façades through a spatial dynamic
media system. Having established a system based on the development of existing media
façades and then positioning the system in the context of other projects, I will discuss
the significance of my system in an architectural context. The field of significance I am
interested in will be argued by comparing qualities which offers the spatial dynamic
media system with spatial qualities to demonstrate through its difference the importance
for architecture.

[2.2]
The Source by
Greyworld

The Source is an eight storey high kinetic sculpture, installed in the atria of the new
London Stock Exchange building. It has been designed by Greyworld, a group of
London based artists who have produced a number of pieces of interactive architecture.

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I am referring here to the two Architectural Design publications Perrella, Stephen –
Hypersurface Architecture, Architectural Design Vol. 68 5-6/1998 (Chichester: Academy
Editions, 1998), and Perrella, Stephen – Hypersurface Architecture II, Architectural Design
Vol. 69 9-10, (Chichester: Academy Editions, 1999)
The Source was installed in the main atrium of the new London Stock Exchange in July 2004. In a cube of 9x9x9 spheres 729 spherical balls are suspended on strings that stretch 32 meters to the top of the main atrium of the newly designed building. These 729 spheres suspend across 162 cables that are 5.6 km in length. 1400 blue LEDs
ensure that each sphere is lit from within and spans 6 floors. These balls, controlled by a computer running Python scripts, can reposition themselves independently of each other, forming dynamic shapes and fluid-like motions that reflect the nature of the stock market itself.

A symbol of the London Stock Exchanges’ position at the centre of London’s financial markets, The Source is a moving sculpture that combines an innovative application of technology and ground-breaking art to visually represent London’s financial and capital markets in an electronic age. The sculpture’s constantly changing shape is intended to reflect the dynamic nature of the stock market. As the Exchange is now fully computerised and no longer has a trading floor, The Source’s highly mobile and active nature also reflects this now hidden activity.

The Source demonstrates how one could create a spatial dynamic object when using single points or pixels and arranging them in a 3D grid, but the nature of the installation utilising a cube that contains spherical balls makes it difficult to react to input quickly. Furthermore the information employed by the installation to drive the changing arrangements of the balls can only be transmitted in a linear way due to the arrangement of these spherical balls in strings, as one can clearly see in the pictures. This limits the sculpture in terms of information that can be displayed.

The installation provides an interactive spatial system, but due to its vertical orientation it differs to architectural elements such as a media façade. It is also limited in the speed of its response time to changes of information provided.

The next project is the physical movement of a full-size wall surface: Aegis Hyposurface (dECOi Architects + Deakin University / Mark Burry). Here, the first steps in creating an interactive surface which can react to influences of the environment have been made.

“In a competition held in early 1999, the Birmingham Hippodrome in UK invited entries for an ‘art/architecture’ embellishment for a prominent wall that sailed away from the proposed new foyer 5 meters
above the pavement over the heads of passing pedestrians. The wall measures approximately 8 meters across by 7 high. [...] This idea innovated in at least two significant ways. Firstly, it democratised the art piece inasmuch as a Hyposurface ‘wall’, in itself, is neutrally and passively flat until made to inflect in/on itself through the injection of information via what dECOi has described as an electronic central nervous system: stimuli are picked up by sensors responsive to video, sound, light, heat, movement, (whatever), and used to activate the wall surface. Secondly, being probably the world’s first interactive physical surface, it calls into question and transcends many of the cognitive precepts that have shaped our collective view of the real and implied boundaries to physical space: while we are used to dynamic surfaces such as sails, ponds and lava flows, to be confronted by an impression of a surface that literally moves is extremely disconcerting.” 85
The project comprises two major components: a physical device - the surface as such - and a control system to run the surface. After winning the competition the design of the physical device quickly raised the following question: “What material exists that can be taut, stretch up to half a metre out from a notional rest state, and snap back to being flat repeatedly over years of ‘n’ frames-a-second activity?”

The physical device consists of a modular frame, a matrix of pneumatic pistons, and a physical surface of bi-polar metallic facets “fractioned into small plates interconnected by rubber ‘squids’. The curved shape to the notionally triangular plates is occasioned by the geometry of movement, and is not simply an effect.”

The rubber squids that connected the bi-polar metallic facets are moved by ‘telescopic fingers’ which reach a speed up to 60 km/h and have a stroke of 50 cm.

“The control system comprises a powerful computational device that connects to a bus system feeding the pistons with information. Commencement of the physical device development preceded that of the control system (in order that the actual operating constraints be fully understood), but the two aspects have been essentially been developed simultaneously.”

The surface is able to react in real-time speed: “If you clap, the wall responds in sympathy and does not simply respond as a delayed reaction. Anything less risked trivialising the relationship between the wall and its environment: people were to be participants not merely spectators.”

For Mark Burry the Aegis Hyposurface is “completely contemporary in providing an amalgam of digital and physical tectonics to move beyond mere surface effects to that of promoting the fascination of skin and its relationship to body.”

The Aegis Hyposurface opens up the possibilities for space to be altered in real-time by an electronic input. The constraints of what the surface can do are not so much set by

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**Fig. 51:** Aegis Hyposurface, 1999 with blue light and a different surface configuration
the media content as the hardware itself. When transmitting an electronic injection of
data into the "flesh" of the bi-polar metallic facets moved by a matrix of pneumatic
pistons, the surface will reach its limits.
The speed of the pistons in moving the surface from one position to another is limited
by the reaction time of the pistons and the time the air needs to move through the
ducts. This air when entering and leaving the pistons will also create a noise level not to
be underestimated, which would make it difficult to use the surface for applications
where noise is a concern. When moving the surface from position A to B the surface,
when moved in full speed, will also generate a blast. With each continuing move a
further air movement will develop. Another problem could arise when moving
mechanical parts, here being the pistons and the small metal plates interconnected with
rubber plates. Moving parts over a longer time will lead to wear and tear.

The Blur Building by architects Elizabeth Diller and Ricardo Scofidio was the
centrepiece pavilion of the sixth Swiss national exhibition 2002. It is a suspended
platform shrouded in a cloud.
The building consists of a 60x100x20 metre metal construction that sprays innumerable
tiny drops of lake water from 31 400 jets. The high-pressure spraying technology
ensures that the fleeting sculpture will be visible in all weather, rain or shine. A built-in
weather station controls fog output in response to shifting climatic conditions such as
temperature, humidity, wind direction, and wind speed, and furthermore the cloud and
therefore the building responds to shifting climatic conditions such as temperature,
humidity, wind direction, and wind speed.
The structure of the building is placed on piles in the water and a tensegrity system of
rectilinear struts and diagonal rods cantilevers out over the lake. Ramps and walkways
weave through the tensegrity system.
The high-pressure spraying is carried out by high-grade steel jets with tiny apertures only 120 microns in diameter. Through these the water is forced at a pressure of 80 bars onto fine needlepoints directly above the apertures and atomised into innumerable tiny droplets 4-10 microns in diameter. The droplets are so small that most of them remain suspended in the air. If sufficient jets are installed in the specific volume they saturate the air with moisture and create the effect of mist, or in this case the effect known as the blur.

The public can approach blur via a ramped bridge. The 400 foot long ramp deposits visitors at the center of the fog mass onto a large open-air platform where movement is unregulated. Visual and acoustical references are erased along the journey toward the fog leaving only an optical “white-out” and the ”white-noise” of pulsing water nozzles. Prior to entering the cloud, each visitor responds to a questionnaire/character profile and receives a “braincoat” (smart raincoat). The coat is used as protection from the wet environment and storage of the personality data for communication with the cloud’s computer network. Using tracking and location technologies, each visitor’s position can be identified and their character profiles compared to any other visitor.
In the Glass Box, a space surrounded by glass on six sides, visitors will experience a sense of physical suspension only heightened by an occasional opening in the fog. As visitors pass one another, their coats will compare profiles and change colour indicating the degree of attraction or repulsion, much like an involuntary blush - red for affinity, green for antipathy. The system allows interaction among 400 visitors at any time.

Visitors can climb another level to the Angel Bar at the summit. The final ascent resembles the sensation of flight as one pierces through the cloud layer to the open sky. Here, visitors relax, take in the view, and choose from a large selection of commercial waters, municipal waters from world capitals, and glacial waters. At night, the fog will function as a dynamic and thick video screen. Blur was part of the Arteplage Yverdon-les-Bains for Swiss EXPO 02, designed in a project collaboration where several architects and artists founded the group ‘extasia’, which won the competition for the site in Yverdon.

What kind of observations can be made from these three projects?

The first two projects *The Source* and *Aegis Hyposurface* both alter their spatial appearances through tangible surfaces made out of spheres or metal plates. The Blur building offers a different approach to how space could be altered, in this case with ‘mist’ as a building material. The three projects developed by others have demonstrated that an alteration of space is possible due to an interaction between space and beholder or participant. As well the interaction was driven via data, questionnaire/character profile, collected to inform the shape the form of the building, in case of *Blur Building* or an internal spatial cognition as it is the case with *The Source* or *Aegis Hyposurface*. This alteration of spatial cognition is shared in common between all three projects. Another element all three share is that they are basically monochrome but, in some cases, have the potential to alter their appearance through colour, mainly by light projection. So far my research has discussed in this Subchapter [2.] only projects by others which alter their form, but not their visual appearance through a change of colour. The following two projects investigate examples that are able to change visual appearance through a change of colour?
The fourth project expresses a town’s collective emotions through dynamic change in architecture via the use of colours: the D-tower, a collaboration between the artist QS Serafijn and Lars Spuybroek/NOX. Lars Spuybroek describes the project:

“*We conceived a tower that would change colour according to the emotions of a town’s inhabitant’s questioned in a daily survey. An urban object that shows the hidden feelings of a whole city … what could be more intriguing? What if art ceased being metaphorical to become real and operational, the inverse of the route to abstraction – though the object can hardly be called realist. The tower doesn’t just stand in public space; it orients itself in a public sphere that includes the electronic realm of the internet.*”

This tower, created in 2003, maps the emotions of Doetinchem’s inhabitants, a city in the eastern Netherlands. It sources information that it converts to a visual display, from responses to a questionnaire filled out by the city’s inhabitants, thus determining the intensity of their feelings of love, hate, happiness and fear.

*Fig. 54: D-Tower by NOX / Lars Spuybroek + Q. S. Serafijn, 2003*
Through the use of colour the tower then abstracts the emotions of these answers submitted online by the town’s inhabitants, transmitting the ‘state of the town’ each evening by assuming the colour of the most intensely felt emotion, so says the homepage of the project. 92 For Spuybroek the “D-tower is a coherent hybrid of different media, where architecture is part of a larger interactive system of relationships. It is a project where the intensive (feelings, qualities) and the extensive (space, quantities) start exchanging roles, where human action, colour, money, value, feelings all become networked entities.” 93 In his book NOX / machining architecture the project is explained:

“The building is directly connected to the website in two ways. First, the website shows a visualisation of the response of a number of selected inhabitants to the questionnaire. The selection repeats every six months and reflects topography and ethnography of Doetinchem’s 50,000 inhabitants. The survey deals with everyday emotion, such as hatred, love, happiness and fear. Every month the questions become more detailed, and answers are graphed in landscapes made visible on the website. Second, the four emotions are represented by green, red, blue and yellow, the colours of LEDs illuminating the building, and are directly related to the website, where the responses are compared and weighed. In addition to the website, which displays which emotion is stronger in what street or neighbourhood, the tower displays the
overriding emotion at that moment. Each evening the tower thus takes on the colour of the number one emotion that day...” 94

The quality of the D-tower and the manner in which it changes colour is described by Brian Massumi:

“The tower changes colour according to the results, becoming a beacon of the collective mood. Affect has been given visual expression. The predominant affective quality of people’s interaction becomes visible. This can undoubtedly reflect back on the interactions taking place in the town by making something that was private and imperceptible public and perceptible. A kind of feedback loop has been created between private mood and public image that has never existed in quite this way before.” 95

This ’feedback loop between private mood and public image’ is achieved on the level of using light to alter the colour of a form. The form of the D-tower does not alter the spatial impression one has when the collective mood of the city changes; it remains the same.

Staying on the level of changing colour asks for a further consideration of the possibility of combining the change of colour through an internet or other questionnaire as a source of potential data input with the effects described earlier in the Aegis Hyposurface, where a movement of a surface has been created. There the wall responded in sympathy and was able to react to each individual’s action in the space around the surface, not just a response to a collective mood, as the D-tower does.

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[2.6] Hypersurface Architecture by various architects

Two issues of the Architectural Design Magazine, Hypersurface Architecture I and Hypersurface Architecture II, both edited and contributed to by Stephen Perrella, looked at the new relations and effects between media and topological surfaces in architecture. I will investigate built examples of this theory as a reference for my own work. The examples I chose are the Fresh Water Pavilion (designed by
Spuybroek/Nox) which is attached to the Salt Water Pavilion (designed by Kas Oosterhuis Associates with Ilona Lénárd). Both projects have been published in the before mentioned magazine AD Architectural Design Hypersurface architecture I, amongst others.

“A Hypersurface”, as Stephen Perrella describes in a lecture at the Doors of Perception conference in 1994 in Amsterdam, the Netherlands, “is a new theory of liquid-embodied architecture to displace the nostalgia and re-realization being carried into the spatial conceptions of new-media technology.” 96 In a later article he states the possibilities for the relation between form and image: “any form whatsoever could be textured with any image – whatsoever.” 97 For him 2D, the image, and 3D, the form, produces the Hypersurface – and “it seemed imminent that a widespread use of this new technology would unleash a new dimension of effects because there is a realm of potential relations between image and form. Currently and historically, however, the relations between image and form are superposed schizophrenically.” 98 The Saltwater Pavilion has evolved from the very beginning of the design process as a three-dimensional computer model, without dwelling too much upon its physical

Fig. 56: Saltwater pavilion by Kas Oosterhuis, 1997 interior view

Fig. 57: Freshwater pavilion by NOX, 1997 interior view
form and how the form has been generated - the main focus should be on the internal
projection used in the building.
On the home page of the ONL, the office of Kas Oosterhuis Associates with Ilona
Lénárd, the interior is explained in two different chapters: sensorium – realtime
behaviour and h2o worlds – diving into virtual extension.
Oosterhuis’ first chapter talks about the actual set up within the space where a
membrane is used as a projection screen to display realtime behaviour with an ever-
changing colour condition from behind the transparent inner skin. The effect of light is
augmented by the use of sound with an array of speakers which makes it possible for
the sound to move dynamically through the sensorial space.
The second chapter, h2o worlds – diving into virtual extension, discusses the media
content and the form of projection that;

“on both the surface of the wave-floor and the interior polycarbonate
skin of the sensorium you are immersed in the projections of a series of
virtual worlds _ they all depict different perceptions of water and
fluidity _ the worlds are generated by two sgi o2 computers and
projected by 6 1000 lumen high-resolution data projectors through
small openings in the transparent skin _ the worlds are navigated by the
public through an interface which is merged into one loop of the
hydra”100 (see picture Fig. 56 above)

The next introduced building, the Fresh Water Pavilion by Lars Spuybroek/NOX, is
for Spuybroek a special building for many reasons:

“It is the first fully topological structure where curvature is not only in
the roof and walls, but also in the floors; no section is horizontal. It is
the first fully interactive building in which visitors can transform light
and sound in the interior through a wide range of sensors.”101
Here, as well as with the Salt Water Pavilion, I will concentrate on the interactive aspect
of the design rather than the building’s actual form. The pavilion’s interactivity is
extended to the installation of projectors, light and sound. This is further explained in
Lars Spuybroek/NOX’s book when he states:

“Specially designed sensors are connected to three interactive systems
that operate together; real-time generated animations connected to LCD
Both projects use projectors, light and sound to animate space. The space in its haptic appearance stays unchanged; but the image changes over time to create the illusion that space does or can change. Through having form and image as an addition to each other the image will never be more then a decorative element texturing and ornamenting the form. Even though both achieved a high level of sophistication in their designs, the aspect of interactivity could also have been transmitted with projection, light and sound in an ordinary box. Having discussed light, i.e. colour, previously in regards to the D-
tower, the main shift in these projects is the use of projectors, and therefore the possibility of projecting movie clips, images, data, among others. The façade of the building or a surface can host information which is no longer static but can be shifted and altered in real-time.

Again, what kind of observation can be made from the projects working with light and projection? In both projects an alteration of the appearance of space has been achieved by concentration on light and projection of images. The projects D-Tower and the two examples for Hypersurface Architecture were premised upon an alteration of space by an input by colour or projection, whereas the projects Aegis Hyposurface, The Source and Blur Building worked on an alteration of space by actually moving structural elements. Both groups, the ones working with image and the ones working with space achieved an alteration of space by either image or space. The question raised from this analysis would be, is it possible to achieve an alteration of space with both methods, image and space: to alter space with a spatial movement of a zone and altering the appearance of this zone by a change of colour or the projected content?

In the next step the five introduced projects will be compared with each other to achieve an understanding of their position and to define my aims and identify gaps to be filled by my research.

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1 These structural elements I am talking about are the spheres, metal plates or mist in the individual projects that compose space.
Why have these projects been chosen? What are the common characteristics shared by these projects? The projects, even though they differ in the way they have been designed or constructed, all share a common element which is relevant for this research. They all document a recent shift in how form in architecture is created. Mark Goulthorpe has discussed this shift in his article “Autoplastic to Alloplastic (Aegis Hyposurface)” when he talked about his own project, the Aegis Hyposurface. I will use the expressions ”Autoplastic substance” and ”Alloplastic substance” from his essay and explain the shift in architecture when using the previously introduced projects and how these projects deal with this shift.

Autoplastic (Greek πλαστείν - to form, to shape, to generate) is a determinate form, a form fixed by the use of classical architectural materials as bricks and sticks, fixed by a designer who arranged these bricks and sticks into a "plastic" without having the ability to rearrange them again. The form has been determined by the architect or designer as the author of the form.

In Alloplastic, space is indeterminate and interactive; a "plastic" can be altered by different inputs and react in variable and different ways in this. All projects mentioned in this chapter have such an input, e.g. stock exchange data for the Source, internet questionnaires for the D-tower, and then react in differing ways through colour, mist, movement of object or surface, projection, to name a few. By having an indeterminate "plastic" that alters its appearance, the determining role of a designer or architect as the author is also shifted to the public as a generator for events that shape form. All these projects pick up on the complexity of privacy and publicity with new tracking technologies, and use them as a form generator manifested in different expressions. Thus all these projects demonstrate an interest in engaging with the concept of “alloplastic mode of operation” or interactive architecture. Designing interactive spaces is arguably a subject of considerable interest in the current discussion of architecture. Current interest in the discussion of interactive architecture has been further documented, i.e. by the Architectural Design Magazine 4dSpace: Interactive.

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1 I want to use the term ‘plastic’ to cover all elements of architecture such as columns, planes and bodies.
Architecture edited by Lucy Bullivant which presents and discusses the topic of interactive spaces.

How do I position my research in this field and in relation to the previously outlined five projects?

Here I want to analyse what kind of expressions have been used by the discussed projects to refer to a way a "plastic" could be delivered in this research. These projects could be classified into two groups: a group that generate an alloplastic with an alteration of form (metal facets, mist, and illuminate spheres) and another group that generates an alteration with image (projection of video clips / images, colour).

My research system on the other hand would allow an alteration of space with both kinds of expressions. It is able to generate an alloplastic mode of operation with an alteration of form due to generating a 3D dynamic zone with light-points and an alteration with image through the use of RGB LEDs. These features are able to give the zone any colour or produce images as do LED screens. The new form of materiality I am investigating could fill the gap between the two approaches to interactivity in architecture discussed above by allowing both alteration of form and alteration of image to deliver a content-driven dynamic zone in real-time.

Having established a theoretical framework for the spatial dynamic media system and then positioning the system in the discussion in architecture, I will discus the significance of my research system for architecture. The new attributes of the zone are listed briefly in the previous Chapter [1.] when discussing in Subchapter [1.7.2] the shift from a 2D arrangement of pixel to a 3D arrangement, and also as follows:

- Dynamic relief
- Dynamic relief through script or sensor input
- Multilayered surface
- Decay Function
- Privileged Perspective
- Movement and speed
- The design process

These points will be further investigated in the following chapter.
Chapter 3 has, so far, delivered an outline of my research in the field of media and architecture by offering a framework for a system which would shift the application of a media façade from a 2D plane into a spatial dynamic device. The significance of such a system cannot be fully addressed by this research. Here my research will open a discussion of what the significances are and outline them briefly, but do not claim to discuss them to a full extent which would extend the possibilities of a single research thesis. The main aim specified in the core-research question is the development of a system, applying it in an architectural context and testing it with two forms of content, firstly media content designed by the author and secondly for media content that the author could curate.
The analysis of projects done by others reveals a current interest towards an interactive space in the discussion in architecture. Architecture has become, as Paola Gregory describes, “a surface for communication; sensitive, reactive and interactive.” As Gregory argues in her book, “Space, is in fact no longer an a priori condition, a simple substrata on which to inscribe experience, but rather an interactive and progressive construction; time is no longer objective, cosmic, measurable, but rather a ‘time acted’ in the dimension of the interaction with the perception based on parameters constantly more instantaneous, unstable and subjective.”

She continues to describe the new architectural space; “...as a system of processes, open, flexible, adaptable, modifiable, the expression of different internationalities and continually reconfigurable, where the co-existence of the two planes – the actual and virtual – may encourage a new stereoscopic vision, or in the words of Virilio that real-time perspective activated in the interface between electronic feedback and the place of real space.”

For Gregory, the surface as an architectural interface should promote, “interactivity, connectivity, multi-mediality, and virtuality, creating new dialogic and multisensorial dimensions that extend the very cognitive and perceptive field of architecture.”

The requirements listed by Gregory could be fulfilled by any 2D electronic interface, so what would be the embellishment, if any, for space through applying a 3D system?

Delivering space in the spatial dynamic media system is defined by four characteristics:

- The possibility of a dynamic amalgam of form and image
- The anomaly of surfaces in a non haptic zone, focusing on multilayered surfaces, the option of a decay function and privileged perspective.
The notion of movement and speed

The shift of the design process when working with the *spatial dynamic media system*.

A precursor for an amalgam of form and image was the use of bas reliefs in architecture, a tradition going back to Mesopotamian architecture. Two main differences can be noticed when comparing a bas relief with my researched system. A relief is made of a physical material - stone, marble, etc - and it is static. A space defined in a zone of a 3D light point matrix delivers a dynamic visual surface, but not a haptic surface. The space becomes dynamic through an input generated from a script or sensor, but what kind of space could it be? The system creates a virtual space only in the sense of the Latin etymology *virtualis*, or that which exists potentially but not actually, but not in the sense of the idea of ”virtual reality” as it is currently and widely used in popular culture. The space defined by light points is incorporeal.

The incorporeal presence of the surface and its anomalous nature opens up two unexplored aspects of architecture; firstly, the creation of a multilayered surface and secondly, achieving a ”decay function”.

A multilayered surface is possible as a result of seeing through more than one surface - an $n$ amount of different surfaces generated by light points can be arranged in layers, one surface behind another, with all of them visible. The number of layered surfaces is only defined by the dimensions of the zone. But not only layering is possible. Several surfaces could be interwoven with each other to define a multilayered surface.

A decay function of the surface could be achieved by writing a script that incorporates a decay factor on each light point. The light point will not be simply switched on and off, it will be decayed to create an after-effect of the façade that has just been, or will be in the future when the zone modifies itself through movement from its present state to its future state.

The system would also offer a privileged perspective where the media content of the façade could be understood from one particular point in space. This draws reference to the anamorphosis effect Hans Holbein the Younger had achieved in his painting *The Ambassador* (1533) National Gallery in London, or in contemporary art works by George Rousses or Felice Varini.
Movement itself is the main factor in how one will perceive space. Traditionally in architecture the beholder takes the role of moving through a static space, and the speed of the beholder then has an influence in how that space is perceived. The focus here is not on Virilio’s \(^1\) discussion of speed and space, but conditioned through the non haptic nature of the zone a delivered surface. When not planar, this surface will create a multilayered surface when viewed from a certain angle. When moving this surface through a digital input, the zone will invert the relation of vision and movement. The system, as Brian Massumi \(^{ii}\) commented with regard to the *Blur Building*, rather than addressing vision first and using vision to guide movement, as is usually the case, will frustrate vision in order to address movement first. Multilayered surfaces have a complexity where a visual expectation of architectural style by presenting space no longer exists. Vision will become vague, but processes of cross-modal interaction will become visible through movement.

Cross-modal interaction will extend the design process when designing space. When designing any kind of object, design allows for \(x\) number of possibilities. Each of these variations could be built at some stage, so the designer has to stop the design process at a point and bring the dynamic process of design into a static form, where the ideas "freeze". The design process in architecture of a spatially dynamic media system is divided into two sections. The first section is similar to conventional design. A core is defined and stays static, but it is the core of the building designed for the end-users, and the skin of the core is only designed as a substructure. The substructure made of LED sticks hosts the zone where the design can be changed in real time and can be defined by processes of cross-media interaction or media content. The design of space could therefore be divided into two main components when using the system. One would be the design of the substructure made of LED sticks, and the other space-defining zone would be the media content represented within the zone by the 3D light-point matrix. This would allow a shift or at least an extension of authorship in architecture where the design of the media content represented within the zone could be shared by many different parties.

\(^{i}\) I am referring here to Virilio, Paul – *The lost dimension*, (Semiotext(e), 1991)

\(^{ii}\) Brian Massumi in an interview published on www.intelligentagent.com/archive/Vol5_No2_massumi_markussen+birch.htm (accessed January 2006)
With my *spatial dynamic media system*, where space is defined through a 3D light point matrix, not only could an existing gap be addressed in the discussion of architecture when shifting from an autoplastic to alloplastic mode of operation, but also with attributes of the zone, such as described in this last part of the chapter, a new dimension for architecture could be introduced. A dimension whereby architecture could pick up on the complexities of private and public and display these complexities through sophisticated forms not taken from a pre-existing repertoire, but through the interactions themselves.

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[3.2.1]
Precursor of form and image

Before discussing the significance for architecture of an amalgam of form and image I want to investigate any precursors of such an amalgam in architecture. What kind of relation existed between the image and the form and what kind of material qualities did this precursor have?

A ”modelled form project” from a flat background has been an element in use since the beginnings of architecture and can be seen in the art of sculpting a relief. Here one differs between two types of reliefs - “low reliefs” or “bas reliefs” which are very shallow, and “high reliefs” which are very deep. Reliefs have been most commonly used for the architectural adornment of building surfaces, both inside and outside, where the stone or marble is part of the building, rather than as a free-standing piece of art to be hung on the wall.

The system discussed in this research follows the tradition of a high relief, which can be seen in the pediments of classical temples, e.g. the Parthenon. Here reliefs were used for a single scene, or to provide a narrative structure. An early example can be found in Mesopotamian art, such as the relief Assyrian army besieging a fortress, c. 883-859 BC; British Museum, London.
The function of a relief in providing a narrative was utilised in Roman architecture, and “they, too (as in Mesopotamian art), wanted to proclaim their victories and to tell stories of their campaigns”\textsuperscript{108}, says E.H. Gombrich in his book ‘The Story of Art’. He continues:

“[…] there we see the Roman legionaries foraging, fighting and conquering. All the skills and achievements of Greek art were used in these feats of war reporting. But the importance which the Romans attached to an accurate rendering of all details, and to a clear narrative which would impress the feats of the campaign on the stay-at-homes, rather changed the character of art.”\textsuperscript{109}

A famous existing example for this architecture is the “Trajan’s Column” in Rome, Italy.

I want to continue here discussing how narratives have been told, as I have noticed an interesting overlap with my research where the image used is a moving image telling a narrative.
Narratives can be told with images in different ways, two of which are important for my research as they connect the image with the position of the beholder.

One way of telling a narrative has been through a relief or picture. This method was, like everything until the development of moving images, a static one. The narrative is explained in a sequence of pictures added one after another and added on a frieze or a column. The beholder viewing the Roman column has to physically move through space to read the narrative. But not only reading the narrative could be achieved with this method. Through the three-dimensionality of the relief, a change of position also allows seeing part of the relief in a different perspective. A good example for this is the Altar of Zeus from Pergamon, c. 164 – 156 BC Marble: Pergamonmuseum, Staatliche Museen, Berlin, where, as Gombrich writes:

“The artist was obviously aiming at strong dramatic effects. The battle [displayed on the altar that represents the struggle between the gods and the Giants] rages with terrible violence. The clumsy Giants are overwhelmed by the triumphant gods; they look up in agony and frenzy. Everything is full of wild movements and fluttering drapery. To make the effect still more striking, the relief is no longer set flat on the wall but is composed of almost free-standing figures which, in their struggle, seem to overflow on to the steps of the altar as if they hardly troubled about where they belonged.”

[110]

The possibilities of my researched system allow the experience of the spatiality of a zone depending on the different positions of the beholder in relation to the surface. It creates a three-dimensional zone similar to a relief. A relief was an art form of the Greek-Roman period that allowed the spatial display of items using the techniques of
the time. An amalgam of form and image through the use of a 3D light point matrix is a current method of displaying items spatially. There are obvious differences between reliefs made from marble or stone and a zone defined by a 3D matrix of light points that could be seen as a dynamic relief. With obvious differences in the haptic appearance the question raised when talking about the delivered zone is, is this form of architecture therefore a virtual one?

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**[3.2.2] Dynamic relief**

The system creates a virtual space only in the sense of the Latin etymology *virtualis*, or that which exists potentially but not actually, but not in the sense of the idea of “virtual reality” as it is used in current popular culture and which has major presence in the mass media. Here “virtual reality” was used as a synonym for “artificial reality”. With the *spatial dynamic media system* a zone has been driven as Massumi explains in his interview:

“It’s a real event. Something has happened. If something has really happened, then how can you say it’s simply artificial? Now, when you say ‘virtual reality’ the emphasis is on the ‘reality’. The old distinction between what is natural versus cultural or artificial falls apart, as forms becomes active – formation.”

My *spatial dynamic media system* continues the idea of telling a story or part of a story as per the presented examples of a bas or high relief. Another difference between a relief and a digital relief is the dynamic aspect of the relief where the amount of stories told is not just limited to one. Similar to the comparison of picture and movie clip a digital relief could tell a story with a narrative setup.

What kind of story could come to life in the zone? Furio Barzon argues that “architecture takes on life; it becomes an electronic and interactive organism; a new type of space is coming to light; indifferently real or simulated”. So what could be fed into this ‘electronic and interactive organism’?

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Generating a dynamic relief through a script or a sensor input

A spatial dynamic system would change this 2D plane of communication into a 3D “Space of Event” that exists as a communicative transmitter between exterior and interior. The form of this surface will “no longer be representing forms taken from a pre-existing repertory as in postmodernist architecture” \(^{113}\) but from an “event”, of which Massumi spoke about at the previous quote. By ‘event’ I mean a cultural, environmental or sociological influence translated into electronic data, that then gets translated into the zone reproduced with the Spatial Dynamic Media Façade. This surface will shape a form, but it is no longer a representing form taken from pre-existing repertory. The event itself will shape the form.

How could the event be fed into the zone? What kind of inputs could be captured and translated into light points which will then generate a zone? I want to offer two options of how an event could be fed into the system to generate a surface movement. Firstly a surface movement could be generated by a script written in a computer code such as VB script, C++ or other codes. Secondly information could be captured by sensors and the sensor data will then be used to create a movement in the zone.

Scripts are computer programming languages that are typically interpreted and can be typed directly from a keyboard. Thus, scripts are often distinguished from programs, because programs are converted permanently into binary executable files (i.e., zeros and ones) before they are run. Scripts remain in their original form and are interpreted command-by-command each time they are run. \(^{1}\) VB scripts for example can take data from an Excel data sheet and use this information to generate a surface movement. The role of scripts as a generator for movement of the zone will be further investigated in Chapter 5 Project 4 where I will provide different scripts to test the system.

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In the following section in this chapter I will discuss some input options to provide an understanding of what types of sensors could be used to generate a movement within the zone.

Michelle Addington and Daniel Schodek state in their book *Smart Materials and Technologies* that the term “sensor” derives from the word sense, which means to perceive the presence or properties of things. A sensor is a device that detects or responds to a physical or chemical stimulus (i.e. motion, heat, or chemical concentration). Addington and Schodek differentiate sensors from *instruments or meters* that measure the amount or extent of something in relation to a pre-determined standard or fixed unit in length, mass, time or temperature. Other forms of capturing data could include ways of recording audiovisual contents with devices such as cameras or microphones among others.

All devices that are capable of providing data could then be used to run other electronic devices, such as a system that creates a zone by a 3D light point matrix. These two introduced options allow the generating of a surface within the zone, and the interest of this research will now focus on the quality of the 3D events happening within the zone. What aspect is common to all surfaces used in a general architectural context for defining space and how do they differ from the zone?

Tectonics delivered by general or common materials, those being materials with haptic attributes such as wood, stone or other tangible materials, have one very trivial characteristic in common. They are not transparent, like glass, but even glass is not 100% transparent, as after several layers glass also becomes non-transparent. Due to these characteristics the delivering of certain forms where materials are morphed together is not possible. When one layer of material is on top of another, the layer below cannot be seen. To weave together two or more materials and still be able to see all the materials is a challenge in craft. These and other issues must be considered when using haptic materials. My research has offered a non-haptic material, light-points, to define space because “*the prima materia of architects is not matter, bricks, stones*”
and concrete, but space” as Paul Virilio says in an interview with John Armitage. Therefore, I have argued that not only materials such as stone, bricks, glass, to name a few can be used to define space but others as well, as Antonio Saggio concludes when he speaks of space; “...it is also built through the use of ‘other’ materials: materials apparently foreign to architecture, ...” When using light points as a material to define space I am using a non-haptic material similar to the Blur Building. The Blur Building, which I have listed in [2.4] in this chapter was built by the non-haptic material mist. There, “computers regulate the spray of tiny drops of lake water from 31400 jets according to climactic changes of humanity, temperature, wind speed and direction.” In the following section I will list characteristics of an intangible zone where the material that defines space is not haptic and therefore allows the beholder to see through the material, and also what kind of tectonics could be generated out of this material.

[3.3.2] A multilayered surface based on an intangible substance

By having a surface based on an intangible substance an overlapping of two or more surfaces is possible.

I will explain what a multilayered surface is and look further at how this appears in nature through two examples. A water surface (Surface A), when the water is clear and not too deep, allows the perception of the ground made from sand, rocks, etc (Surface B). Here two surfaces overlap each other in two different forms, one “parallel” to the other, or in a rock formation such as a reef, where the floor of the ocean breaks through the surface of the ocean. In both cases one can perceive both surfaces, with the exception that one can’t see the water surface covered by the ocean floor in the second example.

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1 Parallel not in a mathematical sense but more in a general sense, where - remaining with the example of water in the ocean, the water surface is above the floor of the ocean.
In architecture at present it is possible to perceive another material through a transparent surface, i.e. glass. With more than one surface within the zone it is possible to see all of them at the same time and to look through them at the same time.

By being able to see through more than one surface an X-amount of different surfaces can be arranged in layers, one surface behind another, with all of them visible. The number of surfaces layered is only confined by the dimensions of the zone. But not only layering is possible. Several surfaces could be interwoven with each other to define a multilayered surface. The picture Fig. 63 below illustrates a multilayered surface when looking at a corner of a rendering where two surfaces join each other and one can see the surface in the foreground as well as the second surface in perspective. Picture Fig. 64 shows the same effect with two surfaces perceived from one particular position.
This demonstrates an aspect which has not been explored in architecture. In comparison with another example, the Aegis Hyposurface, as an example for a dynamic surface the next image picture (Fig. 65) shows the difference. One cannot achieve the same effects illustrated by the both images above.

Here only one surface can be seen. An overlapping of two surfaces, as is the case in other architectural examples, is not possible.
The previous chapter describes an aspect which has not been explored in architecture, to have multilayered surfaces. Another aspect that has not been previously deployed in architecture is a decay of the surface. One can achieve a “decay function” of the surface by writing a script that puts a decay factor on each light point. The light point won’t simply be switched on and off, but will be decayed to create an after-effect of the façade that has just been, or will come in the future.

The picture above explains this phenomenon in a diagram, where the relation of opacity and time are shown in a bell curve. The zone would allow a spatial representation of time, where future, present and past are embedded in moving form. Here the surface will not be located at one point - the most we could say is it ”passes through” a point. Thomas A. Goudge explained the difference of something being at a point with something passing through a point in the introduction of Henri Bergson’s book *An Introduction to Metaphysics* where Goudge compares both terms with an illustration from the ancient philosopher Zeno of Elea:

“Take the phenomenon of a flying arrow. It is easy to show, says Zeno, that it does not really move. For at each instant of its flight it occupies one and only one point of space. This means that at each instant the arrow must be at rest, since otherwise it would not occupy a given point at that instant. But its whole course is composed of such points. Therefore, the arrow does not actually move at all.”117
Goudge argues further, and Bergson agrees that the argument as stated is irrefutable, but what Bergson denies, as does Goudge, is Zeno’s assumption that the arrow can literally be at one point. The most we can say, says Bergson, is that it “passes through” a point. This passing through a point with all the points before and after could be visualized by my researched system.

When comparing this to the Blur Building, for example, one can see that here again is a shift in how space can be represented with the spatial dynamic media system. The Blur Building allows an alteration of the form, but one could not predict with certainty in which direction the building would move and also one could not tell how the form of the building looked before. Similarly when thinking about the Aegis Hyposurface, one can only see the form of the surface at present, but no past and future surface form.

Privileged perspectives in an intangible zone

I want to explain the term privileged perspectives by the means of two examples. Both examples are taken from an art context, but privileged perspectives can also be found in architecture.

Work by the French photographer Georges Rousses gives an example of a privileged perspective by the means of contemporary artwork.

Fig. 67: Georges Rousses, Sargadelos, 2001

The pictures of Rousses’ work appear at first glance to be photos of desolate or abandoned spaces (buildings, rooms, parking garages or streetscapes). However, this is
an intended illusion: what Rousses does is to paint these designs onto the abandoned spaces before taking the photo, correcting such things as the slope of floors or the interruption of beams, so that the painted designs come together to produce the illusion of a simple, flat design floating on the surface of the photo.\footnote{For further information and further pictures please refer to the homepage: http://www.rousseprojectdurham.com/ (accessed March 2007) where Project Durham is documented, on which Georges Rousses worked from 4 – 6. September 2006.}

Another example for a privileged perspective in art would be the 16th century painting *The Ambassadors* (1533), by Hans Holbein the Younger, which is now exhibited in the National Gallery in London. The painting has a distorted skull in the foreground, placed in the bottom centre of the composition, but when seen from a point to the right of the picture the distortion is correct.

![Fig. 68: The Ambassador, Hans Holbein the Younger, 1533](image1)

![Fig. 69: The Ambassador, Hans Holbein the Younger, 1533; Detail of distorted skull](image2)

Both work with anamorphosis, a distorted projection or perspective requiring the viewer to use special devices or occupy a specific vantage point to reconstitute the image. This is what the zone could offer as well.

The following image sequence explains what a beholder would perceive when moving from one point in space to another. In image Fig. 70 the beholder can see several rings in different sizes organised around a centre point.
In this position the beholder is in a privileged position which enables him/her to see the image displayed on the façade. If the beholder would then move from the first position to the right, the impression of the image would change to that illustrated in the next four images.
In the last image above the beholder could not understand what it is actually about, but can do so if he/she changes position, in a very similar way to the anamorphosis effect Hans Holbein the Younger achieved in his painting *The Ambassador*.

Historically, architects have understood movement as the travel of a moving eye in space. Yet architecture, in both its realization and its conception, has been understood as static, fixed, ideal and inert. Themes of motion and dynamics in architecture are
typically addressed through pictorial views of static forms. Not only have buildings been constructed as static forms, but more importantly architecture has been conceived and designed based on models of static and equilibrium. The viewer is the moving object which navigates itself through space. The notion of space has therefore much to do with the speed the viewer travels through space, as the faster the beholder moves the more difficult it is for one to perceive space. Therefore the perception differs if one walks through a city, drives in a car, or in a Shinkansen, the Japanese bullet train. The Dutch architect Kaas Oosterhuis has considered this aspect in one of his design proposals for *Hessing Cockpit* in Utrecht 2005, a car showroom next to a highway where he designs a form generated by the notion of a car passing by. The project is explained on his website as follows:

“The brief was to combine an acoustic barrier with an industrial building. We decided to design with a speed of 120 km/h to streamline the concept by looking at our design in a telescopic perspective. We have studied the splines of cars, powerboats and jet planes which are streamlined to diminish drag along the A2 highway the acoustic barrier and the industrial buildings themselves do not move but they are placed aside a continuous stream of cars passing by the stream of cars flows at a speed of 120 km/h along the acoustic barrier. As a consequence we decided that the proportions of the built volumes immersed in the acoustic dike should be boldly stretched along the length of the dike. The building, as a body fused with the solid mass of earth of the dike, is experienced as a streamlined cockpit. Animation studies indicate that a cockpit described by one powerful spline on top of the acoustic barrier provokes the strongest impact. The cockpit functions as a 3d logo for other industrial facilities hidden behind the acoustic barrier. The most striking design principle is the use of long continuous lines. Supple splines which do not have an explicit beginning and not an abrupt end reaching the actual volume of the cockpit the lines divide into a top and a bottom line between these smoothly curved lines the cockpit building is inserted with the precision of a plastic surgeon. The overall impact must be confirmed by a strong detail: an extra barrier at the top of the body of
the acoustic barrier - shaped as a standard guard-rail - cuts into the top of the cockpit and sinks gradually into a deep gutter. The main design rule determines that the length of the cockpit has to measure at least 10 times its height. This rule guarantees that the cockpit keeps its smooth appearance when passed by at a speed of 120 km/h.\textsuperscript{118}

Oosterhuis’ design considered the fact that one perceives space differently when one passes by in a car. He stretched the form to make it longer so the notion of the building begins earlier and one perceives the main part of the building when one is in the centre, where the actual showroom is located.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{image.png}
\caption{Hessing Cockpit, Utrecht, 2005 space designed in consideration of the speed of the beholder}
\end{figure}

This is an example of where the speed of the beholder has generated the form of the building, in this case with the speed of 120 km/h. This is a rare example in architecture, mainly due to the fact that not all buildings are in close proximity to highways and not all buildings were designed when high-speed devices such as cars were around. Most other buildings have been designed and are perceived from the viewing speed of the pedestrian, the \textit{flâneur}. According to Walter Benjamin\textsuperscript{1}, in his unfinished ‘Arcades Project’, the \textit{flâneur} came to rise primarily because of an architectural change in the city of Paris. This change, rooted in a budding capitalism, involved the creation of the arcades, which were passageways through neighbourhoods covered by a glass roof and braced by marble panels so as to create a sort of interior-exterior for vending purposes. The movement and speed of the beholder has played an important role in architecture, and varying rates of speed created a different form and language of architecture.

\textsuperscript{1} I am referring here to Benjamin, Walter – \textit{The arcades project}, (Cambridge, Mass. : London : Harvard University Press, 2002)
Space defined by movement

What is the meaning of speed and movement when the architectural form, the space, begins to move? How is space perceived by the beholder when the space starts to move?

The introduced system allows space to be constantly changed; the form delivered within the zone will be an ever changing one. Traditionally in architecture the beholder takes the role of moving through a static space, and the speed of the beholder then has an influence in how that space is perceived. This is described in the previous chapter where the *Hessing Cockpit Building* was designed with this in mind.

The focus should not be on the discussion of Virilio about speed and space, but rather architecture could here achieve that which Massumi referred to when talking about the *Blur Building* by Diller+Scofidio:

> “Rather than addressing vision first and using vision to guide movement as usually the case, the 'blur building' frustrated vision in order to address movement first.” [119]

If the design of a building surface ‘frustrates vision in order to address movement first’, a traditional way of perceiving surfaces and the connection between movement and vision would also shift. For Massumi the notion of space would shift in a way that:

> “The Building was built to be vague, and then to become determinated through a process of cross-modal interaction that made a perceptual event of visiting it.” [120]

In Chapter [1.7.1], I have briefly discussed the ideas of Lev Manovich towards the role of information as an input for space design. The "cross-modal interaction" Massumi is talking about could be information, and the change of information over time could be expressed by the movement of space.

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1. Patrik Schuhmacher talks about the relation room and beholder when talking about, “the identity of a spatial unit (a "room") would shift with the respective position of the moving subject.” In Schumacher, Patrick – The architecture of movement (as movement against architecture), *ARCH+ 134/135, Wohnen zur Disposition*, (Aachen: ARCH+ Verlag, 1996)
2. I am referring here to Virilio’s book ‘Lost Dimension’ which discusses the meaning of speed on space. Virilio, Paul – *The lost dimension*, (Semiotext(e), 1991)
I want to explain briefly the design process by the means of parametric modeling. The reason for doing so has its background in the possibility of changing the design within the design process. Parametric modeling uses parameters to define a model (its dimensions, for example). The parameter may be modified later, and the model will update to reflect the modification. Typically, there is a relationship between parts, assemblies, and drawings. A part consists of multiple features, and an assembly consists of multiple parts. Drawings can be made from either parts or assemblies. “The designer has absolute authority over their design, and limitless possibilities for iterative design development experimentations in this medium [parametric design] and context.” 121 This demonstrates a similar relation when thinking of a design process as a model is also defined by a set of parameters, such as experience of the designer, location or use, to name a few parameters. These parameters are altered in the design process through giving them a different importance which leads to a new design or an alteration of one design. “An object that has been designed reflects deliberate decision-making, not a serendipitous occurrence.” 122 So if the designer has ”absolute authority over their design” and “limitless possibilities” when designing an object which ”reflects deliberate decision-making”, when does one end the design process? The question should not discuss how and when a design could be finished, but if the design must be built be it a building, an industrial designed product or a sculpture, when moving from design to built form the design process must at some point stop. In the following section I want to discuss this in regards to designing within the zone of the spatial dynamic media system and the shift of ending a design process as it is the case in design practice at present to a design in real-time which could be achieved with the spatial dynamic media system.
How does my researched system differ when designing space? When designing any kind of object, design allows x-number of possibilities. Each of these variations are ones that could be built at some stage, so at one point the designer must stop the design process and bring the dynamic process of design into a static form, where the ideas freeze and become unchangeable. The design process in architecture of a spatially dynamic media system is divided into two sections. The *spatial dynamic media system* as a type of media façade will be attached to an existing or newly designed building in a conventional way, and the substructure as such stays static. The substructure made of LED sticks hosts the zone where the design can be changed in real time and can be defined by processes of cross-media interaction or content. The design of space could therefore be divided into two main components when using the system. One would be the design of the substructure made of LED sticks, and the other space defining zone would be the media content represented within the zone by the 3D light-point matrix. It is the second part, the design of space within the zone, in which my research is interested.

As explained in Chapter [3.2.3] the space in the zone can be generated by input of a script or by sensor. This input can change in real-time and will therefore change the appearance of the space. Furthermore the input as such can be changed. Space could at one moment be generated by, for example, the temperature of the environment around the zone, and in the next moment the input could change to an artist’s contribution to the façade where the expression of an idea is displayed. The design of the space and therefore the authorship of the space could change each moment, each further influencing the space. But not only could the way the space is designed by the author be altered in real-time - the beholder who perceives the space can also interpret the space depending on his/her position. The notion of the space will differ if one has a privileged position as discussed in Chapter [3.3.4] or if one sees the space from another location.
My research had raised several questions within its narrative hitherto. These questions have been concerned with the development of media façades. My project proposed that media façades, as they exist at present, could be developed further into a three-dimensional display system where with the use of a light-point matrix, media content could generate a zone in real-time.

My research hypothesises a number of questions which the project work will answer in Volume Two and topics raised in this chapter discussing the theoretical framework will be explored further in the project work.

In Chapter [1.7.2] my research has discussed the possibility of defining space with light points and has presented evidence by the means of existing examples where space has been designed by light-points. The examples listed have been drawn from different backgrounds, such as Las Vegas, or the motion of the world in the middleages, but have not been defined space by light a way my system has considered when defining space by light-points. The examples discussed static space such as the Lichterdom by Albert Speer, but not a dynamic space generated by light-points. Here a series of tests assessed that it is possible to define a dynamic space by light-points.

The consideration of the theoretical framework continues in the design of a system such which is able to function as a media façade in an architectural context. If it is possible to define space with light-points and also define a dynamic space with light-points then a system can be developed from this base. My research undertaken in Chapter [1.3.1] when discussing the development of electronic components in particular LEDs should be continued and the façade system will be based on LED technology to create the light-points.
Townsend, Anthony, “Digitally mediated urban space: New lessons for design”, 
*Praxis Issue 6 Journal of writing and Building, Praxis inc*, (Cambridge, MA 2004), p.100

Ibid., p 101

Ibid., p 101

Ibid., p 102


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Ibid., p 76

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Snoonian, Deborah, P.E., “Digital Practice”, in: *Architectural Record, 03/2003* The magazine of the AIA, p.177


Ibid., p 102


[www.ada-ausstellung.ch](http://www.ada-ausstellung.ch), (accessed February 2006)


Ibid., p 76


Ibid., p 5

Ibid.
Ibid., p. 18
Ibid., p. 18
Ibid., p. 51
Ibid., p. 52
Ibid., p. 52
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Ibid., p. 16
Ibid., p. 16
Ibid.
Ibid.
Ibid.
Ibid., p. 20
Ibid., p. 76
Ibid., p. 75
Ibid., p. 75


Ibid., pp. 78
[1.] Methodology and structure of research

When defining my research question I raised six propositions to summarise my interest. These observations lead to my central research question. In the following section I will explain my structure and methodology before listing an annotated bibliography.

What kind of methodology and structure would serve to find an answer to my research question, and what are the implications of the question itself?

For my research, architecture should here be seen as a defined 3D zone in the form of a media façade added on to existing, or as yet unbuilt, buildings in which spatial presentations will occur. Architecture would be dematerialized and electronic media, normally ephemeral, would become more palpable in space.

Existing media facades are constrained to be a 2D screen and cannot be a defined 3D zone. Therefore the first task should be finding a possibility to develop existing media facades further.

My contribution to the field of knowledge will concentrate on this precise zone, which I posit as being that part of the building, which helps to define the space external to it and is therefore intimately part of the architecture. The second task would be applying the developed 3D zone in the form of a media façade to an existing or as yet unbuilt buildings.

In the six propositions listed in the previous chapter, which led me to my central research question, I talked about media content. Consequently the next task was to consider media content in my research and test the developed and applied system by supplying media content. Here are two options of dealing with media content. The research question does not ask for media content as a form of art or communication but whether, with the use of media content, the zone could be in constant flux. For me, one task in generating and regenerating the zone through media content, would be to design the media content myself. Because one media content option would limit the possibility for fully testing the system, a second option of media content should be the fourth task. Thus, I will work as a curator for different media content by offering a
series of software “applets”. Again these software “applets” are neither a form of communication or art; their function is further testing my researched system.

Summarizing the methodology of my research – a system will developed as an evolution of media façades into a 3D zone. This system will be applied in an architectural context and will then be tested by two different media content options: a media option which I design and different media contents in the form of software ‘applets’.

To structure this methodology I am reporting my research in two volumes, Volume One outlines the theoretical research. Volume Two outlines my project work to test the proposals put forward in Volume One.

Volume One commences with four chapters. Chapter 1, as already discussed, is a background chapter. Chapter 2 serves as an introduction to the methodology and structure of my research and is an annotated literature review reinforcing the boundaries set in the methodology. In order to answer the first task raised in the methodology, the development of existing media façades, in Chapter 3 my research will look at the history of media and architecture in order to gain an understanding of media façades. Chapter 4 concludes with an evolution of research and project work, a discussion of my contribution to the field of enquiry and a reflection on my project work.

Thus, in Chapter 3 I include precedents for media and architecture in my research and analyse what could be learned from these first examples of media façades.

I will also analyse the development of different technologies in order to provide an understanding of existing media façades and the shift of the technology of media façades – whether the shift of technology leads to a shift in the appearance of buildings clad with media façades.

To gain an overview of contemporary examples of media façades, looking at new building types that specify embedding media architecture will identify what kind of technologies could be developed further to answer the first task of developing a media façade system.

So far my research has looked into media façade technology and how media façades are applied to a building, two fields important for me to answer the first and

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For my research an applet is a software component that runs in the context of another program, mainly a Rhino script that runs in Rhino™. It performs a narrow function in generating a light point surface movement that has no independent use.
second task raised in my methodology. I will also continue with research into media façade content.
At this point I discuss the characteristics of media façades and the different forms of media content used to gain information for tasks three and four raised in my methodology when talking about testing my system with the use of different forms of media content.
The investigation until this point leads to a theoretical concept of what a media system could potentially look like, I propose a system that is an evolution of existing media façades and which allows the display of media content as spatial and dynamic. Due to its ability to be both spatial and dynamic I will call my proposed system in *spatial dynamic media system* to establish a constant term when talking about my researched system.

I compare this *spatial dynamic media system* with work by others in order to, at least partially, fill the gaps in this field with regard to its relevance to architecture. Chapter 3 concludes by discussing the significance of the *spatial dynamic media system* for architecture and outlines the characteristics of the system.

Lastly, the theoretical framework concludes with Chapter 4, which looks as the evolution of tasks raised in the methodology that defined the research and which project work could have been achieved and which could not. At this point my contribution to the field of enquiry will be discussed. Reflections will be made about the overall project, and the positive outcomes and the limitations will be discussed.

With Volume One providing a theoretical framework for my research, the hypothesis of the *spatial dynamic media system* as an evolution of existing media façades is then tested by a series of four projects works in Volume Two. I have undertaken these four projects to answer the four tasks raised in the methodology. The background knowledge necessary to undertake the four projects has been gained in my theoretical framework.

In the second volume this knowledge will be applied in a series of tests which are embedded in the project work and will help in developing the *spatial dynamic media system*. 
As mentioned in my methodology, when talking about which tasks are necessary to answer the research question, two Projects are dedicated to the design of a technology that fulfils the requirements of the research question and applies this system to an architectural context. The third and the fourth projects discuss media content. In project three, the media content is provided by the author and in project four the author functions as the curator of various media content scenarios through providing a toolset composed of different codes used to influence the generation of form.

Therefore I have developed as a first step a prototype system which, with the use of a 3D light-point matrix, alters space. The tests undertaken to develop such a prototype are described in Project 1: Realisation of system in regards to an industrial design product. The prototype system has then been applied in an architectural context, in Project 2: Applying system to answer if the prototype can fulfill its function as a media façade to become an architectural component. These two projects are dedicated to the design of a technology that fulfils the technical requirements of the research question.

Projects three and four are a test series dealing with the question of media content. In the following the system was tested by applying ‘designed’ media content to it in Project 3: Effect and use – providing media content. Lastly, in Project 4: Effect and use – working as curator for different media contents, I have experimented with writing software ‘applets’ for a third party to adapt to their own input for display purposes.

Technology to actually display media content onto media facades exists, but they must be adapted from a 2D surface into a 3D zone, in order to allow the media content to be spatial and the space to be dynamic.
[2.] Literature review

Introduction

This annotated bibliography defines and reinforces the boundaries of my research methodology and structure. It is not only limited to books, articles or papers read throughout my research, but also covers how personal experience has informed the research. Furthermore the relative value of the internet, books and papers is discussed, what I have learnt from what source and why, in certain cases, one medium has been more useful then another. In this annotated bibliography, I highlight the sources used in my research. Some crucial research most relevant to my research undertaken in university laboratories around the world currently remains unpublished in formal sources such as books or journals. In many cases the internet provides a platform where results can be publicised if not published, in a formal scientific manner. Some of the important resources used in my research are therefore from the internet.

http://futurefeeder.com/ and http://www.mediaarchitecture.org amongst others have been especially helpful.

The research question, based on the four tasks set by the methodology, is divided into foci and each focus is addressed by a number of existing publications or books. This creates a structure to my research and highlights each particular field for its respective contribution and merit. Defining my research question, six propositions are driving my core research-question and form the structure of my research. Concentrating and positioning the research in the field of media and architecture, the focal point considers the further development of current media facades; this being the role of my research as a part-architectural discussion and the area to which I seek to contribute by developing a media façade system which evolves the 2D screen into a spatial representation system.

In recalling the central research-question:

When weaving architecture and electronically applied and managed imagery together, are their respective properties successfully interchanged to the extent that they mutually create a new architectural
zone, one that is in constant flux, generated and regenerated through ever changing content?

Two separate issues arise which must be addressed in detail prior to developing the research and experimenting through project work. Firstly, I need to develop background knowledge in technological resources. Secondly, I need to gain a similar knowledge in media content of media facades through literature review. The necessity of gaining background knowledge in both technology and media content is addressed in two parts of the research question. The question around technology addresses how a [...weaving together (of) architecture and electronically applied and managed imagery...] can be achieved. For media content, how this apparatus or system can then define [...]a new architectural zone in constant flux, generated and regenerated through content that never stands still] is then discussed. Thus questions of media content and what media content will be displayed are also raised.

My research starts with the historical context of media and architecture and the questions provoked by this history when analysing three specific buildings with embedded media facades. I discuss the history of media facades, with a focus on the technological changes over time, specifically the technology used in media facades. Within this discussion, my background knowledge and experience in working with media and architecture enriches the research and has been the starting point for some of the key references.

A study of the history of media facades has helped my research construct a background in the development of this technologically oriented approach to facades. This investigation gave me an understanding of the historical precedents in incorporate media in architecture, how and when media in architecture has been incorporated into buildings. The focus is on the very early years and I cite a few relevant examples here. It will not be a complete history of media and architecture, but, interestingly, I have not been able to find an existing published history of media and architecture combined, focusing on the embedding of media in architecture. The examples and, the literature
discussing the examples, I have selected shows that systems, which have been outlined, in the past could be built today, to demonstrate that the system envisaged at present could be built in the future. These selected examples look at the early stages of the combination of media and architecture and the kind of problems and constraints these projects faced when focusing on the technology. I am aware that other examples exist but Luigi Puglisi’s book Hyperarchitecture - Spaces in the Electronic Age is starting point for research in the history of media and architecture. According to Puglisi, the Centre Pompidou it is held to be the precursor of media and architecture. Its original designed state which included large screens on the facades, has been altered to a metaphorical level due to cost constraints and technical limitations during the construction. Kenneth Powell, in Architecture of the future: Richard Rogers speaks of the Centre Pompidou and the background to its design. Other examples are examined briefly, such as the architectural representation in the movie Blade Runner which has been discussed in essays such as Alex Burri’s Will Androids dream of electric sheep? and Eric Alliez and Michel Feher’s Notes on the sophisticated city, which discusses the still unbuilt media screens showing in this movie. This section of my review of buildings showing media in architecture concludes with Toyo Ito’s book Toyo Ito: 1970-2001 and Toyo Ito and Andrea Maffei talking about Ito’s Tower of Wind in Yokohama, Japan in the book Toyo Ito : works, projects, writings. The literature about the above mentioned projects reveal that certain facades, for example those in Blade Runner, had already been conceived, twenty years but could only be built today thanks to technologies such as LED screens. Without setting out to do so, in order to gain an understanding of the field the background, research has made apparent a cohesive, but hitherto untracked, history of media facades in architecture. The question raised from the reviewed literature is: What new kind of media façade development could be envisaged today and what could be the first steps towards developing such a system?

The literature, read up to this point, has demonstrated that achievements made since the beginnings of media facades are mainly based on technical developments. I have also considered mobile phones and their screens when defining my research question. When looking back at the difference between state of the technology of these phones in the mid-nineties and at present, one can understand the evolution of screen technology and
the potential for further development. Thus my research looks at which shifts in appearance of media facades has been made through which particular shifts of technology. This overview of current technologies investigated fluorescent tubes, LEDs and large display screens, explained by their history and their function.

Fluorescent tubes, LEDs and large display screens were subjects discussed in my training course as an electrician and, when working with media components during my time in the architect’s office, prior to my postgraduate experience. In addition, specific information on a certain product or electronic component, where detailed information has been necessary for the research, has been sourced from the manufacturer directly. Thus my research covered the history and function of fluorescent tubes, LEDs and large display screens.

I outline shift of technology through a brief explanation centered upon two locations which, in their physical development and visual appearance, demonstrate a shift of the appearance locations physical through a shift in technology.

These two locations within varying culturally-driven areas are – Times Square, New York (Western) and Shibuya crossing, Tokyo (Eastern). I have visited both locations more than once over a period of 2-3 years and observed a shift in technology. The shift in technology has been investigated by a literature review and an analysis of changes at Times Square, New York. This analysis is assisted by Christine M. Boyer’s book *Cyber Cities: Visual Perception in the Age of Electronic Communication* and *The Double Erasure of Times Square*, in: *The unknown City First* when she discusses Times Square. Further insights are provided by J. Hoberman’s *42nd Street*, Herbert Muschamp’s *The Alchemy Needed to rethink Times Square*, Robert A. M Stern’s *42nd Street Now! A Plan for the Interim Development of 42nd Street* and Anthony Townsend’s *Digitally mediated urban space: New lessons for design*. Anthony Townsend’s book is also usefully to document another example of that shift, Shibuya Crossing in Tokyo. The history and cultural complexity of this location in Japan is explained in Roman Cybriwsky, *Tokyo - The Shogun’s City at the Twenty-first Century* and articles in the *Architectural Design Profile No 99 – Japanese*

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1 I do not discuss and include projection into the discussion of my research, due to being essentially an old technology, which projects onto a form and therefore can not be altered into a 3D form by itself
Architecture II guest edited by Andreas Papadakes. The literature about both locations reveals that shifts in the buildings’ appearances are caused by shifts in technology, but offers additional the question: what kind of technical development would be required to push this ‘shift of appearance’ further?

Times Square and Shibuya are an assembly of different forms of media facades across different buildings. For a deeper understanding of the kind of technological categories that exist, a classification is made based on concepts outlined in the paper Wandelbare (mediale) Gebaeudefassaden by Alexander Wahl, published online at the Bauhaus University Weimar in 2002. Alexander Wahl’s concepts have been tested through a collection of different projects with different kinds of facades in my research. The selected examples were included, for the same reasons as those examples discussed in my analysis of the history of media facades. The focus of the research is not to provide an overview of existing media facades but rather to indicate a spatial development of media facades. My research moves beyond different projects. It is a hypothetical development of existing technologies to explain how media content can be a method of altering space. Nevertheless, three of the seven categories described by Alexander Wahl in Wandelbare (mediale) Gebaeudefassaden are discussed through built examples to further explain the technology. Wahl’s seven categories also assist in narrowing down the research focus in regards which technology could be used for further development. The seven categories are according to Wahl:

- Projection façades, where a façade is used as a projection screen, with the projector on another building.
- Back projection façades, with a projector behind a translucent projection surface.
- Window raster animation uses existing window grids or fenestration on buildings and each window functions as one pixel. Low resolution messages or early computer game atmospheres are possible.
- Passive media façades is primarily a transparent façade, where the communication is created through different visible layers behind and the users/people in the building.
Display façades, having a mainly LED medium displaying items on the façade. The façade functions as a big screen and available systems are produced by several companies such as Barco, SmartSlab, Versatile, etc.

Illuminated façades, where neon tubes are dimmable and allow the display of low resolution black and white moving images.

Mechanical façades have mechanical driven elements that change the appearance of the façade.

I describe the last three types of media façades in the above list in greater detail: firstly display facades, secondly illuminated facades and thirdly mechanical façades. Why these three types of media façade? A detailed study of resources of all seven types of media façade has shown that only Wahl’s last three categories for media façades, the ones I want to discuss further, have potential to be developed toward the aims of my research.

Research on display facades also references the product information homepages of different display façade manufacturers. Examples of such product information are discussed including the Mercedes-Benz booth of the Automobile Salon Geneva 2004. Analysis of illuminated facades using fluorescent tubes as a medium is found in *A friendly alien: ein Kunsthau für Graz: Peter Cook/Colin Fournier architects* (*A friendly alien: a museum for Graz: Peter Cook/Colin Fournier architects*) written by architects Peter Cook and Colin Fournier/Spacelab. *A friendly alien* explains the Kunsthau Graz, Austria, a recently built project where the circular ‘kitchen fluoro’ has been used. For the Kunsthau project, the Berlin based firm *realities:united* explored a concept that they titled ”BIX”, short for Big Pixel, and published this concept and results of the project on their homepage.

In his book *Twentieth Century Architecture: A Visual History* Dennis Sharp wrote about the mechanical façade of the *Institut du Monde Arabe* in Paris by Jean Nouvel. Jean Nouvel himself described the project in *Architecture and Design 1976- 1995 a lecture in Italy*, and in Oliver Boissière’s *Jean Nouvel* the project is further explained. A project description of the Roger Smith Hotel project, which wraps a street corner in New York, promotes direct interaction between an awning made up of kinetic metal bars and the pedestrians on the street below, was found on the MIT (Massachusetts Institute of Technology) homepage in the Kinetic Design Group, within the Department of Architecture. This project was chosen to investigate what, if any,
insights can be gained for my research in the field of kinetic architecture as a form
dynamic space. Due to using a different medium, pneumatic or hydraulic, my research
and kinetic architecture do not overlap to an extent that kinetic architecture will play a
role in my research. The review of the resources of all three different types of media
façade has shown further that illuminated façades also do not accord to the aims of my
researched system. Development and technical possibilities of fluorescent tubes are not
as versatile as display façades based on LED technology.

The material I have researched and cited thus far encompasses the brief technological
history of media facades and the improvement of facades due to technological
developments. Media facades have been classified and separated into seven different
categories by Alexander Wahl, and, to this point, my research discusses the physical
characteristics of these facades. Having considered the predominant technical aspects,
the collected characteristics and information is used to investigate their influence on
issues of visual media content. The following pages discuss the characteristics of media
content on media facades, where four groups of characteristics will be elucidated. These
characteristics start with a return to the beginning of media facades where again Luigi
Puglisi explains the characteristics of Centre Pompidou in his book *Hyperarchitecture
- Spaces in the Electronic Age*\(^{20}\). Next focus is on the technical enhancements which
are listed by Anthony Townsend’s article *Digitally mediated urban space: New
lessons for design*\(^{21}\). Further the research looks into Toyo Ito’s argument of the
characterisation of architecture in the electronic age in his essays *Architecture in the
Electronic Age is Figuration of Vortex of Information*\(^{22}\) and *A Garden of Microchips – The Architectural Image of the Microelectronic Age*\(^{23}\), and also at informational and
electronic spaces through Paola Gregory’s book *New Scapes, Territories of
Complexity*\(^{24}\) and Pierre Lévy’s *Becoming virtual; Reality in the Digital Age*.\(^{25}\)

Essentially, this technical precedents chapter discusses the characteristics of media
contents, shows the development of media facades and describes how they to be came
classified as separate categories. The question arising from the study of these resources
is: if media facades current technology has transformed architecture and space no more
then as a purely carrier of signs, how can space reassert itself as a main issue when
applied to such facades?
After discussing the technical aspect of media facades up to this point, the literature review’s second phase discusses the role of the media content of media facades. Here, firstly a distinction has to be made. The discussion of media content and research into media content looks into different approaches to generate media content but not as a form of communication. Communication is a field too wide to include in my scope of my research. Books about media including core works by Marshall McLuhan, Jean Baudrillard, Roland Barthes, Rafaeli Sheizaf were used as background material in order especially to gain an understanding of the field rather than platform it as part of my research. I have for this reason avoided using the word ‘communication’ in order to avoid any impression that the research will take that direction. This consideration has influenced the design of projects at the later stage. My research also does not attempt to ‘communicate’ with the environment; my interest is more in the spatial representation of information and the influence media content has on the appearance of the façade or, when developing one’s own system, how such media content could be used as a generator for a dynamic space.

Joachim Sauter’s article *Das vierte Format; Die Fassade als mediale Haut der Architektur (The fourth format; The façade as a medial skin of architecture)* lists four different conditions for the utilisation of a media facade. Autoactive, the first of the four conditions, is presented by two projects published by [blinkenlight.de](http://www.blinkenlight.de) on their homepage. Reactive conditions are mechanical facades such as that by Jean Nouvel at the Institut du Monde Arabe in Paris. The Institut du Monde Arabe in Paris has been discussed above and therefore the books references to this building will not be listed a second time. While interactive content is discussed in a later chapter, a participative content is for Sauter, projects such as Project Blinkenlight, which was created by the German Chaos Computer Club in 2001 as a celebration of its 20th birthday, where a light installation in the Haus des Lehrers building at the Alexanderplatz in Berlin transformed its front into a giant monochrome low-resolution computer screen. The installation is illustrated on [blinkenlight.de](http://www.blinkenlight.de). Following from this view of the type of media contents that exist for media facades, my research uses the three forms of media

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1 The books have been listed in Chapter 6 References
2 Project Blinkenlights was created by the German Chaos Computer Club in 2001 as a celebration of its 20th birthday. A light installation in the Haus des Lehrers building at the Alexanderplatz in Berlin transformed its front into a giant monochrome low-resolution computer screen.
content: pre-recorded content, live content and interactive content evaluated from the characteristics of media facades. Times Square is a location that has a high concentration of pre-recorded content, which can be analysed with Townsend’s *Digitally mediated urban space: New lessons for design* and the *Zoning Resolution of the City of New York* published online. I have compared the mainly commercial pre-recorded content displayed in Times Square is compared with Deborah Snoonian’s article *Digital Practice*. Here she refers to the *Kunsthaus Graz*, where the representation of pre-recorded content has been shifted to non commercial motivations. An example for live content is the real-time broadcasting of sports events, amongst others but Townsend lists in his book another example of live news in Times Square: the Reuters Sign presenting live news. Arjen Mulder talks about interactivity in his article *The object of interactivity* published in *NOX / machining architecture* by Lars Spuybroek as well as Sheizaf Rafaeli and John Newhagen in *Why communication researchers should study the internet: A dialogue* and Terry Flew in *New media: and introduction*. Lev Manovich discusses in his book *The Language of New Media* the role of the screen and claims that we have not “*left the era of the screen*”. This quote by Manovich summarises the outcome of the literature review of media content and has been the key driver for my research: going beyond a 2D display. So if a “*screen is still a screen*” to quote Manovich, what kind of a system would allow content to be more than just a generator of what happens in the “*window into another space*” but be a generator of space itself?

The books listed in the annotated bibliography, up to this stage were highlighted in order to investigate the technological background of media facades on the one hand and the visual content aspect of media facades on the other hand. The literature review added four questions to the central research-question prompted by the investigations in history, technology and content of media facades. To seek answers for the new questions my research had raised at this stage, the following literature and projects have been used to answer my questions. Before discussing the sources further used in defining the enquiry to the field in my theoretical framework, I want to list the four questions raised from the literature review. The four questions thus are:
The question that the historical background of media facades asks, what new kind of media façade development could be envisaged at present and what could be the first steps towards developing such a system?

When investigating the technology of existing media facades by the means of two locations, Times Square New York and Shibuya Crossing Tokyo, it appears that shifts in the media façade appearance of buildings are caused by shifts in technology of media facades, so what kind of technical development would be expected to push this "shift of media façade appearance" further?

A question which rose when researching the technology is that, at present, technology of media facades has reduced architecture and space as a merely the carriers of a sign, how can space reassert itself as the main issue when designing media facades?

Existing technology does not currently extend the screen to being more than simply a "window into another space" to quote Manovich, what kind of a system would allow content to be more than just a mirror of what is happening within the “window into another space” and rather, be a generator of space itself?

These questions complement the central research-question and together form the foundation questions that helped me to define clearly the field of my research. The literature review has helped me so far to gain background knowledge which I apply in the Project Work in volume Two. What the books, papers, articles and journals, amongst others, have not done is help in actually developing existing media façades. All resources have discussed existing systems, sites or application but have failed to consider in how media façades could be further developed. Literature reviews in the following pages will address the issue of future technologies and incipient and be focused on gaining knowledge in how media façades can be evolved.
When reflecting on media and the characteristics of media, the possible qualities of the information delivered by new technologies and materials taken from the research done by Paola Gregory in *New Scapes, Territories of Complexity*\(^\text{39}\) where, in her opinion, buildings and therefore the material that covers them function as ‘urban transmitters’ are considered. Antonio Saggio states in the introduction of Gregory’s book that ‘other’ materials could be possible in order to define space, and that these materials will reflect the scientific and philosophical concepts of their own time.\(^\text{1}\) Saggio suggests that the development of media facades envisaged at present could rely up on a material which has not been used yet to define space. These thoughts will be used as a starting point while still keeping in mind the materials and techniques researched in the section on technology.

So, to define a material which has not been used yet to define space, two premises have been investigated: firstly, how are forms received and can forms be delivered with means other than physical, and secondly how can images produced on a 2D screen be abstracted into a 3D method?

Le Corbusier’s book *Vers une architecture*\(^\text{40}\) originally published in 1923 states how forms could be perceived, but this definition of ‘Architecture [as] the masterly, correct and magnificent play of volumes brought together in light’ is attacked by the German expressionist Paul Scheerbart in *Edison, der vergessene Pionier*\(^\text{41}\) edited by Reyner Banham. Scheerbart twists the Le Corbusier quote so that buildings at night time become light in forms and not forms in light. This statement, that it is possible to define space with light or light points is demonstrated through different examples in architecture and other contemporary events. The first event is taken from recent history, conspicuously during the accidental blackout in New York in August 2003.\(^\text{ii}\)

Architectural examples where light has been used to define space are the "light

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\(^\text{1}\) Antonio Saggio in the Introduction of Gregory, Paola – *New Scapes, Territories of Complexity*; 2003 Birkhaeuser – publisher for architecture, Basel; The IT Revolution Series, Page 5

\(^\text{ii}\) The event has been amongst others publicised by CNN on their homepage, for further information please refer to: [http://www.cnn.com/2003/US/08/15/power.outage/](http://www.cnn.com/2003/US/08/15/power.outage/)
cathedrals” (Lichterdom) designed by Albert Speer for the annual Reichsparteitag (NS party conference) in Nuremberg in 1934, described in Frederic Spotts’ book Hitler and the power of aesthetics.42

Lastly I want to look at different ways architects or urban planners have made use of light. Here Las Vegas is selected as an example of a location where light has been used to a great extent, and therefore we can see if indeed light has been used to define space. This research will use Robert Venturi’s analysis of the architecture of Las Vegas in his book Learning from Las Vegas43, where he also focused on the use of light in architecture.

Light, therefore, can be considered as a medium to define space and offers a possible way for further developing existing media facades. Light, and, to be more precise, light-points, are already generating the images on media facade systems such as LED facades and other similar techniques. Understanding how a picture is first created on a screen and then this 2D arrangement of pixels is altered to a 3D matrix of light points or pixels, permits the advancements of the technical development of existing systems. This pushes a shift in appearance further towards a point where space could again become the main consideration when applying media facades. Space can be altered when the media content changes and the light points in turn react to the change in media content. The reaction of the light points will result in a change of the appearance of a surface and therefore a change of space. In such cases a media façades could then be considered as a spatial dynamic media system which would move if media content was applied and media content, therefore, becomes a generator of space itself.

The literature review has given examples to show space can be defined by other materials. Thus a statement of Antonio Saggoi1 has been helpful in regard to defining space with light points. The phenomenon of defining space with light points has been demonstrated further. The analysis of Robert Venturi’s book Learning from Las Vegas44 did not offer any insights to my research field, but has been included into the research as an example of a well-known location with a high use of illuminated signs and how the signs reflect towards space.

1 Antonio Saggoi states in the introduction of Gregory’s book (Introduction of Gregory, Paola – New Scapes, Territories of Complexity; 2003 Birkhaeuser – publisher for architecture, Basel; The IT Revolution Series, Page 5) that ‘other’ materials are possible in order to define space, and that these materials reflect the scientific and philosophical concepts of their own time.
The literature review into the history, the technology and the media content of media facades has brought the research to where the development of the dichotomy between 3D static form and 2D dynamic image could be overcome. This proposal of a media façade system now finds its position within my architectural discourse. A collection of five projects has been selected in order to frame my research and its ambitions. These projects are underscored by the listed key texts, chosen to identify a gap in the discussion of architecture, when focusing on aspects described in my research questions. The selection of projects were was determinated by two factors: either following a similar trajectory as my research or else I could see possibilities in further developing certain thoughts or concepts presented by their creators. Within the researched field of media and architecture, its technology and discussion of content, I investigate the possibility of filling a gap that exists in architectural discourse, when shifting from an autoplastic to alloplastic mode of operation. By ‘autoplastic’ and ‘alloplastic’ I refer to an article published by Mark Goulthorpe where he defines ‘autoplastic’ as a ‘self-determinated operative strategy’, and ‘alloplastic’ as a ‘reciprocal environment modification’. The fabric I am talking about is the 3D light-point matrix. The driving force to alter the fabric to make it alloplastic could be the injection of content into my research system, of developing existing media facades which will allow the zone to be generated and regenerated. I want to list the five projects thus are:


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1. I am referring here to the article Goulthorpe, Mark - Aegis Hypo-surface: Autoplastic to Alloplastic; Architectural Design Hypersurface Architecture II Vol. 69 9-10, Chichester: Academy Editions, 1999
2. Mark Goulthorpe used these two terms ‘autoplastic’ and ‘alloplastic’ in an article discussing the Aegis Hyposurface, drawing these terms from Ferenczi’s analyses of trauma. For this research these terms are borrowed to explain the shift from a determinate, static space to an indeterminate, interactive space.
- Blur Building by Diller + Scofidio¹, Yverdon-les-Bains, Switzerland, 2002

The first of five projects, a project whose existence is publicised on the homepage ii of the designers is The Source by Greyworld. Most information for this artwork installed in the London Stock Exchange was found on various homepages such as InteractiveArchitecture.com⁴⁵ or Futurefeeder.com⁴⁶.

Aegis Hyposurface, is discussed in publications by Mark Goulthorpe in Aegis Hyposurface Autoplastic to Alloplastic⁴⁷ and Mark Burry in Between Surface and Substance⁴⁸ as well as a joint paper by both authors, Aegis Hyposurface ©: The Bordering of University and Practice.⁴⁹

Blur Building by Diller+Scofidio, is extensively discussed in the book Blur – The making of nothing⁵⁰ by Elizabeth Diller and also in a brief introduction by Laurie Anderson in Scanning: the aberrant architectures of Diller+Scofidio.⁵¹

This project which changes its form by a digital injection is followed by a project that alters its colours as a result of an internet survey - The D-Tower by NOX / Lars Spuybroek + Q.S. Serafijn. It is discussed in Spuybroek’s NOX: machining architecture⁵² and specifically in articles written by Brian Massumi and Arjen Mulder in the same book. Brian Massumi again discusses the D-Tower in the interview Transforming Digital Architecture from Virtual to Neuro⁵³ with Thomas Markussen & Thomas Birch, aka bleep.dk.

Finally for the fifth project, two related projects will represent Hypersurface Architecture. Lars Spuybroek / NOX is mentioned a second time with his project Fresh Water Pavilion, and furthermore the Salt Water Pavilion designed by Kas Oosterhuis Associates with Ilona Lénárđ is discussed. Discussion of both projects is published in the AD Architectural Design magazine Hypersurface architecture I,⁵⁴ amongst other journals.

¹ Now Diller Scofidio + Renfro
² Please refer to: http://www.greyworld.org/#the_source_/i1
The literature reviewed has shown that all work done by others creates an alloplastic mode of operation, either through an alteration of form or an alteration of image. The analysis of the above discussed resources revealed that none of the analysed projects by others seek an alteration of space through both form and image, a combination, in fact, not seen in any example presented when discussing the historic, technological and content background of media in architecture. This gap I will be addressed by creating an alloplastic mode of operation through an amalgam of form and image.

[1.2.4] Resources to discuss possible significance

Until this point I have not included literature which would help to discuss a framework of the significance of such a system operation in an alloplastic mode for architectural discourse. Hitherto books, papers, articles, journal and others have helped me to define a framework of a media façade system based on a 3D matrix of light-points. This 3D matrix of light-points could define a zone which could be generated and regenerated when exposed to an alloplastic mode of operation. The following literature has helped me to define the particularities of a zone generated by a 3D light-point matrix.

Paola Gregory in New Scapes, Territories of Complexity\textsuperscript{55} discusses the role of surface as an architectural interface. For her the surface should promote interactivity, connectivity, multi-mediality, and virtuality, creating new dialogic and multisensorial dimensions that extend the very cognitive and perceptive field of architecture. The spatial dynamic media system extends space in the same direction. The literature reviewed in this section discusses qualities of the spatial dynamic media system, which differ from presently existing media facades.

The spatial dynamic media system follows the tradition of a bas relief, which can be seen in the pediments of classical temples discussed by E.H. Gombrich in The Story of Art\textsuperscript{56} but made from a different material. The intangible material of the spatial dynamic media system allows space to be defined by what Massumi calls an ‘event’ in Transforming Digital Architecture from Virtual to Neuro\textsuperscript{57} by feeding data captured from sensors into the surface. Sensors and the classification of sensors are discussed by Michelle Addington and Daniel Schodek in Smart Materials and Technologies\textsuperscript{58}. 
setting a frame for which sensors can be used as a source of input. The anomaly of surfaces generated by these sensor inputs are discussed, after defining the notion of space, using Paul Virilio in an interview with John Armitage in *From Modernism to Hypermodernism and Beyond*[^59] and in a foreword of Antonio Saggio in Paola Gregory’s *New Scares, Territories of Complexity*.[^60] The spatial dynamic media system offers three characteristics for surfaces: multilayered surface, decay function and privileged perspective.

- Multilayered surface is the possibility of over layering a number of surfaces onto one façade by simultaneously displaying more than one surface on the façade as a 3D object and creating an extra spatial depth.
- Decay function means achieving a ”decay function” of the light surface by writing a script that puts a decay factor on each light point. The light point won’t be switched simply on and off - it will be decayed to create an after-effect of the façade that just existed.
- Privileged perspective talks a about an anamorphic effect, an anamorphic image is a distorted image that only looks right when viewed from a specific angle or with the use of a device.

The options of surfaces such as multilayered surface, decay function and privileged perspective are explored with key references including *An introduction of Metaphysics*[^61] by Henri Bergson, *The Charter of Zurich Eisenman De Kerckhove Saggio*[^62] by Furio Barzon and works by Hans Holbein the Younger or Georges Rousses.

Discussion of movement and speed in architecture are explored through the Hessing Cockpit project in Utrecht, 2005 by Kaas Oosterhuis, and an interview of Brian Massumi in *Transforming Digital Architecture from Virtual to Neuro*[^63], and the book proposal of Lev Manovich for *Info-aesthetics*.[^64] The section ends with a discussion of the shift of the design process to a design in real-time and what kind of parallels can be drawn from a parametric modelling environment as explained by Mark Burry in *Paramorph*.[^65]

Chapter 4 briefly touches on a conclusion to my research. The system offers the possibility of designing a new architecture of information. The idea of a spatial
representation of information has been discussed by Lev Manovich in a number of papers, principally *Information and Form*\(^66\) at the Ars Electronica 2000 Exhibition and *Post-media Aesthetics*\(^67\), and the discussion of form and information will be part of Manovich’s proposed book *Info-Aesthetics*\(^68\), currently outlined as a book proposal on his homepage\(^i\).

After finishing the theoretical component of my research, the focus diverts to the Project Work in Chapter 5 and discussing the type of resources used to gain information about developing a system.

Giving a critical review to my annotated bibliography by summarising the value of the researched material I want to express following thoughts:

- Media façade products such as fluorescent tubes, display screens and LEDs: Literature about their physical specifications and capabilities is available and research towards gaining background knowledge of these products is easily achieved. When the aforementioned products are embedded into architecture and these products are published in articles, journals and others the main concentration of the article is mainly focused on the building and its visual affect. A technological background discussion of these façades is generally omitted. If this background is discussed it is only in publications which explicitly discuss one project as a monograph. Examples for this trend are review books such as, *Blur – The making of nothing*\(^69\) by Elizabeth Diller or *A friendly alien: ein Kunsthaus für Graz: Peter Cook/Colin Fournier architects (A friendly alien: a museum for Graz: Peter Cook/Colin Fournier architects)*\(^70\) written by architects Peter Cook and Colin Fournier/Spacelab to mention two.

- Whereas theoretical literature, like the interview with Brian Massumi in *Transforming Digital Architecture from Virtual to Neuro*\(^71\), and Paola Gregory’s *New Scapes, Territories of Complexity*\(^72\) had value in achieving an understanding of theoretical background of my research, made on contribution to answering technical questions.

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\(^i\) I am referring to: [www.manovich.net](http://www.manovich.net)
Many buildings with media façades have been published in various journals or articles but, as mentioned previously, there is no cohesive published history of media and architecture.

At this point I will not go any further when talking about the resources for the theoretical framework. Further information can be located in the References in Chapter 6 at the end of the work. In Chapter 6 other books, papers and journals are acknowledged and while these resources have influenced the research they are not directly quoted in my research.

[1.3]
Overview resources for VOLUME TWO – Project work

With Volume One providing a theoretical framework for my research, the hypothesis is then tested by a series of four projects in Volume Two. I have undertaken these four projects to develop my research hypothesis, and demonstrate how this knowledge can be applied through a series of tests embedded in the projects in developing systems. I discuss how the projects were conducted, a point which is important for the selection of resources in the project work.

The four projects start with a test to assess the possibility of designing space with light; a proposition made in the theoretical framework. Based on this first test, further projects with their embedded test series, will be based on testings to improve and find evidence towards a final product. Here most knowledge is gained from the results of the undertaken tests. This test series led the research through the following methodology. A research question A which has occurred in a test will be answered by a series of following tests. The question A can be answered, but at the same time it could cause a question B which then has to be addressed in the next tests and so on.

As explained previously in my methodology, the first two projects are dedicated to the design of a technology that fulfils the requirements of the research question and applies this system to an architectural context. The third and the fourth projects discuss media content. In project three, the media content is provided by the author and in project
four the author functions as the curator of various media content scenarios through providing a toolset composed of different codes used to influence the generation of form.

Based on this methodology, the first selection of resources is in the field of electronics and electronic engineering. Having gained a theoretical background of different media components such as fluorescent tubes, LEDs and large display screens when researching the theoretical framework, now the focus is on the specific electronic components of mainly LED technology.

As mentioned earlier, in February 1995 I completed a three and a half year training course as an electrician and I worked for a further year afterwards as an electrician. Why is this history important to my research?

In my research I discuss electronic components such as LEDs, SMD LEDs and I have designed electrical circuits as part of my project work. I refer to different electronic technologies and their history, mainly from internet sources such as the LED display system Barco MiPix 20 or SmartSlab, amongst others. Through my previous training as an electrician, I am able to judge the viability of information on the internet as an information source adding to the books, papers or journals. Significantly, much of the information listed in my research includes cutting edge technologies which are only appearing on the internet now, and are not yet in books and journals. Many technologies used in the research have detailed explanations extracted from the manufacturers’ homepages, describing the products and aspects of how the product can be used and their relative advantages. Certain inventions and particular technologies are not published in books or online due to intellectual property and related commercial imperatives, but, by keeping the research at a user level regarding these products, I have avoided any discussion on how these products have been developed or the kind of technological invention or innovation included in the product.

I have used my experience as an electrician in the Project Chapter 5: Project 1. Most of the references are taken from general books that provide a source for the information I present. This information remained on a level of common knowledge suitable for the

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i  A LED (Light-emitting diode) is a semiconductor device that emits narrow-spectrum light when electrically biased. I will explain LEDs further in Volume Two Project work: Project 1

ii  Surface mount devise (SMD) is a method for constructing electronic circuits in which the components (SMC or Surface Mounted Components) are mounted directly onto the surface of printed circuit boards (PCBs).
purpose of this section, where the focus is on the design of an LED based system but not on the development of LED technology as such, through books such as *The arts of electronics* by Paul Horowitz and Winfield Hill or the book used during my training course written by Stephan Gossner, *Grundlagen der Elektronik – Halbleiter, Bauelemente und Schaltungen.* Specific information on a certain product or electronic component, where detailed information has been necessary for the research, has been sourced from the manufacturer directly.

Achieving a prototype as the result of Project 1, the work of Project 2 includes mainly design based work. The prototype built as a result of 6 tests done in Project 1 is then applied to a building to test its functionality. Questions were asked how it could be attached to a wall. Experiments were made with different resolutions and looking at the approximate cost for the system. The cost calculation has been based on current costs for LED screens produced by an Italian manufacturer *Altoona* and the spreadsheet of Altoona of the costs for their products.

The motivation of the design of a media content in Project 3 was to provide evidence of statements which are essential parts of the design concept. The media content designed for a conference paper had the media content displayed on the façade focused on the “expression of cultural diversity”. The term of ”cultural diversity” should be altered to reflect common characteristics of humans. Rather than focusing on the common grounds of humans, to focus instead on expressing the diversity, diversity of cultural background which will be overlapped by common grounds such, as facial expressions. Facial expressions are a common ground of humans, even those from different cultural backgrounds. The interest of the movement of the face caused by expressing different emotions led to a short study of movement as relative, discussed by Henri Bergson in *An Introduction to Metaphysics*. Here my research uncovered evidence of the proposition in William F. Allman’s *The Stone Age present, how evolution has shaped modern life – from sex, violence, and language to emotions, morals, and communities* where the author assessed that facial expressions are a common ground

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i  Based on a datasheet dated October 2004, for further information refer to the company homepage: [http://www.altoona.it/](http://www.altoona.it/)

ii  The paper has been written for the UNESCO Digital Arts Award 2005 which encourage artists to reflect on the theme of Urbanity and Creative Media
of humans and its importance for the evolution of the human species. These human expressions could be then translated into architectural expressions and therefore humans could create despite their cultural diversity an object informed by their common characteristics. It allows the beholder to find themselves reflected in the building, leading to a negation of the design idea of the façade and therefore the author/architect vanishing behind his/her work - the beholder in fact becomes the person in charge of designing the “temporal events-within form”, an expression used by Stephen Perrella in an article in *AD Architecture and Science* edited by Giuseppa di Cristina. This designed media content is applied in different fields such as a conference paper, competitions and an art installation to test the media content and as well as the designed system in other applications. Project 3 could therefore be seen as a linking project where results gained in Project 1 and 2 are further tested and basic understandings for developments of media content studies are made.

One of the basic outcomes gained from Project 3 was the importance of providing software or codes in order for others to engage with the system, to assist by providing media content and an actual way of feeding input into the system. The discussion of media content is, therefore, structured via two approaches. The one approach, as detailed in Project 3, is by designing media content and the other approach, described in Project 4, is by working as a curator for different media content. Why this second approach? Here my research concentrates on two topics.

- Testing the system on its ability to use data from different sources without being constrained by a discussion of the meaning of media content and its cultural and philosophical explanation. Writing a code for displaying information in the form of an Excel data sheet offers a tool for feeding information of all kind such as sensors. Others can debate the media content as it is beyond the scope of my current research.
- Writing code also offers the possibility of proving some of the propositions made in relation to the significance of the system for architecture. Among my propositions in the theoretical framework has been the task to create an amalgam of form and image, a multilayered surface or a decay function. Even though these propositions are on a
cultural and philosophical level and not fully discussed, my research in Project 4 locates to set itself as a foundation for ways these studies can be continued. Writing a code, on the one hand, suggested that these ideas and proposition can be realized, and, on the other hand, offers myself or other researchers a tool for future studies.

The project work did not require research into background resources. Items from my interest in developing these projects have been studied in the theoretical framework, such as technological input of LED screens. In general my research in the project work is informed by the resources of my previous experiences when working in architecture and as an electrician and designing media facades.


Snoonian, Deborah, P.E., “Digital Practice”, in: Architectural Record, 03/2003 The magazine of the AIA.


Ibid., p. 115

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Burry, Mark C. and Goulthorpe, Mark, Aegis Hyposurface ©: The Bordering of University and Practice; Conference Paper, University at Buffalo, State University of New York, Buffalo, New York, USA October 11-14, 2001.


Massumi, Brian, Transforming Digital Architecture from Virtual to Neuro, An interview with Brian Massumi by Thomas Markussen & Thomas Birch, aka bleep.dk published online at:


63 Massumi, Brian, *Transforming Digital Architecture from Virtual to Neuro*, An interview with Brian Massumi by Thomas Markussen & Thomas Birch, aka bleep.dk published online at:


(accessed November 2006).


71 Massumi, Brian, *Transforming Digital Architecture from Virtual to Neuro*, An interview with Brian Massumi by Thomas Markussen & Thomas Birch, aka bleep.dk published online at:


(accessed November 2006).


**Research questions layout: spatial dynamic media system - Amalgam of form and image to deliver a content-driven zone in real-time through use of a 3D light-point matrix**

<table>
<thead>
<tr>
<th>Question raised in:</th>
<th>Research questions</th>
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| **CHAPTER 1** | Central research question:  
When weaving architecture and electronically applied and managed imagery together, are their respective properties successfully interchanged to the extend that they mutually create a new architectural zone, one that is in constant flux, generated and regenerated through ever changing content? | **spatial dynamic media system - Amalgam of form and image to deliver a content-driven zone in real-time through use of a 3D light-point matrix** |  |
| **CHAPTER 2** | Four questions raised from literature review:  
The question that the historical background of media facades asks, what new kind of media façade development could be envisaged at present and what could be the first steps towards developing such a system?  
When investigating the technology of existing media facades by the means of two locations, Times Square New York and Shibuya Crossing Tokyo, it appears that shifts in the media façade appearance of buildings are caused by shifts in technology of media facades, so what kind of technical development would be expected to push this 'shift of media façade appearance' further?  
A question which rose when researching the technology is that, at present, technology of media facades has reduced architecture and space as a merely the carriers of a sign, how can space reassert itself as the main issue when designing media facades?  
Existing technology does not currently extend the screen to being more than simply a "window into another space" to quote Manovich, what kind of a system would allow content to be more than just a mirror of what is happening within the "window into another space" and rather, be a generator of space itself? | All research questions have been addressed by the development of spatial dynamic media system |  |
| **CHAPTER 4** | | |  |

All research questions have been assessed and tested by project work.
The project work described in Volume Two functions as a test and assessment for points I have raised in my theoretical framework in Volume One. In all chapters background knowledge gained in the theoretical framework has been applied to the project work. My research question investigated the possibility that media facades, as they exist at present, could be developed further into a three dimensional display system where, with the use of a light-point matrix, media content could generate a zone in real-time.

At the outset my research hypotheses around a number of issues including:

- The historical background of media facades raises the question, what new kind of media façade development could be envisaged at present and what could be the first steps towards developing such a system?

- The investigation of the technology of existing media facades through discussing two locations: Times Square New York and Shibuya Crossing Tokyo, suggest that shifts in media façades are caused by shifts in the technology of media facades, rather than through shifts in architecture. What kind of technical development could be expected to further extend this ‘shift of media façade appearance’ and what would be the architectural implications?

- The technology that could support a 3D media façade is about space. At present, the technology of media facades has reduced architecture and space to be merely the supports for a sign. How can space reassert itself as the main issue when designing media facades rather than the image on the planar media façade?
Technology as currently employed in media façades does not extend beyond the attribute of a TV screen – it is no more than simply a ‘window into another space’ to quote Manovich. What kind of a system would allow content to be more than just a mirror of what is happening within the ‘window into another space’ and rather, generate space itself?

The central question has matured into:

*When weaving architecture and electronically applied and managed imagery together, are their respective properties successfully interchanged to the extent that they mutually create a new architectural zone, one that is in constant flux, generated and regenerated through ever changing content?*

The research questions with which I began my journey – speculations on possible extensions of 2D media facades into spatial display elements have been addressed by the development of my *spatial dynamic media system*. This system was then constructed, refined and tested through 4 sequential projects:

- **Project 1: Realisation of system in regards to an industrial design product**
- **Project 2: Applying system**

Project 1 and Project 2 address my research into the technology aspects

- **Project 3: Effect and use – providing a media content**
- **Project 4: Effect and use – Working as a curator for different media contents**

Project 3 and Project 4 address my research into the media content aspects.

My conclusion reflects upon these four projects, which I analyse by raising a series of three issues. Firstly, an evaluation of my research in its two main aspects (Technology and media content). The technology I developed is compared with the development of existing media facades and an evolution of media content is documented as a substantial part of my research. Secondly, I discuss the contribution of developing media facades to the field of enquiry based on my central research question, but also I look at new fields that have been opened up by my research: in seeking to answer these questions I found

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1. I am referring to Manovich, Lev – The Language of New Media, 2001 Massachusetts Institute of Technology, Page 115
2. See reference above
new questions along the way which I comment on. I conclude this final chapter by reflecting on my project work.

How have I evaluated my research?
My evaluation is constructed from my respond to my four initial questions listed on Page 186 - 187, and in particular, my central research enquiry listed on Page 187, avoiding the temptation to speculate too far beyond my stated field of enquiry. I structured these questions in the methodology introduced at the beginning of my thesis.

At this point I want to reflect on the methodology described earlier in this account – first develop a system as an evolution of media facades into a 3D zone, then apply it within an architectural context, and test it by two different forms of media content: a media content designed by myself and different media contents in the form of software ‘applets’ for use by others.

The evaluation of my project based research is divided into two fields which is also the way I have divided my thesis. The first is an evaluation of the technical outcomes and the second is an evaluation of media content outcomes. Both my results and their evaluations have been deeply connected with thoughts and observations made during my background research into the history, technology and the nature of media content in media facades, where a number of questions were raised and answered in my proposed spatial dynamic media system.

In the following section my project work, which was based on my background research is evaluated for its success in an investigation into appropriate technology and media content for 3D media facades.

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[1.2]
Evaluation of Project work - Technology

What part of my research questions was concerned with the technical development of media facades and what methodology did I plan to use to answer these questions?
Part of the central research question raised the issue of is it possible to design an appropriate technology [...weaving architecture and electronically applied and managed imagery together ...] and further to [...create a new architectural zone, one that is in constant flux ...]. The first four questions listed in the bullet points on Page 186 also asked for a technical development of media facades. They particularly questioned whether shifts in the appearance of buildings are caused by shifts in technology. So my research addressed two points: firstly, what kind of technical development would push this ‘shift of appearance’ further? Secondly it asked the question: when media facades push architecture back and space becomes a pure carrier of sign, how could space reassert itself as the main issue when applying media to facades?

In the methodology I proposed the strategy to first develop a system as an evolution of media facades into a 3D zone and then apply this system as a media façade on an existing building or design an object clad with my spatial dynamic media system.

How has my research approached these questions in a technical sense?

At this point the first two projects in Chapter 5 Project work, Project 1 and Project 2 will be evaluated.

My research shows that media façades now have the possibility to not only clad buildings, but be an active component which allows the design of space to occur in real-time. My spatial dynamic media system has been developed using a systematic methodology where each step in the design process had its origin in questions and observations of a previous test. For that reason the design of my LED stick as a single element of the spatial dynamic media façade, has been carefully documented through this research stage. This methodology differs from other systems such as systems by James Clar or TU Delft amongst others which look in a similar direction and which share similar outcomes but without any analysis of how these systems were developed. So far I have not been able to track down publications that explain the methodology of how these other systems have been developed.

Based on my theoretical framework for defining space with light and the alteration of existing LED-based 2D screen technology to a 3D light-point matrix, in Project 1 I developed a methodology where a series of six tests led to the prototype of an LED stick as one component of the spatial dynamic media system. Systematically
developed, each step within the design process had its origin in questions and observations from previous experiments. Within this set-up of tests it was possible to erase difficulties such as mutual occlusion problems that are caused by cables. At this point Project 1: Test Series IV, investigating in how to reduce wiring, did not succeed, but another solution using invisible conducting layers was found. The last test presented in Chapter 5 Project work: Project 1 showed what one LED stick looks whilst being built. My system has been developed to a stage where a prototype could be presented.

For my prototyped system, the LED stick has been twice tested, but only modelled in an architectural environment, once by applying my LED stick on the façade of an existing building in Project 2. The second time by testing the usability of the system when creating a cube completely covered, as it has been done in the VIVOCITY competition in Singapore.

These two tests were important for my research, due to working on a development of existing media facades, where only a test series applying my LED stick could assess that my system can be used as a media façade.

In Project 2 different façade options using my LED stick were tested as well as different scenarios with regard to achieving different resolutions of the spatial dynamic media system caused by openings, such as windows or doors. This lead to an important point that the spatial dynamic media system is assembled from single items, the LED sticks which in my opinion has three advantages:

- Cost control when increasing or decreasing the amount of LED sticks per square metre
- The system allows for openings such as windows on a façade. Images of Shibuya/Tokyo and Times Square/New York show massive screens on buildings running continuously across the buildings façades, which implies that most of the rooms within the building do not have access to daylight. The spatial dynamic media system could

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\[i\] In Project 2 I have applied the LED stick on the façade of building 91 at RMIT city campus

\[\text{ii} \] This has been the case in Project 3 where I designed a media content for my system and at the same time designed a cube covered with LED sticks
both function as a media façade as well as allow openings for rooms behind the façade and access to daylight.

- By arranging the angle of the rode which inhabits the LEDs in relation to the base of the LED stick the system could be applied to a corner situation.

The other main testing of the LED stick was conducted when applying the system in Project 3 in the VIVOCITY competition in Singapore. Even though the cube as such had no internal function, due to its corners being clad with LED sticks they could be tested by applying them in a corner situation. Here the system showed a weak point; external corners could be defined, even where three planes connect with each other, but not internal corners. The spatial dynamic media system reaches its limits in such a situation.

During my research other systems were evaluated particularly in Project 1 [9.4]. In two aspects the spatial dynamic media system differs from these other systems which looked in a similar direction, but were designed for different outcomes. Firstly, my researched system is based in analytical documentation of its development. Secondly, another important difference is the final use of the system. Other systems, such as systems by James Clar or TU Delft amongst others evaluated in Project 1 [9.4] were designed as an art installation or a temporary construction, but not as a system which would find its application in an architectural context as a media façade. Aspects such as vandalism and exchange or replacement of damaged parts were not considered in the design of other 3D display systems, but were so in my design.

[1.3]
Evaluation of Project work – Media content

The media content investigations in Chapter 5 with Project 3 and Project 4 will be evaluated as well based on my central research question and the methodology I proposed to answer the question. The focus of the media content investigation is in after providing a system, successfully developed as a technical exercise, which would then be the vehicle for investigating the possibilities of dynamic 3D media content [...a new architectural zone in constant flux, generated and regenerated through content that never stands still]. The
methodology asked for testing the system by two different forms of media content. A media content which I designed, and different media content in form of software ‘applets’ for others to use. Consequently media content has been developed and designed which acts as a representation for all other possible media content. This designed media content, further explained in Project 3, has been evaluated in three different applications: a conference paper, a competition and an art installation. During these three different applications the media content has not been developed to the extent that one can actually see and experience the media content. A base for further development in this direction has been created by my research, but a full development of a code which could do so has not been undertaken in order to, to limit my research to only one type of media content.

For this reason in Project 4 codes have been written and developed which allow other artists or designers to use the system to express their idea of what media content could generate the zone. My research here could make different codes available for interested artists and designers. The main focus in my research at this point was a program which would allow a translation of a movie clip into a moving surface. The development of the codes furthermore have been used to test the anomalies when developing a zone with the system, such as a multilayered surface and the decay function, and at the same time assessed these propositions through generating, for example, multilayered surfaces.

The designed media content in Project 3 was an exploration in translating human expression into an architectural expression. This media content is one of many possible forms of media content, which I chose to base on the conference paper I submitted for the UNESCO Digital Arts Award Art Center NABI, Seoul South Korea and further explained in Project 3[1]. The theoretical base of this media content provided a relation between the face as a dynamic façade which expresses emotions and the dynamic façade realised with the spatial dynamic media system, which would function as a face and could also express emotion. The content had arguably the ability to demonstrate the potential of the

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1 The conference paper has been submitted for the UNESCO Digital Arts Award in Seoul 2005, the competition has been the VIVOCITY competition in Singapore 2005 and the art installation has been for the ISEA conference in San Diego in 2005.
spatial dynamic media system. Unfortunately the content remained theoretical and could not be realized in the time allocated to this research. A base for further development of media content has been created by my research, but a full development of code which could capture facial emotions and display them with the spatial dynamic media system, for instance has not been developed within the scope of my enquiry.

In Project 4 [4.] a surface movement was generated from the movement captured from a movie clip. Here a new relation between film and architecture was established. The possibility to create a 3D surface based on the shift of colour information per pixel per frame could allow for all kind of media content input based on image or movie. Pre-recorded, live or interactive media content could be fed into the system by an input from a video camera or a pre-recorded movie clip. This test offers a new way of filming movies, when one would shoot films with the main consideration being how the colour information per pixel per frame changes over time.

As a next step in testing the system in Project 4, my research project offers different codes to test the system and to be used potentially by interested artists and designers. The codes written were based on VB scripting language, a computer language I learned during my research. The results were therefore limited to the extent of my new knowledge of scripting. My investigations of the decay function and multilayered surface in Chapter 3 [3.3.] could be tested with two scripts. These two scripts simulated a decay function and a multilayered surface, and are important because they tested the particularities of a 3D media façade.

So far this chapter has evaluated the results of my research. In the following section I discuss the contribution of my research to the field of enquiry.
[2.]
Discussion of my contribution to the field of enquiry

What can be identified as my contribution to the field of enquiry through my research? Based on what I have asked by in my central research questions and methodology I would like to discuss the achievements which have been made in terms of:

- Developing a 3D display system
- An alloplastic mode of operation resulting in an alteration of form and image
- Possible alterations of 3D light-point zone by a media content input
- Further shifts to a communicative space
- Spatial representation of information

In relation to achieving a workable prototype, whilst I was working on my research, unknown to me another group of researchers developed a similar system which will be discussed in the following section. Depending on the media content input injected into my *spatial dynamic media system*, an alteration of the 3D light-point zone is possible which results in surface qualities such as multilayered surface, decay function or privilege perspective. When injecting media content into my system, an amalgam of form and image could be achieved, a topic I discussed when talking about work done by others. Additionally, I discuss how my research has helped to shift space towards a communicative space. According to Puglisi, this process of change started with Centre Pompidou. As a last point I will discuss communicative space with regard to information, which gets represented and communicated through a spatial representation of information.

An architectural discussion of how media facades could be developed into a 3D display

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I am referring to Puglisi, Luigi Prestinenza – Hyperarchitecture - Spaces in the Electronic Age; 1999 Birkhaeuser – publisher for architecture, Basel; The IT Revolution Series
system could emerge from the foundations verbalised in my research, specifically in Chapter 5 Project 1 and Project 2. The spatial dynamic media system has provided a foundational study of how a 3D display system could look when designed as an architectural component and delivered an expertise in the field of media and architecture by offering the framework for a system which would shift the application of a media façade from a 2D plane into a spatial dynamic device.

Parallel to my studies in developing a 3D display system other researchers worked on similar developments. In September 2006 the ETH Zurich opened a three-dimensional colour display in the shape of a 25 cubic meter 3D screen named NOVA\(^1\) at Zurich Central Station for their 150 year anniversary. This 3D display system is very similar to the system I have developed during my research.

\[Fig. 1: \text{Detail picture of NOVA}\]

\[Fig. 2: \text{Rendering of NOVA}\]

\(^1\) For further information please refer to the ETH Zurich homepage were the project gets introduced: [http://www.ethlife.ethz.ch/e/articles/campuslife/novinaug.html](http://www.ethlife.ethz.ch/e/articles/campuslife/novinaug.html)
I see the NOVA system as validating the concepts driving my own system. Questions about the merit of achieving 3D media screens would appear to have been firmly settled. Other researchers from the ETH Zurich see a 3D media façade as valid architectural expression. Both systems try to create a zone made out of light points and allow the zone to be altered in real-time by media content. At the time the system was installed in the Zurich train station in September 2006, my research on Project 1 and Project 2, where I developed the system and applied it on a façade of an existing building, was completed and I had commenced writing my thesis. It was not possible to include any information in my research. In an email exchange with Martina Eberle, the project manager of the NOVA system it was ascertained that no academic papers, articles or other publications were published prior to September 2006. At present the homepage www.horao.biz\(^i\) has published short movie clips about the system which are also publicised on YouTube\(^ii\). My research could possibly help in a discussion of how 3D display systems could be built and designed as a media façade on an external building façade. As Fig. 3 shows also NOVA is installed in an internal projective environment, whereas my system has been designed for external use. This marks a strong point of difference between the two systems. As they are for different functions NOVA does not overlap with my project. As seen in Fig. 1 NOVA connects each light-point with a thin black ‘stick’ which must contain the wiring, one also can notice that there is only one horizontal ‘stick’. With having a system measuring 25 cubic meter or 5

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\(^i\) I have contacted Martina Eberle to get further information in regards publications of the system and she confirmed in an email I have attached at the end of this research that the system has not been published or discussed on conferences before it has been installed in September 2006.

\(^ii\) [http://www.horao.biz/](http://www.horao.biz/) is the homepage which promotes NOVA as a product.

\(^iii\) I refer to movie clips publicised by Horao on YouTube and can be found on: [http://www.youtube.com/user/horaoclips](http://www.youtube.com/user/horaoclips)
* 5 *1 meter one can assume that the black ‘stick’ can not carry the load of a 5 meter long array of LED spheres. NOVA must therefore hang from a ceiling to function, whereas my solution would allow an attachment to a façade, due to using tubes, this renders it more as a large chandelier or light fitting. These tubes with the embedded LEDs (see Fig. 4) also make the system more resistance against environmental influences such as weather condition.

The NOVA system shows what my system could achieve as well’ and it is clear that my system will be a highly effective art environment. In the following section I offer some thoughts for a discussion of what my research system has further achieved.

When discussing work by others in my research domain I have positioned my research as an extension of an interest in architecture towards defining space with an alloplastic mode of operation. All examples discussed in Chapter 3 [2.] also worked on this shift towards designing space, but they either achieved it via dynamic forms or dynamic images - none of them achieved both. My spatial dynamic media system, however, would allow space to be altered by an alloplastic mode of operation resulting in a dynamic zone achieving both – form and image. This created amalgam of form and image allow architectural expression which varies from existing expressions, such as examples of work done by others. For an architectural discussion there is the possibility of achieving new surface qualities which have not yet been explored in architecture.

The development of my system specifically for an architectural use as a media facade has guided my research in thinking about the surface qualities such a system could

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1 The size of NOVA with the measurements 5*5*1 meter has been taken from: [http://www.ethlife.ethz.ch/e/articles/campuslife/novinaug.html](http://www.ethlife.ethz.ch/e/articles/campuslife/novinaug.html)
develop. By surface qualities I am not referring to the visual appearance of the system as such, where a number of LED sticks are attached to a surface and give the building an appearance like a hedgehog, but rather about the spatial qualities of an architectural surface that the activation of this system can achieve. Terms such as “multilayered surface” and “decay function” of a surface are new to architecture. At present the architectural discussion did not include materials which would allow such surface qualities. My research here provides a starting point for this discussion of how to deal with these surfaces and how to treat these surfaces when considering their cultural effect. After gaining access to these new surface qualities I want to discuss possibilities for architecture in applying them. It is clear that my system will be a highly effective art environment, but would it be a useful communication device too?

For Puglisi, Centre Pompidou has been the antecedent for a shift of space to a communicative space.¹ I have discussed the role of Centre Pompidou and the shift towards communicative space at the beginning of the outline of my theoretical framework for my research. The background research addressed again, at a later stage, the role of communication for architecture, when I quoted Anthony Townsend² in Chapter 3 [1.5.2] Townsend talked about architecture mainly neglecting communication and the role of communication up to this date. Communication, till this point when using media facades, has been limited to a 2D screen attached to a building. This attachment of 2D screens as a cladding of architecture has been a criticism of media facades in my research. My spatial dynamic media system has offered a possibility to overcome this two dimensional communication medium by developing a media façade system that could communicate in 3D.

When using a 3D media façade such as my spatial dynamic media system not only is communication through covering buildings with 2D media facades altered into a 3D media façade, but also the way information is communicated is altered. These changes allow architecture to be extended as a spatial representation of information. My spatial dynamic media system is able to display information in real-time in a spatial form and

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¹ I am referring to Puglisi, Luigi Prestinenza – Hyperarchitecture - Spaces in the Electronic Age; 1999 Birkhaeuser – publisher for architecture, Basel; The IT Revolution Series

² I am referring to Townsend, Anthony – Digitally mediated urban space: New lessons for design; Praxis Issue 6 Journal of writing and Building, Praxis inc, Cambridge, MA 2004
allows the display of information with a greater complexity due to the previously discussed new surface qualities. To illustrate this point I want to offer the following examples of information, and how this particular information could be represented by my *spatial dynamic media system*.

- Data and information of any kind, i.e. unemployment rates, temperature to name two examples of change occurring in real-time; they are in a constant flux. This flux could be presented as a spatial representation when using my *spatial dynamic media system*.

- I have provided two examples of information in the previous bullet point; different sets of data can be represented simultaneously, not next to each other, but overlaying each other. Representing the two different data sets as multilayered surfaces allows for displaying the overlaying zones.

- The importance of information can rise and fall in terms of their meaning over time, i.e. the importance of a seasonal data could be greater at the advent of a particular season than in the middle of the season. This can be further stressed when using the decay function of my system.

These three examples show how my 3D media façade could communicate with its environment. Information that otherwise would be invisible could be perceived in our built environment as a part of the spatial impression we receive each day.
[3.] Reflection of project work

My ‘PhD by project’ research combines project work with a written account. This narrative defines the purpose of my research, the factors taken into account in its conception and development, and explains the results of my research. It demonstrates a progression in knowledge and a new understanding in the field of media and architecture. Through a series of projects a prototype could was made, tested in an architectural environment and assessed for two different forms of media content.

The combination between my literature review and project work has helped to achieve background knowledge, which was applied and tested in the project works. My research is the result of tight combination of starting with a project proposal, defining space with light points, constructing, refining and testing this project and, based on the experiences and failures, continuing with the next project. This method continues through my whole research where a test conducted within one of the four projects is bound in a process of testing and learning, before continuing to the next test.

Through my research it has become apparent that a development of a 3D media screen is possible. Thus, my research could be extended in the future by looking in two possible directions. Firstly, a further development of my system to a market ready product, and secondly, further studies on media content. As discussed earlier my system has advantages when being used as an external media façade. The knowledge I gained in developing my prototype could be used for a further development of systems such as NOVA.¹

NOVA also offers the possibility of investigating the anomalies of surfaces in an intangible zone. The option of using NOVA as a future base for testing media content offers more realistic results then testing surfaces in a virtual environment.

¹ NOVA is the name of a 25 cubic meter 3D screen opened in September 2006 the ETH Zurich for their 150 year anniversary.
When reflecting on my research I have discussed the topics and their limits: which topics could not be solved within the scope of my enquiry. Chapter 3 developed an expertise in the field of media and architecture by presenting a framework for a system which would shift the application of a media façade from a 2D plane into a spatial dynamic device. At this point my research could only open up a discussion of what the significance is and outline it in a brief manner. My research does not claim to discuss the significance fully; this would have overextended my research. Nevertheless some of the considerations addressed in the significance for architecture have been taken into consideration in the project work where, for example, a VB code for a multilayered surface or decay of a surface has been programmed. Both projects have been undertaken to test aspects of the hypothesis but not to make an argument for its significance for architecture.

The choice of research method, and the projects applied have been tested successfully to complement 3D media facades by achieving an amalgam of form and image through use of a 3D light-point matrix to deliver a content-driven zone in real-time. By applying my *spatial dynamic media system* future research could open up a discussion are the significance of my system for architecture, outline my research in a brief manner and give other architects, designers, artists and researchers the possibility of basing their research program on my research. In the course of conducting this PhD by project, I have not only gained fundamental knowledge in media and architecture, but I have contributed to the development of a 3D screen which could change the way media content is displayed.
[1.]
Summary Volume One and motivation for project works

The core project within my PhD research has been the development of a system as an extension of existing media facades that allows me to test the representation of information and ideas as ‘form’ within space that is constantly generated and regenerated as a result of fresh input. The hypothesis of my PhD is that this real time reconfiguration of space using light offers a variety of new perceptions ranging from information sharing to public art never experienced previously.

During my research, I have established an extensive body of evidence that points to a growing scholarship around the details and impacts of media façade technological developments and the content displayed on them. In the thesis I define the boundaries of these technology shifts and enhanced content combinations limited to 2 dimensions. In my research I consider the technical and media implications of extending conventional 2D screens which are limited currently to architectural cladding into a 3D matrix thereby causing an alteration to spatial perception through the content animating the 3D matrix.

The central research-question is:

> When weaving architecture and electronically applied and managed imagery together, are their respective properties successfully interchanged to the extent that they mutually create a new architectural zone, one that is in constant flux, generated and regenerated through ever changing content?

In Volume One the thesis so far has been organised into 4 chapters. The background chapter outlines my experience with media and architecture; what questions and motivations have come out of these experiences when working in these fields. The background chapter also summarizes the central hypothesis and the research I have done to define the core research question.
In the next chapter, the introduction chapter an annotated literature review reinforcing the boundaries set in the previous chapter. After providing an annotated bibliography I now want to illustrate the steps made to further investigate the core-research question, the questions raised from the literature review and how the proposition can be proven. Here a description of the structure of the research outlines the methodology of the research.

In this regard, my research will look at the history of media and architecture in order to gain an understanding of the development of media facades. Thus I will analyse the development of different technologies along the way to provide an understanding of existing media facades, where chapter three provides the theoretical framework for my research. Here I discuss the cultural motivation for embedding media within architecture, and introduce the two main interests contained within the research question - designing an appropriate technology [...weaving architecture and electronically applied and managed imagery together ...] as an evolution of media façade technology into a fully spatial representation of content. The discussion of the highly charged issue of content will follow the research of technology; after providing a system which would be the vehicle for investigating the possibilities of dynamic 3D content [...a new architectural zone, one that is in constant flux, generated and regenerated through ever changing content?].

The investigation of these two topics then leads to a theoretical concept of what a system could potentially look like, one which allows the display of information in dynamic 3D. I position my research against work by others in order to at least part-fill the gaps in this field with regard to the relevance to architecture. Chapter 3 concludes by discussing the significance of such a system for architecture and outlines the characteristics of the system.

Chapter 4 concludes with a discussion of results from the research with an evaluation of the research outcome and an indication of where the research could go from here.

With Volume One providing a theoretical framework for my research, the hypothesis is then tested by a series of four projects in Volume Two. I have undertaken these four projects to develop my research hypothesis, and how this knowledge can be applied through a series of tests in developing systems.
To this point my system has been discussed theoretically, without assessing weather the propositions made can be fulfilled by a system that could be built and used. Thus the research will be tested via a series of different projects that answer issues raised in the core-research question, and in statements and propositions made in the theoretical underpinning of the research when analysing existing media facades, keeping in mind the central-research question.

The central research questions will be addressed in Chapter 5 Project work, by firstly how to ‘...weaving architecture and electronically applied and managed imagery together ...’ - here a project should answer if it is actually possible to develop a media facades system able to define space by a 3D light point matrix. The focus of this project is the development of a system, to the level of a prototype in order to test if it is possible to weave together form and image thereby creating space with the use of light points, a claim made at the end of Chapter 3 in Subchapter [1.7.2.]. **Project 1: Realisation of system in regards to an industrial design product** refers to ‘...their respective properties successfully interchanged ...’ where it should possible to test successfully exchange the properties of form, by creating form from 3D light points in space, with the properties of an image, which would also be created by these light points.

The second project, **Project 2: Applying system** will address my aim to ‘...create a new architectural zone ...’ where as in the Project 1 designed system, it is applied in an architectural context to document its function as one which is able to create space. The next two projects will address the issue of ‘...in constant flux, generated and regenerated through content that never stands still? ’ in two different ways. In **Project 3: Effect and use – providing a media content**, a media content will be designed and tested by the author and in **Project 4: Effect and use – working as curator for different media contents**, different media content will be curated by providing a number of different codes which would allow any artist to use the Spatial Dynamic Media System as a form of displaying media content.

Thus the work Chapter 5 Project work describes in will look at two different aspects - an investigation into the actual system as hardware, and how it could be deployed as a media facade as a part of architecture and the second aspect at the software of the system in regards to media content. The first two projects in Chapter 5 deal with hardware, the next two projects in Chapter 5 with software issues.
Project 1: Realisation of system in regards to an industrial design product

[1.]
P1/
Introduction Project 1

The first project, Project 1 is intended to find an answer to the question if space can be defined by light points and if my proposed 3D light point matrix system can actually be built and be recognisable by a participant. This is a key question of the research due to it being the base of all further tests and projects. This project lead to a prototype, called the LED stick, the component that will be used to create a Spatial Dynamic Media System. The Project to realise a system in regards to an industrial design product includes a series of six tests and two research Subchapters on LED technology. They suggest that a conclusion in a prototype based on the previous tests and the research is possible. In the following I want to introduce the series of six tests and two research Subchapters on LED technology.

Test Series I answered the primary question of weather space can be defined by a light point matrix. I made a model in the form of an electrified net with lights attached at the crossing points which I built, tested and filmed. I included waves and other movements in order this to analyse if this moving surface of individual lights could register an effect. Both tests, a static and dynamic surface defined by light-points, had a positive result and therefore provided the impetus for me to develop my research into exploring LED technology in this regard, a technology which was not used for the first test, but became the light source for all my future tests.

This research info LED Technology provides general information about the history and nature of LEDs in order to explain the principle constraints and advantages when using LEDs. Based on this general research of the electronic component of LEDs, more

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1 The explanation of LED technology will stay on a general level to give a broad understanding of how LEDs function. Previous to this research the author has completed a 3 ½ year training course as an electrician in Germany which gave him detailed knowledge of electronic engineering.
specific research was identified investigating the qualities of LEDs regarding their brightness and perception.

In Test Series II, a different type of LED was tested for using a bigger set-up to conduct a series of tests completed in the next test series.

In Test Series III a physical model LEDs were built in a 10 by 10 grid, with each LED in an acrylic tube which provided the armature for the LEDs. The idea of ‘LED sticks’ had its origin in my previous research when the LEDs had to be held in place in order to analyse them, and were therefore embedded into an acrylic substructure. The LEDs were placed in this array of acrylic tubes in such a way that they defined a surface, and this surface created by the light points is now analysed. A test within Test Series III with the model asked: can we perceive a surface created by light points if parts of the lights are potentially obscured by a substructure? For an understanding of the extent of the occlusion created by the armature and the LEDs, a picture of the model with the LEDs in the acrylic tubes was taken, and then one or more LEDs were moved to a new position and another picture taken. With this sequence of pictures a stop motion animation was created to give the viewer a clear understanding of how much of the surface defined by light points could be perceived. This stop motion animation has been made from one fixed position only. The next research test within Test Series III using the model asked: from which angles/positions can the beholder see the full surface (all lights) or can see at least enough lights to understand the form or shape of the surface? Here pictures of the model were taken from different points and analysed. Both trials with the model revealed a problem of masking or occlusion of the LEDs or the substructure. The following solutions for these problems were tested with to develop the LED stick further:

- Using a water-clear LED as it has happened in further models or when using SMD LED Technology as a preferred system for the prototype.
- Arranging more than one SMD LED at each node to create a light point.

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The term ‘LED stick’ will be used in further texts for a single component of the spatial dynamic media system and should also be the final result of this research chapter, where a prototype of an array of LEDs embedded in an acrylic stick should be developed.

SMD stands for Surface Mounted Device, a technology explained further in Project 1: Chapter [5.6.2.]
Not only do the LEDs cause masking but also the cables required for the LEDs are a main source of masking, and this could be improved with conducted layers\(^1\), a technology applied in other applications.

Lastly the LEDs should be placed in small chambers instead of tubes to define a clearer light point.

In Research LED Technology Part 2 based on these improvement options more research was required into LED technology, to answer more specific questions about LEDs and their power consumption. The general power consumption of LEDs is explained later, and the energy consumption of the model was introduced to the Test Series III; how much energy a façade will use when built? These figures were then compared with other electronic applications to gain an understanding of how much energy the façade uses in relation to other products.

The occlusion caused by wiring is a topic within Test Series IV which considered possible options for reducing wiring. Here a model with 12 LEDs was wired with 4 cables and depending on which cable is connected to the positive pole and which is connected to the negative pole of the energy source, a different LED is switched on. It was not possible to improve the system with this step and in the account in Test Series IV I explain why this is the case. Masking caused by wiring could however, be reduced by the previously mentioned technology of conducted layers.

Lastly, I reflect on the tubes being an obstruction to the viewers and their comprehension of the image is investigated in Test Series V.

This test leads into Test Series VI where a designed product based on the previous Test Series I – V was built. This product, the ‘LED stick’, was the result of several considerations and tests documented in the research of Project 1. The LED stick is completed when considering how it could be mounted onto a surface when applied in architecture. Issues like exchanging a faulty LED stick while mounted on a façade or

\(^1\) Light sources are supplied with power through a PVB laminated glass capable of conducting electricity. A transparent conductive glass base is joined together with a polyvinyl butyral flat glass laminate and a cover glass. Further information at: http://www.schott.com/architecture/english/lightsolutions/powerkontakt.html?PHPSESSID=91
how a corner is to be defined with LED sticks played a role in the furthering the design of my prototype. In designing a product based on the above tests I compare the LED stick with the other systems that I discovered during the research, which are able to display media content with a 3D light point matrix. The 3D display systems offered by artists, engineers and designer including James Clar, the electro engineering department TU Delft, Network Wizards and Stephen W. Boyer, are based mainly on the idea of them being used as a temporary installation or as indoor artwork but never actually applied in architecture as a façade system. Having researched the background of media façades in architecture I intend to show that the system could be applied within architecture, and therefore Project 2 tests the application of the system in a built environment.
Test Series I: Defining space with light points

Is it possible to define space with light? This question is essential when designing a system where a surface or a form is generated by light points. Subchapter 1.7.2 in Chapter 3 gave an understanding of the theoretical context that it is possible to define space with light, but none of the indexed examples actually deal with a moving surface generated by light points. All examples had been built objects illuminated through their windows at night time, but never a surface only defined by light points. The first test in a series of tests should therefore answer this question.

Research with model

The model has been constructed in a simple way, similar to a common fabric which is flexible and could be moved - an array of lights should be attached to a fishing net with a distance from light point to light point of approximately 10 cm. The fishing net substructure has been chosen to simulate lights floating in space, for if they were attached to a fabric it would not have been clear if the fabric defines the space or if the light points do. Firstly the net should remain still (unmoving) to investigate if a clear surface could be perceived with light points only. Secondly the surface should move to see if the person viewing (the beholder) could recognise a moving surface defined by light points, and thirdly a person should move in front of the surface. The last test should investigate the possibility of having low resolution images displayed on a surface. The light points used in the model are a common Christmas decoration available at any department store. They have been altered from their linear arrangement into a grid arrangement to allow a surface defined by light points with a distance 10 cm from each other. Due to the alteration of the Christmas lights it was not possible to achieve an exact distance of 10 cm from one light point to another. The differences in distance were nevertheless minimal and did not affect my research result.
The following pictures show the setup of the model. The pictures show blue lights being used due to the availability of blue lights rather than this colour being my preference. Later models and tests will show that the focus when choosing a colour leans towards all colour combinations possible by mixing red, blue and green.

**Fig. 1:** Front view of set up of net with attached Christmas lights, a model which proved the possibility to define dynamic space with light points

**Fig. 2:** Detail view of the same model from the side, the model could not provide a clear grid at the edges

**Fig. 3:** Where as in the center a grid could be established
My research discusses a dynamic zone, images that have shown surfaces or spaces defined by static lights, as discussed in the Chapter 3 [1.7.2] when mentioning New
York during a power failure or the Lichterdom design in the mid 1930s in Nuremberg. When talking about a dynamic zone the possibilities of perceiving a dynamic zone generated by light points should be investigated. Therefore the model should be physically moved to simulate a dynamic light point matrix. This movement should then be filmed to provide an understanding of if it is possible to perceive a dynamic zone generated by light points. The following five images illustrate what has been investigated with the movie. For further information see the title bar of the following movie stills.

Fig. 6: stills from movie clip, this scene shows the front view
Fig. 7: stills from movie clip with person dancing to test possibilities of displaying image

Fig. 8: stills filmed from an angle
Fig. 9: filmed from other side

Fig. 10: Detailed view of the surface generated by light points
[2.3]
Conclusion

The model has proven the first step: it is possible to define space with light points. Furthermore a moving surface could be recognized when perceiving the surface from different angles. Even though these angles have not been specified and the camera has moved randomly through space to capture different views it has been proven that a movement of a surface is readable for the beholder. The next steps will work on the actual light source, due to the use of Christmas lights in this test. The question of mapping one light by others will also be of importance as will an investigation in the differing brightness of LEDs. LEDs will be the source of light used in further tests and they will be briefly introduced in the next chapter.
When designing an industrial product as a result of a number of tests, an understanding of the constraints and the possibilities of the material used is mandatory. Therefore this chapter will investigate the technical aspects of the materials in use. The main focus should be LED technologies. Interests here are how LEDs actually produce light, how different light can be produced, how this leads to the development of RGB LEDs and if there are any other developments that could function as LEDs.

This chapter will be a foundation study of future tests and will illustrate the function of an LED to audience which have no background knowledge in electronics and electronic components.

Even when using small light bulbs in the conducted test, a word about LEDs should be said before starting with my research. This is due to the later use of LEDs and due to the possibilities they offer they should also be used for the designed product, which is a result of these conducted test series. A light-emitting diode (LED) is a semiconductor device that emits incoherent narrow-spectrum light when electrically biased in the forward direction. This effect is a form of electroluminescence. The color of the emitted light depends on the chemical composition of the semiconducting material used, and can be near-ultraviolet, visible or infrared. Rubin Braunstein of the Radio Corporation of America first reported on infrared emission from GaAs and other semiconductor alloys in 1955. Nick Holonyak Jr. of the General Electric Company developed the first practical visible-spectrum LED in 1962.\textsuperscript{i}

\textsuperscript{i} For further information about historical background LEDs please refer to following books: Horowitz, Paul and Hill, Winfield – The Arts of electronics, Cambridge University Press 1997
Lurch, E. Norman – Fundamentals of electronics, John Wiley and Sons, Inc. 1971
Or a source in German which I have used for this research:
LEDs are tiny light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs, they do not have a string that will burn out, and they do not get especially hot. They are illuminated solely by the movement of electrons in a semiconductor material.

I want to continue and explain the basic principles of a LED. My research does not continue any development of the product LED as such, and therefore a more general explanation can be used, which I have assembled for different sources stated in the footnotes and from my experience as an electrician.

A diode is the simplest sort of semiconductor device. Broadly speaking, a semiconductor is a material with a varying ability to conduct electrical current. Most semiconductors are made of a poor conductor that has had impurities (atoms of another material) added to it.

The illustrations will help to explain briefly what happens inside an LED and how the interaction between electrons and holes generates light.

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Gossner, Stephan – Grundlagen der Elektronik – Halbleiter, Bauelemente und Schaltungen (Schulbuch), Shaker Verlag GmbH 1992
**Fig. 14:** At the junction, free electrons from the N-type material fill holes from the P-type material. This creates an insulating layer in the middle of the diode called the depletion zone.

**Fig. 15:** When the negative end of the circuit is hooked up to the N-type layer and the positive end is hooked up to P-type layer, electrons and holes start moving and the depletion zone disappears.

**Fig. 16:** When the positive end of the circuit is hooked up to the N-type layer and the negative end is hooked up to the P-type layer, free electrons collect on one end of the diode and holes collect on the other. The depletion zone gets bigger.
Visible light-emitting diodes (VLEDs), such as the ones that light up numbers in a digital clock, are made of materials characterized by a wider gap between the conduction band and the lower orbitals. The size of the gap determines the frequency of the photon or in other words, it determines the colour of the light. While all diodes release light, most do not do it very effectively. In an ordinary diode, the semiconductor material itself ends up absorbing a lot of the light energy. LEDs are specially constructed to release a large number of photons outward. Additionally, they are housed in a plastic bulb that concentrates the light in a particular direction. As one can see in the diagram, most of the light from the diode bounces off the sides of the bulb, travelling on through the rounded end.
This general explanation gives a brief understanding into how light is produced in a LED, but how can different light colours be produced to allow a coloured image? LED developments began with infrared and red devices made with gallium arsenide. Advances in materials science have made possible the production of devices with ever shorter wavelengths, producing light in a variety of colors. Conventional LEDs are made from a variety of inorganic semiconductor materials, producing the following colors:

- aluminum gallium arsenide (AlGaAs) - red and infrared
- aluminum gallium phosphide (AlGaP) – green
- aluminum gallium indium phosphide (AlGaInP) - high-brightness orange-red, orange, yellow, and green
- gallium arsenide phosphide (GaAsP) - red, orange-red, orange, and yellow
- gallium phosphide (GaP) - red, yellow and green
- gallium nitride (GaN) - green, pure green (or emerald green), and blue
- indium gallium nitride (InGaN) - near ultraviolet, bluish-green and blue
- silicon carbide (SiC) as substrate – blue
- silicon (Si) as substrate - blue (under development)
- sapphire (Al₂O₃) as substrate – blue
- zinc selenide (ZnSe) – blue
- diamond (C) – ultraviolet

**Fig. 19:** Inside a light emitting diode, the colour of the cap is not responsible for the colour of the light
aluminum nitride (AlN), aluminum gallium nitride (AlGaN) - near to far ultraviolet

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**[3.2.2]**

**RGB LEDs**

RGB LEDs work on the same principles, the main difference here is that three crystals are imbedded in one plastic bulb. Therefore each of the three crystals needs either a common anode or a common cathode. *(See Fig. 20 and Fig. 21)*

*Fig. 20: Common Cathode, where the minus pole is the common pole*

*Fig. 21: Common Anode, where the plus pole is the common pole*

It does not create any difference if one uses an LED with a common Anode or Cathode in regards to colours.
Fig. 22: Comparison LED (top) and RGB LED (bottom), one pole for anode or cathode and the others for the colour

Fig. 23: Tri colour spectrum

The light created in the above shown example gets produced with (AlGalpn) for red, (GaInN/GaN) for green and (GaN) for blue.

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[3.2.3]

OLEDs

A new technology is OLED technology, an organic light-emitting diode (OLED) is a thin-film light-emitting diode (LED) in which the emissive layer is an organic compound. OLED technology is intended primarily as picture elements in practical display devices. These devices promise to be much less costly to fabricate than traditional LCD displays. When the emissive electroluminescent layer is polymeric, varying amounts of OLEDs can be deposited in rows and columns on a screen using simple ‘printing’ methods to create a graphical colour display, for use as television screens, computer displays, portable system screens, and in advertising and information board applications. OLED may also be used in lighting devices. OLEDs are available as distributed sources while the inorganic LEDs are point sources of light. Prior to

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Further explanation of the OLED technology can be found on a homepage from an internet community for the newest Display Technology OLED/Pld, [http://www.oled-display.net/oledinfo.htm](http://www.oled-display.net/oledinfo.htm). This home page keeps one updated with the development of this product and stands in close relation to the Fraunhofer Institute/ Germany.
standardization, OLED technology was also referred to as OEL or Organic Electro-Luminescence.

One of the great benefits of an OLED display over the traditional LCD displays is that OLEDs do not require a backlight to function. This means that they draw far less power and, when powered from a battery, can operate longer on the same charge.
A research model has been built to test the façade. This model contains 9 LEDs in a row with the main focus on the last LED and how much of the light transmitted from this last LED can be seen when covered by the LEDs in front of it. The distance between each LED is 10 cm with the LEDs 10 cm from the edge of the board. Each LED is in a clear acrylic tube with an inner diameter of 5 mm and an outer diameter of 8.5 mm. This acrylic tube will function as a structural element to hold the LEDs in place and protect the system from factors such as weather conditions.

Test set up:
In order to compare the LEDs and determine which are best for the façade, a table with the following columns should be introduced:

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
</table>

After building the model the first test series was performed with an unspecified LED. The results show that this type of LED is not efficient enough to be seen in a side view.

To gain more accurate results LEDs with the following parameters will be tested and compared with each other.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED</td>
<td>Red</td>
<td>-</td>
<td>NO</td>
<td>-</td>
</tr>
</tbody>
</table>
Following pictures document my research outcome.

**Fig. 24:** unspecified LED, with no information of brightness or angle

With this LED type the system would not work, there is hardly any light visible, but it can be seen that most of the light is transmitted to the front and not to the side. When looking at applications for this kind of LED, most of them require light in a small viewing angle, this has its background due to be built in e.g. a Computer screen to show that the screen is on or off.

Further sequences have been shot: picture series 1 in a movement upwards and in picture series 2 from a position side view to a 45° angle.
Fig. 27: Movement upwards picture first position of set up

Fig. 28: Second position in set up

Fig. 29: Third position in set up

Fig. 30: LED light is only visible when not masked by other rods.
Fig. 31: The same set up has been tested with a movement vertical

Fig. 32: Second position, light is not clearly visible

Fig. 33: LED becomes more visible

Fig. 34: From now on no masking of other rods exist, therefore LED light clearly visible
[4.2.2] Model One B:

To show the difference between an LED with and without a reflector an old bicycle light has been photographed without the reflector (See Fig.36) and with the reflector (See Fig.37).
To improve the result a reflector has been built. The use of reflectors to improve the brightness of light sources can been found in the front and back lights of cars as well as in the lights for bicycles. The bicycle lamp shown above has been used and altered (See Fig.46 and Fig. 47) to increase the brightness of the LED. Even this ‘home made’ reflector shows the potential improvement of brightness.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED</td>
<td>Red</td>
<td>-</td>
<td>YES</td>
<td>-</td>
</tr>
</tbody>
</table>

*Fig. 38: unspecified LED used in the first test set up*

*Fig. 39: self constructed reflector; side view to cover LED*
Following pictures document my research outcome.

Even only a minimal improvement can be seen, it shows a tendency to a better result, with the help of a reflector around the LED.

[4.2.4] Model Three

The set-up stays the same: the LED used in tests ONE and TWO has been replaced with water clear LED (See Fig. 42 and table Fig. 43).

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear</td>
<td>Red</td>
<td>-</td>
<td>NO</td>
<td>-</td>
</tr>
</tbody>
</table>
Fig. 42: Water clear LED, as well not specified in brightness and angle

Following pictures document my research outcome.

Fig. 43: stronger glow, mainly seen in reflection

An improvement can be seen in using another lamp. The light is mainly seen in the reflection on the below surface.

----------------------------------------------------------------------------------------------------------

[4.2.5]
Model Four

The set up stays the same: the LED used in tests three plus the reflector introduced in test two.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear</td>
<td>Red</td>
<td>-</td>
<td>YES</td>
<td>-</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.
The light gets a focus through the reflector.

[4.2.6]
Model Five – Nine

The set up stays the same: the unspecified LED used in previous tests has been replaced with LEDs with Data provided by JAYCAR ELECTRONICS 2004. The Data sheets are attached at Chapter 6 Appendix: Appendix 2 – Tables.

For following four tests: LEDs will be used, chosen for their brightness and the view angle. The name in the brackets is the product name used by JAYCAR for these LEDs and has been used as well for specifying them in the test. For further information see data table attached at Chapter 6 Appendix: Appendix 2 – Tables.
LED used as explained in Data table.

**[4.2.7]**
Model Five

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-0152)</td>
<td>Red</td>
<td>500</td>
<td>NO</td>
<td>30</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.

![Fig. 46: nearly no glow](image)

The unspecified LEDs used in the tests before must have been a higher value than 500 mcd.

---

**[4.2.8]**
Model Five B

Same LED has been used this time with the introduced reflector.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-0152)</td>
<td>Red</td>
<td>500</td>
<td>YES</td>
<td>30</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.
Due to the use of a reflector an improvement could be seen, but the LED is still to dark.

---

LED used as explained in Data table.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-0154)</td>
<td>Red</td>
<td>4000</td>
<td>NO</td>
<td>15</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.

**Fig. 48:** The light glow is stronger due to an increased brightness (from 500mcd to 4000mcd)

Light is brighter due to using a 4000 mcd LED.
Same LED has been used this time with the introduced reflector.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-0154)</td>
<td>Red</td>
<td>4000</td>
<td>YES</td>
<td>15</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.

![Fig. 49: again in the center a stronger concentration of light, but not much difference with or without reflector](image)

The brightness definitely plays an important factor how the light will be received.

LED used as explained in Data table.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-0156)</td>
<td>Red</td>
<td>10000</td>
<td>NO</td>
<td>15</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.
Even with more then double the brightness (from 4000 mcd to 10000 mcd) improvements are not visible.

---

[4.2.12]
Model Seven B

Same LED has been used this time with the introduced reflector.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-0156)</td>
<td>Red</td>
<td>10000</td>
<td>YES</td>
<td>15</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.

![Fig. 51: Same LED this time with Reflector](image)

As happened before light gets denser in the center.
LED used as explained in Data table.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-1790)</td>
<td>Red</td>
<td>20000</td>
<td>NO</td>
<td>-</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.

![Figure 52: Again increase of brightness caused by using a 20000mcd LED](image)

As to be expected, with the double brightness from 10000 mcd to 20000 mcd the light got brighter.

Same LED has been used this time with the introduced reflector.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-1790)</td>
<td>Red</td>
<td>20000</td>
<td>YES</td>
<td>-</td>
</tr>
</tbody>
</table>
Following pictures document my research outcome.

**Fig. 53:** Increase of brightness when using a reflector

Same result as with the other LED’s when using a reflector.

---

**[4.2.15]**

Model Nine

LED used as explained in Data table.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangle 5x2mm</td>
<td>Red</td>
<td>15</td>
<td>NO</td>
<td>180</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.

**Fig. 54:** Greater Angle do not increase brightness, on the other hand the brightness have been only 15 mcd, compared with 20000mcd in Fig.53.
The lack of brightness (15 mcd) could not compensate for the improvement of the view angle to 180°.

[4.2.16] Model Nine B

Same LED has been used this time with the introduced reflector.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectangle 5x2mm</td>
<td>Red</td>
<td>15</td>
<td>YES</td>
<td>180</td>
</tr>
</tbody>
</table>

Following pictures document my research outcome.

![Image](image.png)

*Fig. 55: Greater Angle do not increase brightness even when using a reflector*

The reflector could not compensate for the lack of brightness.
A research model has been built to test the façade. The model will demonstrate in a model scale what a full size façade could do when attached to a building or as a space defining object. This mock-up is also important to test if the proposed system allows for seeing a surface defined by lights with the constraints of having a substructure to hold the LEDs in place and protect them from the environment.

Having modelled so far a surface only in a virtual environment where the light points, representative of the proposed LEDs, have not been masked by the substructure, this test will therefore examine the following questions:

- Can a surface created by light points be perceived if parts of the lights are masked by a substructure?
- From which angles / positions can the beholder see the full surface (all lights) or can see enough lights to understand the form or shape of the surface?
- How much masking is caused by the substructure and how much is caused by the LEDs as such and are there any potentials of improving the set up to eliminate these problems?

This model contains a grid of 10 x 10 LEDs with a distance of 5 cm to all three axes allowing a display volume of 50x50x50 cm in total. Each LED is in a clear acrylic tube with an inner diameter of 6mm and an outer diameter of 9.5 mm with a length per stick of 55 cm. This acrylic tube will function as a structural element to hold the LEDs in place and protect the system from weather conditions and similar. The LED has been chosen regarding my research results in the previous Chapter [4.]. In this research an
LED with 10,000 mcd has been bright enough to provide the necessary illumination and definition of a point on a surface. The reflector introduced in the before mentioned research series has not been used again. As a first step in answering one of the three above mentioned research questions a water-clear LED has been used. The advantage of this will be a minor masking of light through a transparent product. This will be an improvement achievable within the conditions of building a model in a student environment. Other improvement possibilities would be the introduction of SMD LED technology further described in Subchapter 6.2.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Brightness in MCD (mille candela)</th>
<th>Reflector</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-0156)</td>
<td>Red</td>
<td>10000</td>
<td>NO</td>
<td>15</td>
</tr>
</tbody>
</table>

**Fig. 56:** LED Water clear red 10000mcd used for the following tests

The model has been made in a similar way to the model in my research test earlier, to create a similar outcome. Major alteration has been done to the colour of the model, i.e. painting the model in matt black to avoid a reflection of the surface, an occurrence that has happened with the earlier model.

**Fig. 57:** 3D model of test set up used for tests in this series
Fig. 58: 3D model of test set up viewed from a different position

[5.2.2] Plans model

Plans of the model set up are attached at the Chapter 6 Appendix 1 – Plans at the end of Volume Two.

[5.3] Defining surface

To compare a surface generated with LEDs with a planar surface a surface has been drawn in Rhino as a comparison. The form of the surface has been chosen to test following points:

- Depth - can a depth in a surface be perceived
- Multilayered surface - to see two surfaces at the same time and how this can be read and perceived by the beholder.
- Three dimensionality - the main subject of this research is to see how a 3D surface can be built by light therefore a plane surface only would not fulfill the interest of my research.

To fulfill the above mentioned points a surface in a cube with the dimension 50x50x50 cm has been generated.
This surface has been divided with 5x5x5 grid lines regarding the resolution of the LED arrangement.
The surface has been remodelled to a small extent to guarantee that an LED is actually located in its position within the 5x5x5 grid. This method is similar to the one when the surface would have been transformed with the use of a script into a point cloud. This method will be explained in greater detail in a following essay.
Even if the points in the above pictures do not clearly define a surface, visibility will improve if the points are glowing light sources. This can be seen in a preliminary render where the points have been transformed into light sources to give a better understanding of the final result.

Following pictures show the model built, as detailed in Chapter [5.2.2] from different positions.
Fig. 69: Front view of the actual built physical model

Fig. 70: Perspective view of model LEDs not yet in position

Fig. 71: Top view of model in the Photo lab where the test series happened

Fig. 72: Connection LED on the backside of the model with the designed electric circuit
When switching on the LEDs that have been positioned in the way described in Chapter 3, the following result could be achieved:

Due to the reflective attributes of the acrylic tubes light points could not be perceived. This happened due to the direction of the viewing angle of the LED that sends out the light away from the LED in a 20° angle and therefore illuminates the acrylic tube. This can be seen in a detail in the next picture, where the LEDs have been moved to shape an undefined surface.
Conclusion for my research question; Can a surface, created by light points, be perceived if parts of the lights are masked by a substructure? :

With not having single light points but instead an illuminated linear element, the glowing acrylic tube, a surface could not be perceived. This has not happened because the tubes mask the light points, the model have been not able to answer this question, because the lights points could not be produced. This can be seen in the following chapter where several pictures have been taken to create a stand motion animation.

To test the differences of a moving surface to a picture, a sequence of pictures has been taken. In each picture one or more LEDs have been moved from its original position to a new position to create a stand motion animation.

This technique has been used in the past in creating special FX, for example in science fiction movies. Due to having only ‘one layer’ of LEDs, this method enables creating a moving surface without having many LEDs.

The sequence contains 18 pictures and runs from the left to the right, top to bottom.
As explained earlier in Subchapter [4.2] a surface could not be perceived, this can be seen in particular in picture 39, where only an array of illuminated sticks can be seen.
Even if the tests in the previous chapter failed, research question 2 should still be conducted, to prove if a result could be achieved.

Here the model was placed on a rotating plate, known as ‘lazy Susan’ in Chinese restaurants to rotate food so people sitting around the table can equally reach the food. With this system the model could be rotated without changing its position regarding the fixed camera position. The model will rotate from a position facing the camera in 15° steps rotated anticlockwise to position 90° from its original position. The camera will be placed on a tripod in three different positions. First, in a height 1.20 metres above ground and therefore in the center of the model with a camera angle of 0°. In the second test series the camera will be at a height of 1.50 m above ground with a camera angle of 10° towards the ground. Finally in a height of 1.80 m above ground with a camera angle of 20° towards ground. The plans of the set up are attached at Chapter 6 Appendix: Appendix 1 – Plans.

Series 1: Camera at 1.20 m and an angle of 0° (See Fig. 76 - Fig. 82)

Fig. 76: 0° angle
Fig. 77: 15° angle

Fig. 78: 30° angle

Fig. 79: 45° angle

Fig. 80: 60° angle
Fig. 81: 75° angle

Fig. 82: 90° angle

Series 2: Camera at 1.50 m and an angle of 10° downwards (See Fig. 83 – Fig. 89)

Fig. 83: 0° angle

Fig. 84: 15° angle
Fig. 85: 30° angle

Fig. 86: 45° angle

Fig. 87: 60° angle

Fig. 88: 75° angle
Series 3: Camera at 1.80 m and an angle of 20° downwards (See Fig. 90 – Fig. 96)
[5.2.2] Comment

In the first two series with a parallel view to the surface, due to the position and the angle of the camera, no clear surface could be seen. This is again a result of the unwanted illumination of the acrylic tubes. In series 3 with a higher position and a
camera angle of 20°, more of a surface could be seen, especially in pictures (Fig. 95 – Fig.96). Here the illumination of the sticks becomes not as visible as in the images before. When enlarging Fig. 104 a square in a much distorted position can been seen, enlargement can be found in Chapter 6 Appendix: Appendix 3 – Images.

Fig. 97: Specifying of Square to be seen in Picture

The line defined by the LEDs in the back of the square is a line one can see masked by 9 rows of acrylic tubes.

[5.6] Conclusion of research with Model Test A and B

The general conclusion after executing several tests is, that the surface could not be perceived in a way it has been imagined when creating a virtual images. The main reason for this is the illumination of the acrylic tubes, which start glowing from the point of the light source till the end of the tube. This phenomenon could be mainly seen when the angle and the position of the camera have been in favour of this phenomena, e.g. when both parameters (angle/position) allow a full view of the illuminated stick.

If these two parameters have been altered towards the specified location a surface could be recognised. A masking problem could be still an issue once the problem of the glowing acrylic tubes is solved. Therefore, in the following chapter I firstly want to discuss further steps of how a masking could be avoided and reduced and then offer a solution as to how the problem of the glowing tube could be solved.
Two items could cause a masking of light points within the system: a masking by other LEDs and/or a masking caused by the substructure.

Firstly I want to discuss improvements when using different types or different arrangements of LEDs.

When using LEDs to display several things in one colour, e.g. red, the colour of the light is not defined by the resin bulb, but typically by a conductor material such as aluminium-gallium-arsenide. The interaction between electrons and holes in this material generates light. The colour of the light depends on the size of the gap between conduction band and lower orbitals, due to the size of the gap determining the frequency of the photon.

As an addition, they are housed in a plastic bulb that concentrates the light in a particular direction.

Modern LEDs are also available with a water-clear head and therefore a masking of other light points can be reduced. This has been done when building the model where 5 mm LED water clear (ZD-0156) has been used (See picture Fig. 99).
With the use of a water-clear LED a simple but effective improvement could be achieved. These must be used in a final set up anyway, due to using RGB LEDs that produce a whole spectrum of light colours and therefore have to have a water-clear bulb.

Surface mount technology (SMT) is a method for constructing electronic circuits in which the components are mounted directly onto the surface of printed circuit boards (PCBs). Electronic devices so made are called surface-mount devices or SMDs. In the industry it has largely replaced the previous construction method of fitting components with wire leads into holes in the circuit board (also called through-hole technology). Components were mechanically redesigned to have small metal tabs or end caps that could be directly soldered to the surface of the PCB. Components became much smaller and component placement on both sides of the board became far more common with surface-mounting than through-hole mounting, allowing much higher circuit densities.

Where components are to be placed, the printed circuit board has flat, usually tin-plated copper pads without holes, called solder pads. Solder paste, a sticky mixture of flux and tiny solder particles, is first applied to all the solder pads with a stainless steel stencil. If components are to be mounted on the second side, a numerically controlled (NC) machine places small liquid adhesive dots at the locations of all second-side components. The boards then proceed to the pick-and-place machines, where they are
placed on a conveyor belt. Small SMDs are usually delivered to the production line on paper or plastic tapes wound on reels. Integrated circuits are typically delivered stacked in static-free plastic tubes or trays. NC pick-and-place machines remove the parts from the reels or tubes and place them on the PCB. Second-side components are placed first, and the adhesive dots are quickly cured with application of low heat or ultraviolet radiation. The boards are flipped over and first-side components are placed by additional NC machines.

The boards are then conveyed into the reflow soldering oven. They first enter a pre-heat zone, where the temperature of the board and all the components is gradually, uniformly raised. The boards then enter a zone where the temperature is high enough to melt the solder particles in the solder paste, bonding the component leads to the pads on the circuit board. The surface tension of the molten solder helps keep the components in place, and if the solder pad geometries are correctly designed, surface tension automatically aligns the components on their pads.

After soldering, the boards are washed to remove flux residue and any stray solder balls that could short out closely spaced component leads. Rosin flux is removed with fluorocarbon solvents, high flash point hydrocarbon solvents, or limonene, derived from orange peels. Water soluble fluxes are removed with deionized water and detergent, followed by an air blast to quickly remove residual water. Where aesthetics are unimportant, non-corrosive flux residues are sometimes left on the boards, saving the cost of this processing step and eliminating a waste disposal issue.

The above mentioned assembly techniques proves that the possibility of soldering this technology in a student lab environment is difficult, but it would be never the less possible to achieve a major improvement of reducing the size of the LEDs and therefore avoid the masking of light point through LEDs. Following pictures published on homepage www.ledmuseum.home.att.net shows the scale improvements regarding a 5 mm water-clear LED used in the executed test.
The photograph on the left shows the illuminated LED and the one on the right shows it compared in size to a 5mm through-hole LED.

The picture above shows the possibilities of the introduced SMD technology and the problem of a LED masking the light point becomes obsolete if the light source is an SMD LED.

The size of these SMD LEDs can be reduced to a pin head size. The above mentioned homepage shows the following images and gives the following information about a 470nm blue SMD (0603) by International Systems Processing (ISP Korea).
This miniscule LED measures 800 microns wide by 1,000 microns long. It uses traditional InGaN on artificial sapphire technology, so it should be very bright for its size.

Here are the specs published on the homepage www.ledmuseum.home.att.net:

Forward voltage: 3.6 volts typical, 4.5 volts max.
Forward current: 30mA continuous maximum, 100mA pulsed maximum
Luminous intensity: 55mcd typical (remember, wider view angles mean lower mcd numbers)
Viewing angle: 120°
Spectral line half width: 20nm
Dominant wavelength: 470nm Size specifications (SMD 0603)
Length: 1.6mm
Width: 0.8mm
Height: 0.8mm
Solder pads: 0.4mm x 0.7mm
Spacing between solder pads: 0.8mm

The following pictures show the LED when switched on and its illumination as well as pictures taken of the model in Subchapter [4.] when using a 5mm LED water-clear (ZD-0152) with 500 mcd / 20° and a Rectangle 5x2mm LED (ZD-0234) with 15mcd and 180°.

*Fig. 105: Photo of a SMD LED taken with flash*

*Fig. 106: Photo of same SMD LED this time taken without flash*
The introduced SMD Technology allows an improvement in reduction of the masking of LEDs. This improvement has been mainly achieved through its small size. Even if, as shown with the last pictures, the brightness of 55mcd is not bright enough for the required purpose, an array of several of those LEDs could produce the demanded brightness, if this product should be used. But the main purpose of introducing the LED by IPS Korea has been to show to which size SMD LEDs can be produced. With a slightly 'bigger' LED and a smaller viewing angle the brightness could be higher and therefore the aimed 10,000 mcd achieved.

With SMD LEDs only several millimetres in size, the possibility of using more than one LED to create one light point exists. This also will be an important factor when
considering the viewing angle of an LED. In the table of the previously written essay I introduced several LEDs where the ones with a higher brightness were also the ones with a small viewing angle. As mentioned in the data table of the LED by IPS Korea, there is a relationship between the brightness and the viewing angle. The following quote explains the relation.

“Viewing angle is one of the most confusing terms regarding electronic LED signs. Most people and manufacturers assume that the viewing angle is the angle at which you can view an electronic display. In reality, viewing angle is related to brightness. The LED industry defines viewing angle as the full angle at which brightness is half of the brightness from dead center. More scientifically, if \( \theta \) (angle theta) is the angle from off center (0°) where the LED's brightness is half, then \( 2\theta \) is defined as the full viewing angle, as represented by Figure 75 below. The entire yellow portion represents a 70° viewing angle, while the orange portion represents a 90° viewing angle.

![Fig. 109: LED Viewing angle as a diagram](image)

![Fig. 110: Example brightness based on a 70°viewing angle](image)

Figure 76 illustrates how brightness is influenced by a viewing angle of 70°. An electronic messaging display with a brightness of 8,000 NIT viewed at 50° from off center will be just as bright as a LED display with
a brightness of 2,000 NIT viewed head on. While a LED display is not as bright when viewed at an angle beyond the stated viewing angle, there is still sufficient brightness to read the display. Therefore, a viewer can still read a LED display beyond the stated viewing angle. How much further? The answer is dependent on the LED display's brightness, ambient light and contrast conditions.  

When combining more than one LED i.e. an LED as displayed in picture 69 with a viewing angle of 70° in a spatial arrangement, an optimal brightness can be achieved in an actual 360° angle. This is important due to having a wider reading angle of the display when displaying images or forms in actual 3D and not as conventional LED displays only in plane.

The images below show how LEDs can be arranged to create this actual 360° angle and how the viewing angles overlap each other to allow an optimal brightness in all directions.

Firstly, six LEDs have been arranged around one centre point. The direction of the light is North, East, South, and West and upwards and downwards (See Fig. 111 - Fig. 112).

![Diagram of LED arrangement](image)

**Fig. 111:** Arrangement of the first six LEDs with the purpose to great a brighter light source
Secondly, four more LEDs added to allow more brightness around the ‘Z’ axle (See Fig. 113 - Fig. 114).

Thirdly, eight more LEDs are added to create an equal brightness 360° around a centre point (See Fig. 115 - Fig. 116).
With a total 18 LEDs per light point a total coverage can be achieved. There will be still minor points where no optimal brightness exists, but due to having fluent transition in the brightness of light, it will not create any dark spots in an otherwise optimal illuminated light point. (See white arrow at Fig. 117)

The use of 18 LEDs will be possible if one uses SMD LEDs, as due to their size they will not cover other light points. When adding up 18 LEDs enough brightness will be produced even if a single LED will have only a smaller brightness.
[5.7.4] Improvement through using invisible conducting layer instead of cables

With the use of conducting layer embedded into the pipes, wires become invisible. As seen in the LED glass provided by the company LIF in cooperation with SchottGlas, Schneider+Fichtel and Doeppner, LEDs have been embedded into a glass panel and the power supply is provided via virtually invisible conducting paths on the glass (See Fig. 119).

![Fig. 119: Sample LED glass with conductive layers, where one can not see wires any longer](image)

In the case of the glass panel the conductor plate is protected by a laminated cover glass this will be done inside the Acrylic tube when used for the LED Stick (See Fig. 120).

![Fig. 120: Schematic Diagram conductive layer LED glass](image)
As the test has shown, the light of the LED gets reflected along the acrylic tube and thus creates an illuminated element instead of a single light point. This effect could be solved by locating the LEDs in the arrangement explained in Subchapter [6.3], i.e. in chambers instead of one acrylic tube.

These chambers will then be connected with solid acrylic tubes, which are necessary to allow maximum transparency. The connecting tubes will also work as a structural element to hold the grid in place as well as embed the conducting layer as described in Subchapter [5.6.4.]. The following schematic drawing illustrates how such a chamber and connecting stick could look.
This solution would also create the possibilities for a modular system that could be plugged together to allow a quicker assembly.

---

**[5.8]**

**Conclusion of the complete project and outlook how the project could be continued**

With the improvements introduced in the earlier chapter the possibility of achieving a product that can display a 3D surface created by light points is possible. The model and how it was assembled has been done in a student environment with the possibilities and financial resources a research student has. These resources are limited, not only in a financial aspect but also in what production facilities are available. An improvement such as using a water clear red LED instead of a red colour LED could be made and in comparison with Test Series II: Qualities of LEDs regarding brightness and perception an improvement has been achieved. Due to not having the possibility in achieving an improvement through using invisible conductive layer instead of cables in a student environment testings in reducing wires will be done after another research into LED technology.
In the following I want to discuss the advantage of LEDs compared to light bulbs when considering the energy consumption. LEDs have several advantages over conventional incandescent lamps. They do not have a filament that will burn out, so they last much longer, additionally to that their small plastic bulb makes them a lot more durable. Due to their size they also fit more easily into modern electronic circuits.

But their main advantage is efficiency. In conventional incandescent bulbs, the light-production process involves generating a lot of heat, because the filament must be warmed up. This is wasted energy, because a huge portion of the available electricity is not going toward producing visible light. Relatively speaking LEDs generate very little heat; a much higher percentage of the electrical power is going directly to generating light, which cuts down on the electricity demands considerably.

Up until recently, LEDs were too expensive to use for most lighting applications because they are built around advanced semiconductor material. The price of semiconductor devices has plummeted over the past decade, however, making LEDs a more cost-effective lighting option for a wide range of situations. While they may be more expensive than incandescent lights up front, their lower cost in the long run can make them a better buy. In the future, they will play an even bigger role in the world of technology.

The International Sign Association, Muhammad Khan, an ISA Technical Expert, has done the following calculation to calculate the power consumption of signs. He compared:

A sign built with eight fluorescent lights with a sign built with two neon transformers with a sign built with 100 LED modules.

His main interest has been in the running costs of each sign, but due to having the costs for electricity fixed and the specification of the sign in regards to signage as well a comparison can be done:

---

1 I have discussed the decrease of costs of LEDs previous in the research introduction
Here are the examples on how to calculate per-year energy-use costs for a medium size sign:

**Example 1:**
Assumptions--A sign built with eight fluorescent 40-watt lamps remains on for 10 hours a day, 365 days per year, and the energy use cost per kWh is 10 cents.

The calculation--8 lamps X 40 watts each = 320 watts; divided by 1,000 = 0.32 kilowatts; multiplied by 10 hours = **3.2 kWh**; multiplied by $0.10 = $0.32 per day; multiplied by 365 days = $116.80 per year. If the sign ballast were the magnetic type, then the per-year cost = 3.2 X 365 X 1.15 X 0.10 = $134.32.

**Example 2:**
Assumptions--A neon sign built with two neon transformers operating at 85 percent of rated load yielding primary VA of 225, remains on for 10 hours a day, 365 days a year, and the energy cost is 10 cents. The nameplate ratings are: 120V, 2A, 0.5PF.

The calculation--2 transformers X 225 watts X 0.5 each = 225 watts; divided by 1000 = 0.225 kilowatts; multiplied by 10 hours = **2.25 kWh**; multiplied by $0.10 = $0.225 per day; multiplied by 365 days = $82.13 per year. Based on the nameplate ratings, the per-year cost = (120 X 2 X .5 X 2 / 1000) X 10 = 2.4 X 365 X 0.10 = $87.60.

**Example 3:**
Assumptions--A channel letter sign built with 100 LED modules rated 0.5 watts each, operated with two power supplies, remains on for 10 hours a day, 365 days a year, and the energy cost is 10 cents. The nameplate ratings of power supply are: input 120V, 30W, efficiency 84 percent; output 12VDC, 25W.

The calculation--As the efficiency of the power supply is 84 percent, and each power supply is driving 50 LED modules of 0.5 watts each, that amounts to 50 X 0.5 = 25 watts, which is equal to output ratings of the power supply. Considering the 85 percent efficiency, the input wattage is: 25/0.84 = 30 watts. Therefore, for the entire sign, the annual energy use cost is: 2 X 30
watts each = 60 watts; divided by 1,000 = 0.06 kilowatts; multiplied by 10 hours = 0.6 kWh; multiplied by $0.10 = $0.06 per day; multiplied by 365 days = $21.90.

The numbers for these examples are arbitrary, but are close to real-life situations. However, they should not be considered as final. For each sign, you should use one of the applicable examples and plug in the correct numbers for that sign to accurately calculate the sign energy consumption use.³

These data reflect what the ‘Wissenschaftszentrum Nordrhein-Westfalen (Science centre North Rhine Westphalia) state on their homepage:

“Energy consumption
LEDs have a low current consumption with low capacity. Only one tenth of the energy of a lamp needs a colour LED when having the same luminous intensity.

Resources consumption
LED are resources careful. LED have a long life span - dependent on the colour - up to 100,000 operation hours, those are more than 11 years with 24-h-usage. LED keep up to one hundred times longer than lamps, without thereby crucially losing their brightness.”⁴

The conclusion: energy consumption of LEDs will definitely have a better energy ratio mainly because they do not produce so much heat, compared with a standard bulb that only uses 5% of the input energy for producing light and the other 95% is transformed into heat.

[6.1.2]

Power consumption of the built model

To get an understanding of a built context, the energy consumption of the surface / model introduced in Test Series III gets calculated.

Here 100 sticks have been used, each stick in the model contains on LED and therefore 100 LEDs maximum are in use at once.
The used LED is a 5mm LED water clear (ZD-0156)

![LED Water clear red 10000 mcd 20° view angle]

**Fig. 124:** LED type ZD-0156 the LED the power consumption is based on

The specifications on the datasheet provided by the distributor JAYCAR are as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>Emitted Colour</th>
<th>Wave Length nm</th>
<th>Pd W mW</th>
<th>If mA</th>
<th>If mA (peak)</th>
<th>Min mAs</th>
<th>Vf (V)</th>
<th>Type</th>
<th>Max mAs</th>
<th>IV min mA</th>
<th>Brightness mcd type</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mm LED water clear (ZD-0156)</td>
<td>Red</td>
<td>625</td>
<td>130</td>
<td>50</td>
<td>150</td>
<td>2.0</td>
<td>2.3</td>
<td>2.6</td>
<td>7000</td>
<td>10000</td>
<td></td>
</tr>
</tbody>
</table>

Important for the energy consumption is the Pd value = 130 mW or 0.13W.

As a cost value the following figures have been found on [www.uic.com.au](http://www.uic.com.au), a homepage documenting the energy costs for Victoria:

The Cost of Electricity

Much electricity in Australia is now traded so that distribution companies buy at the best price available from hour to hour from competing generators. In cents per kilowatt hour some 2004 pool prices were:

---

Average Victoria 2.8 c/kWh
Average NSW 3.9 c/kWh
Average Qld & SA 3.2 c/kWh

The model is built with 100 LED modules rated 0.13 watts each, operated with one power supply, remains on for 24 hours a day, 365 days a year, and the energy cost is 2.8 cents (Energy costs used on average in Victoria). The nameplate rating of power supply (battery) is 12VDC, initial current less than 0.39 A with approximately 4.68 W.

The calculation with the power supply is driving 100 LED modules of 0.13 watts each, that amounts to 100 X 0.13 = 13 watts; divided by 1,000 = 0.013 kilowatts; multiplied by 24 hours = 0.312 kWh; multiplied by $0.028 = $0.008736 per day; multiplied by 365 days = $3.19

The surface covered with the model is 0.5m * 0.5m = 0.25 m², to calculate the energy use per square metre 13 watts gets multiplied with 4 = 52 watts/square metre divided by 1,000 = 0.052 kilowatts; multiplied by 24 hours = 1.248 kWh; multiplied by $0.028 = $0.034944 per day; multiplied by 365 days = $12.75 per square metre per year.

[6.1.3]
Power consumption of façade when realised

Due to not having a functioning system yet, a system that has been tested and published should be used as a comparison model to calculate the energy consumption of the façade when realised.

I want to use the SMARTSLAB system for this test, due to an interest in the system as well as in regards to the possibilities of using it as an outdoor system on a building. I have briefly introduced the SmartSlab system in the Chapter 3 [1.3.2.]. The system works as a 2D display system therefore the LEDs are only arranged in a plane.

SmartSlab uses an arrangement they call Hexel™, and referencing their datasheet the Hexel™ density per square metre is 1867 LED per m². In my system a configuration should be used in a similar resolution as used in the model with a grid of 50mm*50mm in X and Y plane as well as 50mm in Z plane. This will result into 20*20= 400 LED/m². When defining one single layered surface the maximum numbers of LEDs that can

---

See attached datasheet SmartSlab at Chapter 6 Appendix
be switched on are these 400 LEDs. I want to call this set up LED-Surface MIN. The length of the sticks used in the model allows 10 LEDs in the Z-plane, therefore with 20*20*10 LEDs the maximum number of LEDs that can possibly be switched on = 4000. I want to call this set up LED-Surface MAX. These two numbers are the two extreme values between one surface and the whole grid being switched on. All other possibilities in between are considered in this as a number between LED-Surface MIN and LED-Surface MAX and will therefore not be further investigated.

Set up for Calculation for LED-Surface MIN and LED-Surface MAX. When the Hexel™ Density/m² has a power consumption LED (one Hexel™ is equal one Pixel is equal one LED)/m² = 264 Watts/m², one Hexel™ has 264 Watts/m² divided by 1867 Hexel™ Density/m² = 0.1414 Watts or 141.4 mW.

For LED-Surface MIN 400 LEDs multiplied with 0.1414 Watts = 56.56 Watts/m² divided by 1,000 = 0.05656 kilowatts; multiplied by 24 hours = 1.35744 kWh; multiplied by $0.028 = $0.038 per day; multiplied by 365 days = $13.87 per square metre per year.

For LED-Surface MAX 4000 LEDs multiplied with 0.1414 Watts = 565.6 Watts/m² divided by 1,000 = 0.5656 kilowatts; multiplied by 24 hours = 13.572 kWh; multiplied by $0.028 = $0.38 per day; multiplied by 365 days = $138.70 per square metre per year.

These numbers are based on a typical surface facing (in Australia) any direction but north and therefore not exposed to direct sunlight. SmartSlab offers two different systems to provide a suitable product for different sun exposure.

“SmartSlab [as] a high brightness display with a full viewing angle that can be seen in daylight and artificial lighting condition. It is available in either standard (1000Cd/m²) or high brightness (5000Cd/m²) versions”5

The high brightness version with 5000 Cd/m² has a power consumption LED (one Hexel™ is equal one Pixel is equal one LED)/m² = 783 Watts/m², one Hexel™ has 783 Watts/m² divided by 1867 Hexel™ Density/m² = 0.4194 Watts or 419.4 mW.

For LED-Surface MIN 400 LEDs multiplied with 0.4194 Watts = 167.76 Watts/m² divided by 1,000 = 0.16776 kilowatts; multiplied by 24 hours = 4.02 kWh; multiplied by $0.028 = $0.1127 per day; multiplied by 365 days = $41.14 per square metre per year.

For LED-Surface MAX 4000 LEDs multiplied with 0.4194 Watts = 1677.6 Watts/m² divided by 1,000 = 1.6776 kilowatts; multiplied by 24 hours = 40.2
kWh; multiplied by $0.028 = $1.127 per day; multiplied by 365 days = $1387.00 per square metre per year.

The total result of this exercise can be seen in the spreadsheet below:

<table>
<thead>
<tr>
<th>Type</th>
<th>Consumption per day (KWh/m²)</th>
<th>Costs per day ($/m²)</th>
<th>Consumption per year (KWh/m²)</th>
<th>Costs per year ($/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model surface built</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Watts used in built model</td>
<td>0.312 kWh</td>
<td>$0.034</td>
<td>113.88 kWh</td>
<td>$3.19</td>
</tr>
<tr>
<td><strong>Model surface MAX</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52 Watts/m²</td>
<td>1.248 kWh</td>
<td>$0.034</td>
<td>455.52 kWh</td>
<td>$12.75</td>
</tr>
<tr>
<td><strong>LED Surface MIN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56.56 Watts/m²</td>
<td>1.35 kWh</td>
<td>$0.038</td>
<td>492.75 kWh</td>
<td>$13.87</td>
</tr>
<tr>
<td><strong>LED Surface MAX</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>565.6 Watts/m²</td>
<td>13.57 kWh</td>
<td>$0.38</td>
<td>4953.05 kWh</td>
<td>$138.70</td>
</tr>
<tr>
<td><strong>LED Surface MIN (Bright)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>167.76 Watts/m²</td>
<td>4.02 kWh</td>
<td>$0.112</td>
<td>1,467.3 kWh</td>
<td>$41.14</td>
</tr>
<tr>
<td><strong>LED Surface MAX (Bright)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1677.6 Watts/m²</td>
<td>40.2 kWh</td>
<td>$1.127</td>
<td>14,673 kWh</td>
<td>$1387.00</td>
</tr>
<tr>
<td><strong>SmartSlab Surface (Standard)</strong></td>
<td>6.34 kWh</td>
<td>$0.177</td>
<td>2,314.1 kWh</td>
<td>$64.75</td>
</tr>
<tr>
<td><strong>SmartSlab Surface (Bright)</strong></td>
<td>18.79 kWh</td>
<td>$0.526</td>
<td>6,858.35 kWh</td>
<td>$192.05</td>
</tr>
</tbody>
</table>

[6.1.4]
Conclusion
The above introduced figures have to be seen in relation to other technical equipment to judge if the energy consumption is high or not. Therefore I want to introduce a few figures as a comparison, such as the electricity consumption by end use in U.S. Households in 2001.

Table US-1. Electricity Consumption by End Use in U.S. Households, 2001

<table>
<thead>
<tr>
<th>End-Use Category and End Use Consumption</th>
<th>Households (millions) kWh</th>
<th>Units a (millions) (percent)</th>
<th>Per Unit b (kWh)</th>
<th>Per HH (kWh)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating, Ventilation, and Cooling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air-Conditioning c</td>
<td>80.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>182.8</td>
<td>16.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>57.5</td>
<td>-</td>
<td>-</td>
<td>2,796</td>
<td></td>
</tr>
<tr>
<td></td>
<td>160.6</td>
<td>14.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual Room Units</td>
<td>23.3</td>
<td>38.2</td>
<td>580</td>
<td>950</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.2</td>
<td>1.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Space Heating d</td>
<td>43.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>115.5</td>
<td>10.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main System</td>
<td>30.9</td>
<td>-</td>
<td>-</td>
<td>3,524</td>
<td></td>
</tr>
<tr>
<td></td>
<td>109.0</td>
<td>9.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary Equipment</td>
<td>12.9</td>
<td>-</td>
<td>503</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>Related Appliances</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furnace Fan</td>
<td>57.4</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>76.3</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>38.2</td>
<td>3.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceiling Fan</td>
<td>69.6</td>
<td>192.8</td>
<td>50</td>
<td>138</td>
<td>9.6</td>
</tr>
<tr>
<td>Dehumidifier</td>
<td>12.1</td>
<td>-</td>
<td>400</td>
<td>-</td>
<td>4.8</td>
</tr>
<tr>
<td>Humidifier</td>
<td>15.6</td>
<td>-</td>
<td>100</td>
<td>-</td>
<td>1.6</td>
</tr>
<tr>
<td>Evaporator Cooler</td>
<td>2.7</td>
<td>-</td>
<td>1,183</td>
<td>-</td>
<td>3.2</td>
</tr>
<tr>
<td>Kitchen Appliances</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td>304.5</td>
<td>26.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>106.8</td>
<td>126.0</td>
<td>1,239</td>
<td>1,462</td>
<td></td>
</tr>
<tr>
<td></td>
<td>156.1</td>
<td>13.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freezer</td>
<td>34.2</td>
<td>37.9</td>
<td>1,039</td>
<td>1,149</td>
<td></td>
</tr>
<tr>
<td></td>
<td>39.3</td>
<td>3.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dishwasher a</td>
<td>56.7</td>
<td>-</td>
<td>512</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>29.0</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range Top f</td>
<td>59.7</td>
<td>-</td>
<td>536</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32.0</td>
<td>2.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oven g</td>
<td>47.8</td>
<td>-</td>
<td>440</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21.0</td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microwave Oven</td>
<td>92.1</td>
<td>-</td>
<td>209</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19.3</td>
<td>1.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee Maker h</td>
<td>51.3</td>
<td>-</td>
<td>116</td>
<td>6.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Toaster Oven</td>
<td>36.1</td>
<td>-</td>
<td>50</td>
<td>1.8</td>
<td>0.2</td>
</tr>
</tbody>
</table>

i [http://www.eia.doe.gov/emeu/reps/enduse/er01_us_tab1.html](http://www.eia.doe.gov/emeu/reps/enduse/er01_us_tab1.html)
<table>
<thead>
<tr>
<th>Category</th>
<th>2010 kWh</th>
<th>2011 kWh</th>
<th>2012 kWh</th>
<th>Total kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Heating</td>
<td>40.8</td>
<td>-</td>
<td>-</td>
<td>2,552</td>
</tr>
<tr>
<td></td>
<td>104.1</td>
<td>9.1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>107.0</td>
<td>-</td>
<td>-</td>
<td>940</td>
</tr>
<tr>
<td></td>
<td>100.5</td>
<td>8.8</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Home Electronics</td>
<td>82.3</td>
<td>7.2</td>
<td>-</td>
<td>313</td>
</tr>
<tr>
<td></td>
<td>105.8</td>
<td>242.6</td>
<td>137</td>
<td>107.0</td>
</tr>
<tr>
<td></td>
<td>33.1</td>
<td>2.9</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60.0</td>
<td>-</td>
<td>-</td>
<td>384</td>
</tr>
<tr>
<td></td>
<td>23.1</td>
<td>2.0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>96.1</td>
<td>161.9</td>
<td>70</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>11.3</td>
<td>1.0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>80.3</td>
<td>-</td>
<td>-</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>24.4</td>
<td>-</td>
<td>120</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>13.9</td>
<td>-</td>
<td>130</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>81.5</td>
<td>-</td>
<td>26</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>65.7</td>
<td>-</td>
<td>35</td>
<td>2.3</td>
</tr>
<tr>
<td>Stereo k</td>
<td>28.7</td>
<td>2.5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Cable Box</td>
<td>6.5</td>
<td>-</td>
<td>1,500</td>
<td>9.8</td>
</tr>
<tr>
<td>Satellite Dish</td>
<td>3.3</td>
<td>-</td>
<td>2,300</td>
<td>7.6</td>
</tr>
<tr>
<td>Cordless Phone</td>
<td>65.9</td>
<td>5.8</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Answering Machine</td>
<td>84.1</td>
<td>-</td>
<td>120</td>
<td>2.3</td>
</tr>
<tr>
<td>Laundry Appliances</td>
<td>76.0</td>
<td>6.7</td>
<td>-</td>
<td>1,079</td>
</tr>
<tr>
<td>Clothes Dryer</td>
<td>61.1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>65.9</td>
<td>5.8</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Clothes Washer e</td>
<td>84.1</td>
<td>-</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Other Equipment</td>
<td>28.7</td>
<td>2.5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.5</td>
<td>6.4</td>
<td>900</td>
<td>5.7</td>
</tr>
<tr>
<td>Other End Uses</td>
<td>88.0</td>
<td>7.7</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>U.S. Total</td>
<td>107.0</td>
<td>-</td>
<td>-</td>
<td>10,656</td>
</tr>
<tr>
<td></td>
<td>1,139.9</td>
<td>100.0</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

I have highlighted a few numbers from several household items to use them as reference numbers.

Compared with these figures the consumption of a spatial dynamic media system seems reasonable – it can express a new form of architectural expression based on the technical possibilities at present. Furthermore all the figures are based on 100% usage of building surface as a media façade; these numbers can be reduced when introducing windows and other openings into the skin.
Test Series IV: Reduction of wiring

The model designed in Test Three used 100 LEDs with two wires connected to one LED. RGB LEDs need 4 wires to create a light in any colour. (See Fig. 125)

![Comparison LED (top) and RGB LED (bottom)](image)

The expected high amount of wiring makes it necessary to consider other ways of controlling the input of LEDs with fewer cables included. In the built model 12 LEDs (orange colour only) will be controlled with 4 wires.

<table>
<thead>
<tr>
<th>Number of LEDs</th>
<th>Wire combination</th>
<th>LED direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>1 – 2</td>
<td>A</td>
</tr>
<tr>
<td>02</td>
<td>1 – 3</td>
<td>A</td>
</tr>
<tr>
<td>03</td>
<td>1 – 4</td>
<td>A</td>
</tr>
<tr>
<td>04</td>
<td>2 – 3</td>
<td>A</td>
</tr>
<tr>
<td>05</td>
<td>2 – 4</td>
<td>A</td>
</tr>
<tr>
<td>06</td>
<td>3 – 4</td>
<td>A</td>
</tr>
<tr>
<td>07</td>
<td>2 – 1</td>
<td>B</td>
</tr>
</tbody>
</table>

To control 12 LEDs with 4 wires a simple principle of combining numbers with each other has been adopted. Another important matter is that LEDs work in principle only in one direction.

The combining principle will be explained in the table below:
An LED works in a similar way as a common switch diode. The following text explains the basic principles of a diode:

“The term diode usually implies a small signal device with current typically in the milliamp range. A semiconductor diode consists of a PN junction and has two (2) terminals, an anode (+) and a cathode (-). Current flows from anode to cathode within the diode. An ideal diode is like a light switch in your home. When the switch is closed, the circuit is completed; and the light turns on. When the switch is open, there is no current and the light is off. However, the diode has an additional property; it is unidirectional; current flows in only one direction (anode to cathode internally). When a forward voltage is applied, the diode conducts; and when a reverse voltage is applied, there is no conduction. In electronics, a diode is a component that restricts the direction of movement of charge carriers. It allows an electric current to flow in one direction, but essentially blocks it in the opposite direction. Thus the diode can be thought of as an electronic version of a check valve.”  

So if an LED is unidirectional the current should also flow only in one direction from the anode (+) to the cathode (-). When having two wires, cable A positive and cable B negative then LED 1 with anode attached to cable A and cathode to cable B will glow. LED 2 with anode attached to cable B and cathode attached to cable A will not glow. LED 2 will glow if one changes the polarity on cable A and B. Therefore the LEDs 07 – 12 will glow because they will be attached in an opposite direction then the LEDs before.
[7.2.2] 
Electronic circuit

The electronic circuit attached at Chapter 6 Appendix: Appendix 1 – Plans explain the set up.
The before mentioned wires 1, 2, 3 and 4 have become, due to the colour of the physical wires orange, red, white and black.
Each LED component (01 – 12) contains a 470 KΩ resistor to protect the LED as well as a switch diode. The switch diode has become necessary because the LED did not block completely the current in one direction.

[7.2.3] 
Pictures Model

Illustration attached at Chapter 6 Appendix: Appendix 1 – Plans gives an impression of the model, a distance of 50mm LED to LED has been chosen, with no relation to a later resolution option.
The Pictures below shows the model from different angles, in particular the 4 wires in the above mentioned colours.

![Fig. 126: four wires black, red, orange and white and model set up including battery](image)

[7.3] 
Model outcome

The following 12 pictures shows what has been described in the model set up. Please pay attention to the fact that the cables plugged into the battery changes when the LED change.
Fig. 127: White [+] and red [-] are connected to the battery

Fig. 128: White [+] and orange [-]

Fig. 129: White [+] and black [-]

Fig. 130: red [+] and black [-]
Fig. 131: red [+\ ] and orange [-\ ]

Fig. 132: red [+\ ] and white [-\ ]

Fig. 133: orange [+\ ] and red [-\ ]

Fig. 134: orange [+\ ] and black [-\ ]

Fig. 135: orange [+\ ] and white [-\ ]
The test has proven that with the existing set-up a reduction of wires is not possible. Current could find a connection from [+] to [-] in uncontrolled ways. Improvements are not possible without introducing further wires.
Test Series V: Reflection of tubes

The built model introduced in Test Series III had a tendency of reflecting the light of the LEDs onto the tubes. This question will be analysed in this Test Series to prove and document if the reflection has any possible influence in perceiving a surface.

The model set-up has changed in regards to lights that have been switched on. Instead of having all 100 LEDs switched on, I switched on only one - in the first sequence, one LED in the bottom row of the model and in the second sequence, one LED located in the middle of the model.

The first sequence shows the reflection of tubes when switching on an LED in the bottom row (See Picture Series 1).
(Series 1: Sequence Reflection of tubes when using bottom LED)

The second sequence shows the reflection of tubes when switching on an LED in the centre of the model. (See Picture series 2)
There is a strong reflection of the light from the tubes; one reason for this could be the illumination of the whole tube. This will increase the illuminated surface and therefore also the reflection.
Test Series VI: Design of a product based on previous tests

Introduction

The tests conducted in this chapter have now led my research to the design of a prototype which should demonstrate how the proposed system could look. Each of the Test Series has answered questions which then influence the design of the LED stick. This knowledge should then influence the final design of the prototype. The prototype tries to stay as close as possible to how a finished off the shelf product could look.

The purpose of the system is to be applied in an architectural context. This will define several parameters in how the LED stick will be designed and will separate it from other design options introduced at the end of this chapter.

Model set up

As explained above the aim of the prototype is to deliver a system which could be applied in an architectural context, not only a system suitable for an installation or in a protected environment. Therefore the following thoughts will guide the design of the LED stick:

- The LED stick should be able to resist weather conditions, e.g. be waterproof
- Impact resistance, the LED stick should not be fragile and should not be damaged with normal usage
- Repairing of a single element, without greater difficulties
- Adaptable for different situations on a building (planes, corners)
- Easy to assemble onto a substructure
- Costs
- Resolution
The first five points will be discussed in this chapter, the issue of cost will be further discussed in Chapter 4 Project work: Project 2: Subchapter [4.], and resolution discussed in Subchapter [3.].

The two sketches above show some of the first thoughts of how the product could be realized. Soon after these sketches the computer was used to draw a 3D model. The following renders will illustrate how the first model would look.

**Fig. 139:** First sketch of LED stick to illustrate the concept

**Fig. 140:** Sketch of how LED sticks will be arranged

**Fig. 141:** First rendering of LED stick
Before working on the actual prototype a first test model created using wood should answer some questions in regards to proportion and dimensions of the LED stick. The 3D model introduced by the rendering above has been used to produce a physical model with the use of a CAD CAM machine.

The following pictures show the model.

**Fig. 142:** Detailed rendering of LED stick

**Fig. 143:** Picture of form test in wood, test of more then one LED stick perspective view

**Fig. 144:** Picture of form test in wood with two LED sticks from a different position
The concluding design should offer a solution which could be applied in an architectural context. In such a context the question of removing default components will be raised.

The system therefore should be made from one single item which could be replaced when being fixed onto a façade. The replacement should include only the single default LED stick without removing any other surrounding LED sticks.
Fig. 150: Replacing elements in an existing system

Fig. 151: Hole to fix element with screw
Fig. 152: Ring to lift up element

Fig. 153: Demonstration in video clip, lift up ring
The system could also be used in a corner situation. One would not need any different systems to define a corner, due to a changeable angle of the stick in regards to the base. The following pictures demonstrate how the sticks fixing-screw is loosened and the angle of the stick could be altered in a 360° angle. This alteration must be done manually, not by an engine. Due to altering and determining the angle only once, during construction of the façade this step could be justified. The use of an engine which controls the angle and places the stick into position would have been too expensive and complicated for a one time use.
Fig. 155: Changing direction of LED stick when applying in a corner situation

Fig. 156: opening up fixing screw
Fig. 157: Loosen fixing element

Fig. 158: Fixing element is loose, LED stick can be altered in its angle
regarding to the base

**Fig. 160:** Change of angle from one point

**Fig. 161:** To another point
The LEDs used in the prototype are RGB LEDs which use a built in timer to change the colours automatically after a certain period.

The datasheet for the LED has been copied from the supplier’s homepage¹ and is attached at Chapter 6 Appendix: Appendix 2 – Tables.

<table>
<thead>
<tr>
<th>Colour:</th>
<th>Multi-colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension:</td>
<td>5mm</td>
</tr>
<tr>
<td>Voltage:</td>
<td>3V / DC (with a 690 Ω resistor) 12V / DC</td>
</tr>
<tr>
<td>Type:</td>
<td>F45B</td>
</tr>
<tr>
<td>If:</td>
<td>20 mA</td>
</tr>
<tr>
<td>Luminous intensity:</td>
<td>170 – 500 mcd</td>
</tr>
</tbody>
</table>

The LED colour changes - it begins with red and will then change after 5 seconds to white, blue, green and then yellow and then start again with red. The following pictures demonstrate the colour change.

Fig. 162: Picture of RGB LED used in prototype

---

¹ www.conrad.de
The acrylic tubes should be formed with little chambers so they could contain one light point. This has been previously discussed in Subchapter [5.6.5.]. The single tube should be formed with the use of a negative and then be vacuum formed with clear acrylic.
Here the tube should be as clear as possible, while the chamber carrying the LEDs is translucent to create the effect discussed in the above mentioned chapter. The CAD CAM built negative moulds used for the first series of test tubes has proven to be unsuitable. The surface was not smooth enough to create a clear surface, a result of a milling bit that during the milling process leaves fine lines on the surface. Sandpapering this surface could achieve an improvement, but not to the extent which would create a suitable surface. Therefore a second negative mould has been created slightly smaller than the first one. This mould will first have a vacuum formed cover made of a white acrylic material to create a smoother surface. The progress is documented in the pictures attached below.

With this method a suitable acrylic tube could be produced.

---

**Fig. 167:** First negative with surface too rough

**Fig. 168:** Detailed view of negative

**Fig. 169:** Vacuum formed acrylic tube with too rough surface
**Fig. 170:** Second negative with acrylic cover

**Fig. 171:** Detailed view

**Fig. 172:** Detailed view with tube on bottom negative

**Fig. 173:** Acrylic tube used for prototype
Fig. 174: Comparative picture with result negative from one at the top and acrylic tube used for prototype at bottom

The plans of the model illustrate how the LED stick could look are based on the plans published in Chapter 6 Appendix: Appendix 1 – Plans. What has not yet been explained is the base of the LED stick and the necessary wiring.

Due to the opportunity of using a 3D prototype printer a plaster model has been built as a base. The advantage is the greater possibilities for detailing and precision over a CAD CAM model. The base is hollow to host the necessary electro circuit. This circuit contains a switch for each individual LED, to demonstrate that light points can not only change colour but also be switched on and off at any wanted time. Furthermore the LED needed a 690 Ω (Ohm) resistor because of the 12 V / DC as an energy source.

The following renderings were made to illustrate how the system could look when an array of sticks are attached to a façade.
Fig. 175: Rendering of an array of LED sticks

Fig. 176: Rendering of an array of LED sticks

[9.3.3] Pictures

The pictures show the finished model on a plinth.

Fig. 177: Prototype side view, the prototype is based on all previous tests discussed in this chapter

Fig. 178: Prototype front view
Fig. 179: Prototype perspective view

Fig. 180: Prototype perspective back view

Fig. 181: Prototype back view with detailed view of the designed electric circuit

Fig. 182: Prototype side view with all LEDs switched on, the LEDs can be individual switched on or off
The introduced prototype is one option of how a zone delivered by a 3D light point matrix could be established. During my research other options have been discovered. These other options will be introduced and compared with the ‘LED stick’. Electrical engineering students at the Delft University of Technology in the Netherlands created in May 2006 a 3D-display. The display consisted of 8,000 suspended ping pong balls that each contained a red LED light. It played games of 3D snake, 3D pong, and 3D duck hunt, as well as displaying mobile phone text messages and simple animations. According to the publication on the Interactive architecture Homepage the display used 4 kilometres of copper wire, 3 kilos of solder, a couple of hundred metres of aluminium and eight printed circuit boards. Following are some images of the display.

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**Fig. 183**: Prototype perspective view

**Fig. 184**: Prototype front view
Fig. 185: Image of installation in Delft, a system built by Dutch electro engineering students

Fig. 186: Image of installation in Delft, closer view

Fig. 187: Image of installation in Delft, with pre-defined shape

Fig. 188: Image of installation in Delft, with a pre-defined shape in a wave form
The installation was assembled by a group of electro engineering students in Delft, Holland. The main aim was the technical aspect of setting up such an installation. Due to the size of the installation and its realisation, the project could be seen as a proof of concept. Due to the difference in how the system has been built a comparison between the two systems, the researched one and the system offered by TU Delft should be discussed.

The system by TU Delft has been assembled by a number of LEDs placed into ping pong balls. The ping pong balls help the LED to shine brighter. Without having details of what kind of LEDs were used in the installation, it is quite likely that due to cost considerations an LED with a lower brightness was chosen and that the ping pong ball were attached as a result.

One of the main problems in having such a system is the fragility of the system. The wires used for wiring the LEDs are at the same time the ones which allow the system to be stable, supported by the metal frames around it. In an installation where no one touches the system this set up could work, but for an application where vandalism plays an important role it will not be appropriate.
The second problem will be the repair and replacement of single components when they are damaged or no longer functioning, for example if one of the LEDs in the centre of the cube stops working a possible repair becomes quite difficult. Wind loads, weather conditions and other environmental conditions will probably harm the system as well. It functions in an installation context but certainly has its limits when applied in an architectural context.

The students from TU Delft have quoted an installation by New York based artist James Clar as their main inspiration. James Clar & Associates is a collective of forward-thinking individuals that merge technology and art to create new visual systems, innovative products, and dynamic architectural environments. Design, form and structure are played with in new ways to create inventive solutions to problems. One of their designs is the 3D display cube: “a patented system that integrates LED technology to create true three-dimensional imagery, the 3D Display Cube has wide spread uses with retail and public display, signage applications, home display, and advertising.” The system is indeed very much the same that TU Delft copied for their installation.
The Cubatron is another project similar to the two introduced earlier. On a Homepage by Network Wizards the Cubatron was claimed to be the world's largest true 3D colour graphics display from 2004-2006. It is 8x8x8 feet in size. It consists of 729 voxels (3D pixels) arranged in a 9x9x9 matrix, spaced 10 inches apart from each other. Each voxel is a 40mm diameter ball that can be independently set to display a 21-bit RGB colour. The entire display can be updated about 30 times per second. The voxels "float" in space so that the viewer can see through the cube and have a view of most of the voxels from any position. It is held up by 4 guy wires, one at each of the top corners of the cube.

The previously quoted homepage raises the problem of the fragility of the construction, when saying:

“A "fence" 5 feet from each side of the Cubatron keeps people from touching it, as it is fragile. Thus it requires a footprint of approximately 18x18 feet.” This confirms
the difficulties my research has raised when talking about the installation in Delft, Holland.

In 2006 the Cubatron project’s successor named ‘The Big Round Cubatron’ (BRC) is claimed to be now the world's largest 3-dimensional full colour dynamic light sculpture. It is an array of lights 40 feet in diameter and 10 feet high. It consists of 28 spokes, each of which is 24 lights wide by 9 lights high. Each light is independently controllable to display any colour and brightness level and the entire display can be updated 50 times per second. There are 6048 total lights (28 * 24 * 9) made of 18,144 LEDs.

Fig. 194: Big Round Cubatron at Burning man Festival 2006

Fig. 195: Big Round Cubatron at Burning man Festival 2006

Fig. 196: Big Round Cubatron at Burning man Festival 2006, detail shows again that the system is fragile and function more as an installation but not in an architectural context
LED cube by Stephen W. Boyer

One of the first persons exploring the use of LEDs in order to display objects in 3D is Stephen W. Boyer. According to his homepage\(^\text{11}\) he handed in a patent for a ‘Light Art Structure’ in 22\(^{\text{nd}}\) May 2001. The system here claimed to be an “ornamental design for a light art structure”\(^\text{12}\) and included 125 LEDs embedded into acrylic tubes, as can be seen in the drawing below.

![LED Cube](image)

**Fig. 197:** LED Cube Stephen Boyer, regarding to his homepage the first 3D display system

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Conclusion

The produced stick has reached a stage where it could be seen as a prototype which could be developed to a further extent in future research. Certain technical problems occurring at present could be solved by technical developments in the near future. The examples shown in the previous chapter have demonstrated that an interest in creating a 3D display system exists and that researchers look at the possibilities of developing such a system. At present most of the introduced systems remain on an installation level or as an indoor solution, both of which are not suitable for architectural applications.
Conclusion of Project 1: Realisation of system in regards to an industrial design product

The tests conducted in this chapter have proven that it is possible to design a system that allows the beholder to experience a visual zone defined by a 3D matrix. This research has covered an aspect raised in the title of this research, Spatial dynamic media systems – an amalgam of form and image through a 3D light point matrix to deliver a content driven dynamic zone in real-time – and confirms that a ‘3D light point matrix’ can be built and fulfils the theoretical aspects discussed in Chapter 3.

The last test presented in this chapter proved what one stick looks like whilst being built. However, the stick has not gained its full potential. What has been presented is more or less a prototype which can be further developed in the future. But as raised in the introduction of this chapter, the aim has not been to deliver a product that could be presented to a market and to be purchased by customers. Still my research wants to discuss briefly about what kind of requirements need to be fulfilled to continue working on the system and to allow the execution of a product.

Fig. 198: Picture of stick to locate the different building components

The LED stick will be divided into different building components, as follows:

- Body of Hardware
- Electronic circuits to run stick
- Stick with embedded LED

Firstly my research wants to discuss the requirements of working further on the body of the hardware. Here progress could be achieved within a student environment, due to having at the laboratories at RMIT University different plastic and resin components
which could be used, developed and produced. This hardware body would not look much different when compared with the plaster model presented in Subchapter [9.2.1.] when working on a prototype produced from plaster.

When working on the next step of designing the electronic circuit, a student environment will have its limits in regards to what can be produced. Here electronics parts used will be as well as SMD (Surface mounted device) technology, a technology previously explained in Subchapter [5.6.2.]. SMD technology has the advantage of being smaller and allows for the placing of all circuits necessary into the hardware body.

The stick with the embedded LED will require similar manufacturing methods due to using SMD LEDs as well. Furthermore when using conductive layers instead of wires, to avoid masking of LEDs through wires, conductive layers also can not be manufactured in a student environment.

[10.2]
Step toward Project 2

The constraints explained in this chapter arise mainly from a technical nature. My research has still not been applied to the system in a built environment to analyse its function when using it in a built environment.

So far the system has been seen as a single item, without investigation of how it could function when applied on a façade of a building or arrayed on a wall as an art installation. These should be the interests in a continuation of the project when applying a greater number of sticks. Here the question of resolution will be further discussed, this time not only in how much a surface could be perceived but also the costs of the system itself.
4  Wissenschaftszentrum Nordrhein-Westfalen,
5   Ibid.
10  Ibid.
12  Ibid.
Project 2: Applying system

[1.]
P2 /
Introduction Project 2

As a test field for an application I used the rather plain façade of Building 91 located at RMIT University City Campus. The building was documented in the first chapter for data such as floor plans, elevations, etc. Based on this data I conducted two tests to offer several design options that differed in regards to resolution and cost.

In Test Series I the research offered six options of how the LED sticks could be arranged on one square metre. The amount of LED sticks varies from 100 per square metre down to 48 per square metre when arranging them in an ordered way, including one option where the LED sticks are randomly arranged. All six options are documented in Subchapter [3.2.4] of Test Series I, similar to the test made in Project 1: Chapter [5.5.1] where photographs of the model from different positions were analysed. In Subchapter [3.2.5] of Test Series I the camera positions were positioned with the use of 3DMax™ to investigate how the surfaces will differ from each other with a lower number of sticks per square metre. I then compared the images were with each other to gain an understanding of what resolution is possible till one can no longer recognize a complete surface anymore. Based on these two tests in Subchapter [3.2.4] and [3.2.5] a small surface with 20 * 20 points, a second and bigger surface should be looked at from a greater distance and also from different angles. These tests give an understanding of what kind of resolutions could be practically and economically applied on the façade of Building 91.

Not only is resolution of interest when cladding a façade with more then one LED Stick. In Test Series II, the cost factor of one LED stick was another important question for understanding how much surface can actually be used as a ‘digital relief. An Excel™ spreadsheet with costs for 2D LED surfaces was used, and this data was translated to derive a first cost estimation for a single stick. From this, a cost calculation was made for the different resolutions using 100, 75, 67 and 50 sticks per square metre.
Based on the information of Test Series I and II regarding resolution and cost, three design options for the façade were drawn in Test Series II and presented in elevation, as well as a number of renderings, to illustrate the different projects.

The explained Project 1 and Project 2 have allowed the design of the Spatial Dynamic Media System, the ‘hardware’ of the project. The Spatial Dynamic Media System provides artists or architects with a system, changeable by a media content provided by artists or architects.

These two projects, Project 1 and Project 2 will conclude the first part of the project work where the concentration of my research has been on the hardware aspects – it should now go from hardware to software. The project work demonstrated to this point, that the system can be built, but not within a student budget and not within the time frame of this research.
Using Building 91 on the RMIT city campus as a project with the potential to realise the system on the façade of the building, steps towards different designs of openings in the façade have to be analysed. Furthermore the issue of cost for the system implementation is of great importance to the client and an important aspect of the success of the proposal. Therefore the following test series will be used to analyse what kind of and how many openings can be adopted by the system while still allowing enough pixels to read an image displayed on the façade.

Due to the lack of existing plans of the elevation a 3D model has been built to construct an elevation of the building. As a result of difficulties in measuring certain points on the façade, some points have been estimated and are therefore not absolutely accurate, but they do fulfil their function in using the building and its façade as a potential site in adopting the system.

All floor plans have been provided by Property Service RMIT, as mentioned before, the elevation has been drawn based on measurements I done by myself. The plans attached in Chapter 6 Appendix: Appendix 1 – Plans explain the building and its layout:

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When talking about an image, I refer here to any possible 3D arrangement displayed on the façade with the use of my system, not a picture, e.g. a picture of a person.
Fig. 1: View of building from Victoria Street

Fig. 2: View of building from Victoria Street
[3.1] P2 / Test Series I: Introduction

Analysis sticks per square meter

Due to the anticipated high number of sticks per square metre when having a resolution of 10*10*10 cm from light point to light point and therefore 100 sticks per square meter, an investigation of how to reduce this number from 100 sticks per square metre \((s/sqm)\) should be made.

My research will look at what kind of arrangements the sticks could be positioned in within each square metre to achieve a variety in the number of sticks used per square meter. As a second step each of the introduced resolutions will be analysed in regards to how much one can see of a surface which would be generated from a various number of LEDs. This analysis will be done with the use of the following:

- Renderings of the surface defined at chapter P1/Test Series III
- Renderings when creating a bigger surface \((5*5m)\) with a random surface.

These tests should help to create a better understanding of what kinds of resolution are necessary to read an image\(^{ii}\) or a surface on a façade.

[3.2] Resolution tests [3.2.1] Background image resolution

Image resolution describes the detail an image holds. The term applies equally to digital images, film images, and other types of images. Higher resolution means more image detail. The interest for my research is how many pixels does one need for one to understand an image. Basically, resolution quantifies how close lines can be to each other and still be visibly resolved. Resolution units can be tied to physical sizes (e.g. lines per mm, lines per inch) or to the overall size of a picture (lines per picture height,

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\(^{i}\) \(s/sqm\) is a unit introduced by the writer and does not have any relation to any existing physical unit used in other fields of science.

\(^{ii}\) When talking about an image I am not talking about a picture in the sense of, for example, a landscape picture but more about a digital representation on the system. This could be 2D, 3D or a movie.
also known simply as lines, or TV lines). Furthermore, line pairs are often used instead of lines. A line pair is a pair of adjacent dark and light lines, while lines counts both dark lines and light lines. A resolution of 10 lines per mm means 5 dark lines alternating with 5 light lines, or 5 line pairs per mm. Photographic lens and film resolution are most often quoted in line pairs per mm.

In Chapter 6 Appendix: Appendix 3 – Image I attached an illustration of how the same image might appear at different pixel resolutions, if the pixels were poorly rendered as sharp squares (normally, a smooth image reconstruction from pixels would be preferred, but for illustration of pixels, the sharp squares illustrate the point better).

At the attached image one can see that with 10 x 10 sticks per square meter an image could be recognised. Furthermore, and important for how one can understand an image is the distance of the image to the beholder. The technique of creating an image of several pixels or dots has been used in comic prints in the fifties or in images in newspapers and is widely known through the paintings of Roy Lichtenstein.

[3.2.2] 2D sketch diagrams

These have been studies conducted to investigate the possibility of reducing the number of sticks per square metre. The purpose of this exercise is the reduction of cost per square metre on the one hand, but also to allow window openings in the façade to gain access to daylight.

Six different options for façade openings were designed and analysed. Here the number of sticks per square metre starts at 100 s/sqm (Sticks/square metre) down to 48 s/sqm.

Fig. 3: 100 Sticks per square metre
Fig. 4: 75 Sticks per square metre

Fig. 5: 67 Sticks per square metre

Fig. 6: 50 Sticks per square metre

Fig. 7: 48 Sticks per square metre
Fig. 8: Random arrangement with random number of sticks

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3.2.3 Renderings of surface I

Similar to a test done in Project 1: Subchapter [5.5.] when photographs of the model from different positions were shot, this time these camera positions will be re-enacted with the use of 3DMax to investigate how the surfaces will differ from each other when having a lower number of sticks per square metre. The camera positions will be described in the following sketch. The interest here is the perception of a surface with different resolutions analysed in the previous chapter. The set up and plans can be found as well in Chapter 6 Appendix: Appendix 1 – Plans.

The following diagrams will explain the steps undertaken in the test. Each diagram will compare the six different options a different number of sticks with each other on one of the camera heights (1.20 metre / 0°, 1.50 metre / 10° or 1.80 metre / 20°) and have the image rotate from 0° to 90°.

Fig. 9: Screen shot 3DMax of test set up

The tables are attached in Chapter 6 Appendix 2 – Tables.
When comparing the different surfaces with each other Option 2, 3 and 4 all achieved good results when compared with option 1 (100s/sqm). Option 5 has, when one considers the improvement of only 2 sticks less per square metre compared with Option 4, no advantages. Option 6 with a random number of openings will have a good resolution if one does not have less than 50% reduction of a full surface. Option 6 is interesting when considering that window openings do not necessarily have to be in a ridged grid and therefore can be arranged randomly over the façade.

The next test will look at an arrangement where a façade would have a combination of openings and higher and lower resolution. Firstly various kinds of options described earlier should be used:

- Option 1 with a resolution of 100s/sqm
- Option 2 with a resolution of 75s/sqm
- Option 3 with a resolution of 67s/sqm
- Option 4 with a resolution of 50s/sqm

Again the above explained five different combinations of options should be analysed in regards to viewing these 5 different combinations form different angle, as well as from varying distances of the beholder to the object. As explained at the beginning of this chapter the distance of the beholder to the object plays an important role in how one will perceive an image.

Therefore a 5x5 metre surface should be built by light points with a view from 1.80 metres, this being the height of an average person. Images should be taken from that height from a distance of:

- 1.0 metre to surface
- 2.0 metre to surface
- 5.0 metre to surface
- 10.0 metre to surface

Furthermore the surface should be analysed from different angles. Here the angles start at 0° to 60° in steps of 10° for the distances from 0.5 metres to 2.0 metres, and from 0° to 65° in 5° steps for the following tests.
The following images show the results from the first test using Option 1. Here also the set up should be tested to see if improvements are necessary to achieve a better understanding of the conducted tests. The pictures below show the surface with a depth of 0.4 metres (four light points in the colours yellow, gold, orange and red) from a distance of 1.0 metres rotating from 0° to 60° in steps of 10°.
Fig. 13: 1.0 meter distance moving in 10° angle to the right

Fig. 14: 1.0 meter distance, 20° angle to right

Fig. 15: 1.0 meter distance, 30° angle

Fig. 16: 1.0 meter distance, 40° angle surface gets denser on the right side
Next row of pictures show the surface with a depth of 0.4 metres (four light points in the colours yellow, gold, orange and red) from a distance of 2.0 metres rotating from 0° to 60° in steps of 10°.

**Fig. 17:** 1.0 meter distance, 50° angle

**Fig. 18:** 1.0 meter distance, 60° angle allows to see surface clear

**Fig. 19:** 2.0 meter distance, 0° angle, distance to surface has been doubled

**Fig. 20:** 2.0 meter distance, 10° angle towards right side
Fig. 21: 2.0 meter distance, 20° angle

Fig. 22: 2.0 meter distance, 30° angle

Fig. 23: 2.0 meter distance, 40° angle

Fig. 24: 2.0 meter distance, 50° angle
Fig. 25: 2.0 meter distance, 60° angle due to not pre-defining a particular surface any statement in regards the surface can be made.

Next row of pictures show the surface with a depth of 0.4 metres (four light points in the colours yellow, gold, orange and red) from a distance of 5.0 metres rotating from 0° to 65° in steps of 5°.

Fig. 26: 5.0 meter distance, 0° angle, the light points are not perceived very well due to render program.

Fig. 27: 5.0 meter distance, 05° angle.
Fig. 28: 5.0 meter distance, 10° angle

Fig. 29: 5.0 meter distance, 15° angle

Fig. 30: 5.0 meter distance, 20° angle

Fig. 31: 5.0 meter distance, 25° angle

Fig. 32: 5.0 meter distance, 30° angle
Fig. 33: 5.0 meter distance, 35° angle

Fig. 34: 5.0 meter distance, 40° angle

Fig. 35: 5.0 meter distance, 45° angle when light points come closer to the beholder due to altering camera angle one can see points better

Fig. 36: 5.0 meter distance, 50° angle
The pictures above already show a tendency of a surface with a depth of 0.4 metres or four points is not sufficient to compare different surfaces with each other when looking at how different resolutions could affect the overall impression. As mentioned earlier a new surface should be created for a better visualisation. The surface should have a greater depth as well as bigger pattern of the same depth. A simple surface defined by a sinus curve and extruded in the z-plane should be used in the following tests.
The tables will firstly compare only one of the before mentioned options with each other.

The comparison of the different surfaces with each other will be done in a set up similar to the one described in Subchapter [3.2.4.]. Therefore pictures of Option 1 - 4 from a distance varying from 1 to 10 metres will be compared with each other when seeing them from different angles.

The tables attached in Chapter 6 Appendix: Appendix 2 –Tables will show the results.

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[3.3.]
Conclusion

The tests conducted in this chapter show that it is possible to reduce the number of sticks from 100 to 50 per square metre, especially if one considers that in these tests each of the light points are only a sphere object with a minimum of self illumination.

In Project 1 - Realisation of system in regards to an industrial design product, different LEDS have been tested in regards to their brightness and perception. Here my research has shown that a LED will produce a much stronger light and therefore give a much stronger impression of a closed surface and not so much that of a surface created by isolated points.

With this in mind the next step will be analysing the options available with consideration of the financial aspects.
Test Series II: Analysis costs per square meter

To gain an understanding of the approximate costs per square metre an excel data sheet should be used. With the use of this data sheet the costs per pixel from an existing system should be investigated and then translated into the cost of one LED stick. This figure should then help to calculate the cost of a square metre when using the different resolutions introduced in the previous chapter.

The excel data sheet has been provided by Altoona, an Italian company providing large-screen displays. The data of this spreadsheet is used to analyse costs are based on 2D systems and the costs of providing all needs for such a system. For a 3D system in general the same component has to be used for controlling and playing images. So numbers for a 2D screen could be used as well as for a 3D screen. The main components in both cases are software, control units, LEDs and other electronic parts. As one can see in the data sheet in Chapter 6 Appendix: Appendix 2 – Tables different LED with different attributes are listed as having a price per square metre in English Pounds based on October 2004 prices.

The data sheet also contains other information that has to be taken into account when using the sheet as a base for cost calculation.

- Row 1 gives information about the pitch of the LEDs and therefore the resolution as can be seen in the row at the bottom when the costs are explained, the higher the resolution the higher the price, the reason for this is in the greater amount of LEDs per module.
- Row 2 explains an aspect that feeds back into the design of the system. The number of red, green and blue LEDs per pixel is usually not equal. For example, the last column explains the characteristics of
the PN 40 LED type. Here one pixel contains 3 green LEDs, 2 blue LEDs and 4 red LEDs.

- Rows 3 and 4 do not contain information of any importance in analysing the price of the system.
- Row 5 contains the number of pixels per module. The size of the modules is explained in row 9 – 12, with using this number the cost per pixel could be calculated and therefore a cost figure for the system established.
- Rows 6 – 8 do not contain information that is relevant in this research topic.
- Rows 9 and 10 contain, as mentioned previously, the Pixel/module width and height.
- Rows 11 and 12 explain the dimension in millimetres.
- Rows 13 specify the square metres and the costs to be expected.

The data sheet can be found in Chapter 6 Appendix: Appendix 2 – Tables.

[4.2.2] Analysing costs per pixel and per stick

Having explained in Project1 / Test Series III that SMD LEDs have to be used to minimise the masking caused by the substructure, only SMD LEDs should be used and only the costs for these should be analysed. Here three different SMD LEDs are listed in the spreadsheet. The price per pixel should be investigated for all three to see if there is any difference in the way they are built or if the price difference is caused by the higher resolution.

The costs mentioned in the spreadsheet are all in English Pounds, though due to basing my research in Australia all costs should be stated in Australian Dollars. The exchange rate for Pounds to Australian Dollars is 1 £ = 2.50 A$.

The following formula should be used in analysing the costs:

\[ \text{Cost in A\$} = \text{Cost in £} \times 2.50 \]

\[ \text{Cost in A\$} = \text{Price per Pixel} \times \text{Number of Pixels} \]

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\( ^1 \) The exchange rate is based on the value of the British Pound to the Australian Dollar mid September 2006, changes to the exchange rate will not be considered in my research.
(Cost of screen) / (Pixel/sqm) = Cost per pixel

- Cost calculation for PV5 SMD LED: 63,296 $AUD / 40,000 pixel
  = 1,58 $AUD /pixel
- Cost calculation for PV7 SMD LED: 39,288 $AUD / 20,400 pixel
  = 1,93 $AUD /pixel
- Cost calculation for PN16 SMD LED: 31,971 $AUD / 3,900 pixel
  = 8,20 $AUD /pixel

There is a big difference, especially between the PV5 and PV7 SMD LEDs to the PN16 SMD LED type. One can estimate that due to the 3 in 1 system of red, blue and green pixel in one element production costs for this kind of LED are higher.

It is thus likely that the PN16 SMD LEDs are the smallest in size and therefore most likely to be used for the system.

Therefore the cost per pixel will be 8.20 A$ in my system. When defining one light point in the model built and introduced in Project 1/Test Series VI, four LEDs or four pixels have been used to create one light point. This will increase the costs per light point when using 4 pixels per light point to 32.80 A$.

The total cost for one stick with a depth of 10 light points would therefore be 328.00 A$ / Stick.

This price should include all the costs for building the stick, because it would include also the costs for the extra hardware needed for a 2D screen.

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[4.2.3]
Costs per square metre

For 100 sticks per square metre

The costs per square metre are based on the previous calculations. The cost per stick is approximately 328.00 A$. Therefore the total cost per square metre when using 100 sticks is:

(100 Sticks/square metre) x (328.00 A$) = 32,800.00 A$ per square metre
For 75 sticks per square metre

The costs per square metre are based on the previous calculations. The cost per stick is approximately 328.00 A$. Therefore the total cost per square metre when using 75 sticks is:

\[(75 \text{ Sticks/square metre}) \times (328.00 \text{ A$}) = 24,600.00 \text{ A$ per square metre}\]

For 67 sticks per square metre

The costs per square metre are based on the previous calculations. The cost per stick is approximately 328.00 A$. Therefore the total cost per square metre when using 67 sticks is:

\[(67 \text{ Sticks/square metre}) \times (328.00 \text{ A$}) = 21,976.00 \text{ A$ per square metre}\]

For 50 sticks per square metre

The costs per square metre are based on the previous calculations. The cost per stick is approximately 328.00 A$. Therefore the total cost per square metre when using 50 sticks is:

\[(50 \text{ Sticks/square metre}) \times (328.00 \text{ A$}) = 16,400.00 \text{ A$ per square metre}\]

[4.3]
Conclusion

The costs for a square metre seems relatively high compared with ‘normal’ façade systems, but one should not forget that each square metre contains highly technological elements. Therefore a comparison with the systems provided by ALTOONA should be made. Here also the square metre price for SMD LEDs should be considered to have similar parameters such as size or brightness, as well as the cheapest option ALTOONA has in stock.
ALTOONA offers a square metre of:

- **PV5 SMD LEDs** for £25,339 or 63,497.50 A$ per square metre
- **PV7 SMD LEDs** for £15,728 or 39,320.00 A$ per square metre
- **PN16 SMD LEDs** for £12,799 or 31,997.50 A$ per square metre
- **PN40 LEDs** for £6,711 or 16,777.50 A$ per square metre

When comparing these figures with the expected costs of my system, it becomes obvious that the prices per square metre for a spatial dynamic media system are comparable with a common system.

The most expensive system offered by ALTOONA is actually nearly the double of the cost of a system with 100 sticks per square metre.
As per the results of my research tests conducted in the two previous chapters of Project 3, the design of the façade of building 91 should be based on these results. The design should be guided by the following parameters:

- Conserving as much as possible of the existing window to gain maximum daylight for the rooms
- Designing for the maximum resolution to allow the artist the greatest possibilities in defining a design
- Design under cost considerations
- Creating a design language / arrangement of the sticks on the façade based on images or sketches

Due to creating a dichotomy with these parameters, a well designed object does not always have to be the cheapest option e.g., different design options should be presented to fulfill different needs. As a result of this dichotomy several designs will be introduced, all designed under different emphasis to fulfill different needs.

Before designing the façade on Building 91 some preliminary studies should be done. These studies contain rough calculations of the amount of sticks used in different design scenarios.

As a premise a certain distance between the system and the ground should be introduced. This distance will be 3.10 metres from street level, from its highest point. This should protect the system from vandalism, i.e. people swinging on the sticks. This height measure must be taken due to the risk of possible damage. With this premise the maximum façade available for coverage with the system would be 13.0 metres in height and 33.55 metres in width.
This would result in a total of 452.93 sqm or 45,560 sticks when having a 100 sticks/sqm. The total cost then would be A$14,943,680.00. Even though it would create one of the biggest screens in 2D and definitely 3D at present, it would be, due to cost issues and no providing any opening such as windows, difficult to achieve.

As a first step all existing windows should be kept open to allow natural illumination for the room within the building. Here the total amount of sticks would be 32,277 when having 100 sticks/sqm, with a total cost of A$10,586,856.

An option, herein called option 1, which would give the artist the greatest possibilities in using the system as a ‘digital relief’, would be using a top part of the building which is currently a car park and therefore no natural illumination is needed. This option would need 21,775 sticks when having 100 sticks/sqm, with the total cost of A$7,142,200.

Due to the relative distance to the street level and the beholder an option of having 50 sticks/sqm could be considered which would result in using 10,877 sticks in total and therefore bringing the total costs to A$3,567,656. The total size of this surface would be 6.40 metres in height and 33.55 metres in width with 214.72 sqm in total. This option seems worth exploring further as it allows the artist a good space to work with.

An option, herein called option 2, with a consideration of cost, would be exploring a 1 metre high stripe of the system placed approximately at the position of the slab between 2nd and 3rd floor. With a dimension of 1 metre height and 33.55 metre width a total of 33.55 sqm or 3355 sticks would be used at a cost of A$1,100,440. This option again could be altered, when considering the costs to a 50 sticks/sqm option, and then using 1677 sticks in total and having a total cost of A$550,056.

A further option, herein called option 3, tries to integrate all design aspects to i.e. balance costs, artist’s requirements or natural daylight.

As discussed in the preliminary studies the first design will give artists a maximum of space, while the design for the second option is mainly driven by cost considerations.
The third design has more design-based aspirations. Here the idea of camouflaging the existing building with a skin came to mind. Therefore the arrangement of the sticks should be in a similar pattern as one can find in camouflage. The following images show some mood pictures.

**Fig. 41:** Image Camouflage as an inspirational image for designing the arrangement of LED sticks on the façade of Building 91 RMIT

Due to the rectangle size of the sticks, round forms are not possible to create. It has also been proven while working on the Mercedes-Benz booth in Geneva 2004 that it is not possible to recognize round openings when having a square shaped media system. Therefore the above introduced pattern has been altered to a rectangle form. As a method of translating the form into a rectangular one, forms seen in the computer game ‘Tetris’ should be used. These forms are built as explained in the graphic below.

**Fig. 42:** Variation of Tetris figures as a translation of the camouflage pattern into a way of arranging the LED sticks

These ‘Tetris’ elements create a pattern as displayed below, which will then be used as a method to arrange the sticks on the surface.
**Fig. 43: Surface pattern of how LED sticks are arranged on façade Bld 91 RMIT**

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**[5.2.2] Plans Option 1**

**Elevation**

Option 1 has been designed with the consideration of giving a commissioned artist the maximum surface to work with. See plan “Artist option” attached in Chapter 6 Appendix: Appendix 1 – Plans.

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**[5.2.3] Plans Option 2**

**Elevation**

Option 2 has been designed under cost considerations. See plan “Cost option” attached in Chapter 6 Appendix: Appendix 1 – Plans.

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**[5.2.4] Plans Option 3**

**Elevation**

Option 3 has been designed with the idea of placing a patterned screen on the building. See plan “Design option” attached in Chapter 6 Appendix: Appendix 1 – Plans.
The following details will show how the system will be attached to the existing wall of Building 91. Firstly a substructure according to the dimension of a civil engineer will be mounted to the wall. This substructure will carry the LED sticks. Due to each LED stick operating as a plug-and-play system wiring can be reduced to a minimum. The main wiring will be to the control units and from there to the CPU inside the building. See plan Detail attached in Chapter 6 Appendix: Appendix 1 – Plans.
My research has been applied in an architectural context on Building 91 RMIT University City campus, explained in the introduction of Project 2 in this chapter. The raised question of how many sticks per square metre are necessary has been answered in the sense that it is up to the designer or architect designing the façade as to what resolution the façade would take. All arrangements starting with 100 sticks per square metre down to 50 sticks per square metre offered an acceptable resolution where a surface could be perceived.

These different resolution types allow the designer to both have a variety of window openings one could choose from, or as it has been done in the example of my design to frame window openings with a stick arrangement that has been driven by other constraints. The introduced example presented in the previous chapter has for instance used the idea of camouflaging the building by using a camouflage pattern as a conceptual idea.

It is possible through different methods of arranging the sticks on a façade to achieve both a density of LED sticks which would allow the recognition of an image, as well as allow possibilities for openings for natural illumination. This possibility of different methods has another importance when considering the cost aspects of the façade. Cost calculation based in the excel data sheet introduced in Subchapter [4.2.1.] gave an understanding of the costs of the façade. By arranging the sticks in different ways it would allow flexibility in controlling the costs of a built façade when balancing the relation resolution/density and costs per square metre.

My research does prove that an arrangement of sticks could be found which allows a visible image on the façade, but it has also proven that the costs for having such a system are relatively high. Relative because it is in a price range one has to accept when applying media to architecture, but too high for a renovation project with a limited budget.

Furthermore the price per square metre is still too high to be paid without any funds. Therefore it could cause problems due to financial constraints, when considering to build a square metre as a test object to conduct different tests which are from interest of this research.
Step toward Project 2

With having constraints of a financial and technical nature in continuing my research, other options have to be considered. As it is not possible at present to build a system as a physical model, the system could be tested in a virtual environment. This step, when going from physical to virtual, could be justified with my research explained so far and the results of the tests which have proven that it is possible to deliver a system that could fulfil the requirements mapped in the theoretical underpinning.

What has not been considered in this research and will be the topic of the next two projects is the design of the media content that will happen in the zone, where all spatial representation will happen, itself. My research title: *Spatial Dynamic Media System – Amalgam of form and image through a 3D light point matrix to deliver a content driven dynamic zone in real-time* has an important focus on the media content which will be discussed and the subject of different tests in the next chapter.

Even when having a physical system one could use, the next step has to be the design of what will happen on the façade. Here the interest will be in what can be displayed when looking at two different forms both dealing with media content.

The first way in designing a media content will be me delivering a media content. This solution will be of course a very personal solution, which do not exclude the possibility of the existence of other solutions. The designed media content will be introduced in the next Chapter 5 Project 3, and will be applied on different tests where not only the media content but the system gets tested in applications for conferences, competitions and calls for art installations.

In the Chapter 5 Project 4, the second option in dealing with media content will be when one curates a media content and works as a curator for different media content. Here the task will not be working towards the solution of a design; it will be the offering of a tool for someone else’s solution.

After discussing a possible solution for the question of how a 3d light point matrix could be designed in the Chapter 5 Project 1 and then applied in Chapter 5 Project 2, the focus now will shift to how a media content driven dynamic zone in real-time could be delivered. The following projects *Project 3: Effect and use – providing a media content* and *Project 4: Effect and use – working as curator for different media*
contents are digitally generated animations of media content that could be delivered with the Spatial Dynamic Media System.
Project 3: Effect and use – providing a media content

[1.]
P 3 / Introduction Project 3

Following from the two projects investigating the research possibilities in developing a system that could display media content in a 3D matrix and applying this system in an architectural context, the next two projects investigated the effect and use of such a system. The developed LED stick, as part of the Spatial Dynamic Media System, does not create a surface - nothing has been designed yet. The exercise so far has focused on the initialisation of a platform where the design of a spatial movement could happen, as soon as the system received an injection of an electronic sensory-input. In Project 3, I provide a media content such as an electronic sensory-input to design a surface delivered through the 3D light point matrix. This will be only one option of many, thus Project 4 focused on the role of working as a curator for different media content where the research offers different tools (computer programmed codes) to translate media content into a surface movement.

The designed media content in Project 3 was tested in conference papers, competitions and art proposals. The designed media content was based on a call for a paper by the UNESCO Digital Arts Award 2005 hosted by ART CENTER NABI, a prestigious centre for new media art in Seoul, Republic of Korea, looking for young artists around the world to reflect on how urban spaces and city environments could be transformed into creative outlets cultivating artistic innovation and new forms of expression. The media content designed for a conference paper i had the media content displayed on the façade focused on the “expression of cultural diversity”. ii The term of cultural diversity should be altered to reflect common characteristics of humans rather than focusing on the common grounds of humans, instead on expressing the diversity, diversity of cultural background will be overlapped by common grounds such, as facial expressions. Facial expressions are a common ground of humans, even those from different cultural backgrounds. Even humans from differing cultural backgrounds have

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i The paper has been written for the UNESCO Digital Arts Award 2005 which encourage artists to reflect on the theme of Urbanity and Creative Media

ii This quote has been taken from the organisers homepage

www.nabi.or.kr/unesco_awards
characteristics common in all races, such as many facial expressions. These expressions could be translated into architectural expressions and thus humans could create, within their cultural diversity, an object derived from their common characteristics.

The conference paper included in Project 3 was submitted for the conference and it was subsequently translated into a designed object for a Design competition hosted by VIVOCITY in Singapore, October 2005. Here both the hardware - the LED Stick - was applied in a design proposal as well as the software - the designed media content - and tested as one design. My submission reached top 20 and participation in their exhibition demonstrated the value of the research to the organizers. Ultimately the main barrier to achieving a position in the top 3 was not having an off-the-shelf system which the organizers asked for as it was stated in a letter by the jury that, “production cost is limited, therefore to review how design can be done within a budget”.  

With the problem of there not being an existing system available, the media content was tested as an art installation at the ISEA2006 Conference in San Diego, USA. The ISEA2006 Symposium is a Global Festival of Art on the Edge that was open to groups and individuals to submit proposals for exhibition of interactive artworks and projects reflecting the themes of the Pacific Rim. Here, instead of having a physical system, my media content should be displayed in a VR environment as an installation where the public could participate.

[1.2]

**Design of media content**

My proposal includes an examination of new kinds of public participation in urban environments. I intend to set up the proposed system, with movement and human expression being compared to conventional architectural ‘expression’, which will be considered together with how different cultural groups can be involved in this arrangement.

Henri Bergson discusses a relative movement when he talks about; “..., the movement of an object in space. My perception of the motion will vary with the point of view, moving or stationary, from which I observe it. My expression of it will vary with the system of axes, or the points of reference, to which I relate it.”  

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1 The letter of the Organisers is attached in Chapter 6 Appendix – Appendix 4 Documents
example; “when you raise your arm, you accomplish a movement of which you have, from within, a simple perception; but for me, watching it from the outside, your arm passes through one point, then through another, and between these two there will be still other points; so that, if I began to count, the operation would go on for ever.”

But instead of focusing on the metaphysical relations that have been the topic of Bergson’s essay I want to concentrate on the perception of a movement from an outside view and how it can be read.

William F. Allman argues in his book about evolutionary psychology The Stone Age Present that humans are more competent in memorising and reading animated objects such as faces than in remembering unanimated objects or numbers. The ability to read and understand animated objects and read them in the same way through all cultures can be seen in the ability to universally interpret the movements of the human face such as smiling, frowning, or shock.

Communication between humans can be held verbally but at the same time non-verbally by miming and gestures. Non-verbal communications are generally easier to understand, will be similar in most cultures and will by read by all cultures in the same way. So will the movement of an arm, the example used by Bergson in explaining a movement perceived from the outside, be understood as a movement with a certain intention to express emotion. This non-verbal understanding has found its artistic expression in the performance art of a mime artist. Modern mime is a branch of theatre in which the performer usually uses no voice but instead performs using spatial and corporeal movement, full-body physical expressions, body language and gesture, often with little or no theatrical props. It is often, but not always, done in white face and the movements and expressions are heightened for greater effect.

As Allman states, “Emotional cues are so important to human survival that a “universal grammar” has evolved in human facial expression. The human facial expressions that spring from feelings of grief, sadness, anger, disgust, surprise, fear, and happiness are universal among all human societies.” Allman argues as well that:

“For the most people, the facial muscles involved in shaping the face when they are experiencing emotions are not under conscious control. Only 10 percent of us, for instance, can voluntarily pull the corners of the mouth down to make the prototypically human “sad” face. The rest of us can make this face only while also moving the muscle near the chin,
which is a giveaway for a phoney expression. Likewise, only 15 percent of people can voluntarily raise their eyebrows at the center of their forehead to duplicate the forlorn look of grief and distress.”

To allow humans an easier recognition of these facial expressions a study of the nature of beauty in human faces was undertaken. The conclusion Allman took from this study was that;

“The research suggests that the human brain has been sculpted by evolution to regard as most attractive those faces that are, ironically, most average. This preference may have evolved in our ancestors because, as representatives of the community at large, these average faces would be easier to read for subtle expressions of happiness or concern that serve as important social clues.”

Communication through mime has therefore been an important part in our daily life, but what is miming in a spatial sense?

When one moves one’s face to express something the surface of one’s face changes and therefore creates a changing surface. The surface face is alterable through parameters such as emotions that will be shown by different arrangements of the face so even if the faces look different the emotion or meaning will always be the same. These expressions can be digitalized and reproduced in a façade that allows the display of 3D images. As referred to above, each part of the face is responsible for expressing a certain kind of emotion – Allman refers to the mouth muscle being responsible for expressing sadness, while the chin muscle stays still. Each expression on each part of the face will be then located in a field of the façade, ideally in approximately the same location of its original location on the face.

The mimicry of the human face and expression via 3D imagery can be consolidated by the use of colours for expressing different emotions. Studies of the relation between colours and emotions have been done in chromatics, the study of the science of colour. It includes the perception of colour by the human eye, the origin of colour in materials, colour theory in art and colour psychology. With colour psychology as a field of study devoted to analyzing the effect of colour on human behaviour and feelings, it is shown that these effects differ as various cultures see colours differently. So colour alone, as seen in the D-Tower, bears the risk of being misunderstood in a cross-cultural
community. In addition a determined form designed by an architect still does not allow culturally diverse communities to express themselves in an architectural gesture. The D-tower was designed by an architect coming from one cultural group which could be used by people from different cultural groups, so even though the colour and the appearance express the emotions of the participants the architecture itself does not. So regardless of linguistic diversities and cultural differences, the façade or face – and here I want to highlight the linguistic similarity between these two words – could function as a ‘friendly alien’ to mediate between different groups within the community. This will be done through miming the same expressions as humans, but through its artificial nature stands between them and puts the focus onto the human behaviour by adopting human behaviour. It will strengthen the community relations and respect the linguistic diversity and the cultural knowledge of different languages by not having the need to use them, through communicating with non-verbal methods.

So far architecture has been determined mainly by the education and the cultural background of the architect. A design of a building mainly comprised the cultural and social background of the designer. An involvement of the beholder as a user did not exist. This involvement and identification with the building and its cultural context decreases when a diversity of cultures lives together. When, as happens in post modern cities, different cultures live together, a design made by a member of one cultural group can exclude members from the other groups.

A light-animated surface that is defined by the captured similar emotions – the participation of the beholder in a cross-cultural form of expression – ensures an exclusion of one or more cultures no longer occurs. It allows the beholder to reflect themself in the building so it leads to a negation of the design idea of the façade and therefore the author or architect vanishes behind his/her work and the beholder becomes the person in charge of designing the “temporal events-within form”, an expression used by Stephen Perrella when he talks about topological space as “influenced by the inherent temporalities of animation software, augmented reality, computer-aided manufacture and informatics in general.”

A façade that is a “temporal event-within form” can allow the beholder as a participant to be engaged in the design of the temporary appearance of the spatial relation they have with their environment, i.e. it allows creation through participation.
The media content explained in the previous Subchapter [1.2.] was used in a call for conference papers by UNESCO and Art Center NABI for the UNESCO Digital Arts Award 2005. The UNESCO Digital Arts Award, which forms a special category of the UNESCO Prize for the Promotion of the Arts dedicated to recognizing outstanding creative achievements by young artists in different fields of arts, aims at promoting cultural diversity and encouraging dialogue between cultures through innovative artistic ideas and forms, using new media and technology. The Award 2005 was organized in association with Art Center NABI, a prestigious centre for new media art in Seoul, Republic of Korea, founded on the basis of a non-profit centre in December 2000. Art Center NABI is engaged in research, education, production and exhibition of new work, with special emphasis on nurturing creativity through intercommunication between various experimental fields such as humanities, social sciences, pure and applied sciences, technology and art.

Both organisations wanted to encourage young emerging artists to reflect on the theme of ‘Urbanity and Creative Media’ and to send project proposals in the categories of digital art (including media installation, interactive art, wireless art, digital sound art and other forms of creative digital practices) that focus on the following topics of urbanization and the critical issues surrounding urbanity and new media: 7

- Urban space as fluid interface, geographical canvas, social playground
- Transforming urban spaces into fostering dialogue
- Revitalization of urban spaces through active community engagement
- Mapping and networking in areas of conflict and post-conflict
- Imagining futuristic cities
SPATIAL DYNAMIC MEDIA SYSTEMS

My project proposal is an investigation into the perceptual boundaries between the virtual and physical world and how to break them. It asks how architecture can creatively adopt a fourth dimension, in this project a dimension provided through the use of digital technologies. The project draws from two examples of existing buildings / installations are used to demonstrate how movement and light colour have been used in architecture with the participation of the public. The first exemplar project is the physical movement of a full-size wall surface: ‘Aegis Hyposurface’ (dECOi Architects+ Deakin University / Mark Burry). The second project expresses a town’s collective emotions through dynamic change in architecture via the use of colours: the D-tower (QS Serafijn & Lars Spuybroek/NOX).

SEARCH FOR AN INTERACTIVE 3D DYNAMIC SYSTEM

Three discreet considerations are required in order that such a system achieves its full potential.

Firstly how are forms received and can they be defined with the use of light? The illumination of the city gives the beholder a notion of space at night time, where they can locate the city and its buildings in relation to his own position - something one could not do if there had not been any light in forms and therefore the possibility to define space with the use of light.

Secondly, I want to investigate the potential existing media technologies beyond their typical application to architecture. Currently the typical application of arrays of lights (Times Square for example) can only offer the display of apparent 3D images and forms – but these ‘3D forms’ are never actually 3D, they only become 3D when one ‘moves’ it with a computer mouse. The reason for this is the 2D nature of the display. Extended beyond their typical 2D application set to give an illusion of 3D is my proposed façade built with a 3D grid of lights each with X,Y,Z coordinates with point lights at each intersection of the grid. This façade will be erected by a number of ‘sticks’, attached in a 90 degree angle to the existing façade, and each of these sticks contains an array of LEDs in certain distances to each other along the stick. An equal resolution could be achieved in all three axes; images displayed in the X, Y, and Z planes and more importantly as 3D objects. Through their ‘non-physical’ existence, it can change its image and its spatial boundaries over time and therefore allow a strong relation between
time and space and create new concepts of space, time, and social relationships in an urban environment.

Thirdly, I want to investigate the potential existing media technologies beyond their typical application to architecture. These stations contain 3D face scanners that are open to the public. Face expression will be scanned in at these stations; collected and displayed on the facade.

A REDEFINITION OF ‘PLACE’

Why do I want to do this? One of my core questions is to reconsider what new relationships are possible between place and media, and the consequences for interactive projects that result. ‘Place’ is a term that has a variety of meanings in a dictionary sense, but which is principally used as a noun to denote location, and primarily in the sense of what is actually within that location. By using 'place' in architecture, it defines 3D static objects that create the urban landscape and therefore notion of space and density. Media in a place on the other hand, is a two dimensional dynamic element mainly added on a 3D form, i.e. onto a building. This leads to the result that the ‘user’ of the place only being able to consume its surface/media appearance, without allowing participation. Can these two elements be combined to create a three dimensional dynamic element enabling participation by the city’s inhabitants and if so, in what ways could people participate and play within the urban environment in the dynamic formation of cities?

THE SET UP OF FACE / FAÇADE

My proposal includes an examination of new kinds of public participation in urban environments. I intend to set up the proposed system, with movement and human expression being compared to conventional architectural ‘expression’, which will be considered together with how different cultural groups can be involved in this arrangement. Bergson discusses a relative movement when he talks about; “the movement of an object in space. My perception of the motion will vary with the point of view, moving or stationary, from which I observe it.” William F. Allman argues that communication between humans can be held verbally but at the same time non-verbally by miming and gestures. Non-verbal communications are generally easier to understand. This non-verbal understanding has found its artistic expression in the performance art of a mime artist. Allman states, “Emotional cues are so important to human survival
that a “universal grammar” has evolved in human facial expression. The human facial expression that spring from feelings [...] is universal among all human societies.9 Communication through mime has therefore been an important part in our daily life, but what is miming in a spatial sense? When one moves one’s face to express something the surface of ones face changes and therefore creates a changing surface. These expressions can be digitised and reproduced in a façade that allows the display of 3D images. So far architecture has been determined mainly by the education and the cultural background of the architect. A light-animated surface that is defined by the captured similar emotions – the participation of the beholder in a cross-cultured form of expression – ensures an exclusion of one or more cultures no longer exists.

CONCLUSION

Through having a system that can display the time dimension within a spatial construct, the focus of the project will be the subject of interactivity. How this concept allows the participation of the public and its cultural-sociological meaning will be examined. This will be a far-reaching proposition of how the public will be included in the decision process of defining space, through expressing our innermost feelings through an architectural medium. Thus emotions of the individual have a platform and can be brought indirectly to the public, and in turn open up discussions about the state of the community through the state of the façade. An alliance of media and place in an urban context can be achieved and created, with the participation of its inhabitants, along with a new perception of how media and architecture can together shape and inform spatial relations.

----------------------------------------------------------------------------------------------------------

[2.3]

Result

The paper was not accepted at the conference. Due to not getting any feedback by the organizers it is not possible to evaluate my research proposal for further participation in competitions or conferences. Nevertheless the original media content idea should now be applied in an actual project and be tested in a context by participating in a competition.
The next test in applying the media content described in Subchapter [1.2.] was a design competition in Singapore organised by Mapletree Investments. Mapletree Investments is the developer of Vivocity, the shopping complex with approximately 1.5 million square feet of gross floor area and 1.1 million square feet of retail space built on the site of the exhibition halls of the former World Trade Centre, now the HarbourFront Centre in Singapore. The complex was designed by the Japanese architect Toyo Ito and was officially opened on 1 December 2006.

Vivocity has taken part in Singapore’s first biennale by lending itself as a site under its art and design program. The international student design contest Vivocity had the theme ‘fluidity’ to reflect the design of the building. Here the organizers asked entrants to create interactive street furniture. The theme of fluidity is an interest of the investigate Spatial Dynamic Media System of this research, where fluidity is not only suggested by a form but is made possible due to a visual zone where space can be shifted and altered in real-time.

The following pages were sent to the organizers as a contribution to the design competition. They represent a mixture between the paper submitted for the conference in Seoul, South Korea and illustrations and plans of how the system could be adopted as the fluid street furniture the competition brief required. Some aspects of the text presented in the panels have been further developed and discussed in this research since the time of the competition in October 2005, but represent the material handed in to the organizers at that time. The plans show, attached in Chapter 6 Appendix: Appendix 1 – Plans, a possible arrangement of LED sticks in plan and section, and also contain a first illustration of how the zone could look when visualised.
[3.3] Result

The submitted design achieved a position in the top 20 of 365 submissions from various countries. The organisers then asked for further developments to be made in a second stage of the competition where all 20 competitors had the chance to review their project.

The review included comments from the judges. One of the comments was more general, asking about the interactive relation between people/viewer and design (see letter from Vivocity in Chapter 6 Appendix: Appendix 4 – Documents). The specific comments/queries from the judges in regards to my design, at that time called ‘Light animated Hypersurface’, were answered in a separate sheet and sent with the reviewed plans to the organizers.

In this second round the design could not achieve any further improvements and did not make it to the top three of the competition.

In feedback from the judges, one of the main reasons of not finishing in a higher position was highlighted by the judges’ second ‘special’ comment in regards to production costs.

Due to not having an existing product/LED stick and only a very limited budget provided by the organisers to build the street furniture it was difficult to respond to this comment in a convincing way. All other responses in regards to the design considered the concerns of the organisers and provided them with a rational explanation as to how the design could be altered. The responses of the jury have been attached at Chapter 6 Appendix: Appendix 4 – Documents.
Due to cost and realisation concerns of the organizers as a result of the last experiment when applying the system with a designed media content the next step will be applying the system without using the LED sticks. With this step the possibilities of applying the system without major cost for the further development of the LED stick should be investigated. Therefore the function of the LED stick will be taken over by a back projection and 3D glasses similar to the VR (virtual reality) centre located in Building 91 RMIT City Campus or the IMAX cinema. This step will reduce the costs for the hardware and works with existing products available on the market. This will be applied on the call for invitation by the ISEA 2006 Symposium and ZeroOne San Jose: A Global Festival of Art on the Edge, for groups and individuals to submit proposals for exhibition of interactive artworks and projects reflecting on the thematic of the Pacific Rim. The organizers seek proposals that address, but are not limited to, art works that emphasize radical and alternative responses to contemporary cultural conditions throughout the Pacific Rim. They want to encourage proposals specifically from emerging artists. Of particular interest are projects that focus on engagements and interaction strategies with Diaspora communities as well as works that enable new discourses, platforms and explorations.

As the Pacific Rim contains a cross cultured population, the competition appeared like a possible experiment field for the designed media content - a design that shifts authorship from mono-culture to cross cultured design and functions as a cultural-sociological focus point.

The plans show, attached in Chapter 6 Appendix: Appendix 1 – Plans, the set up of the installation.
The Installations Hardware (3D bodyscanner, Computer and 3D Projector) will be located in one temporary room with the approximate size of 35 square metres. Following table is an explanation of how the installation will be used to give the organizers of the ISEA 2006 conference an idea of the narrative of the installation:

<table>
<thead>
<tr>
<th>1. Getting to the installation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants are asked to wait in line if they want to participate in the installation; people which choose not to participate can pass by them and view the installation without being scanned.</td>
</tr>
</tbody>
</table>

(see attached image on the right)

<table>
<thead>
<tr>
<th>2. 3D head scanning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants enter the 3D head scanner and getting their heads scanned in. This will take a few seconds, for further reference to the timeframe of the installation please have a look at the time line attached to this application.</td>
</tr>
</tbody>
</table>

(see attached image on the right)

<table>
<thead>
<tr>
<th>3. Taking 3D glasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>After being scanned in, each visitor can take 3D glasses and enter then the actual installation space.</td>
</tr>
</tbody>
</table>

(see attached image on the right)
4. **Viewing the installation**  
Viewers are able to see their own facial expression displayed by the mentioned array of light points, projected by the 3D projector. Their image will then after a certain time vanish and will be replaced by the next image produced with the head scan of the next person.  
*(see attached image on the right)*

5. **Information about the artwork**  
After experiencing the installation the participants can get further background in technical aspects and other details of the installation.  
*(see attached image on the right)*

6. **Returning 3D glasses**  
Participants are asked to return their 3D glasses to be used by the next participants.  
*(see attached image on the right)*
The diagram below shows the timeline of the installation. When person 1 enters the installation through the 3d head scanner it will take approximately 15 seconds for the scanner to scan the head in. After this time frame the 3D head scanner is empty and ready to use for the next person. Person 1 will continue to pick up the provided 3D glasses, while Person 2 will enter the 3D head scanner. At time T=35 sec. Person 1 will see his/her face displayed as a 3D light point matrix based on the media content explained in Subchapter [1.2.]. Also after T=35 sec. the transparency of ones translation of a human expression into an architectural expression will be displayed with 100% transparency. In the time between T=35 sec. when person 1 sees one image/surface on full transparency to T=55 sec. when person 2 would see one image/surface of human/architectural expression in full transparency an overlapping of both images occurs.

Here two characteristics explained in the Chapter 4 [2.3] can be experienced. The first is a multilayered surface when at approximately T=45 sec. both images are visible and
will be overlapping each other. The second is a decay of a surface or image, e.g. the one of person 1 between time T= 15 sec. till T= 55 sec. when the surface will have 0% transparency at time T= 15 sec. and 100% at T=35 sec. and then going back to 0% transparency at time T= 55 sec.

[4.2.3]

Technical description

The system contains three major items, the Hardware (3D bodyscanner, Computer and 3D Projector) and the Software that runs the system.

Firstly, with a 3D bodyscanner, e.g. the Vitrus ahead – 3D head scanner © (see Fig. 1),

“three dimension scanning is as easy as can be: a person stands in the center of the measuring portal and the laser light sources (which are not harmful for the eyes) are switched on. [...] A few seconds later, the necessary data is collected. A so-called ‘3D point cloud with colour overlay’ composed of several million 3D measuring points has been generated. A virtual duplicate of the person has been created with maximum precision. Due to its high resolution the 3D head scanner VITUS ahead is able to scan even delicate details of the face. The products generated with the scanned 3D data show an amazing similarity to the real object (see Image 2). The non-contact measurement is carried out by 8 triangulation cameras with a resolution of approx. 1 mm within less than 10 seconds. [...] The data can be used for animations as well as for medical purposes.”

Regarding information from the manufacturer, the first format of the so-called ‘3D point cloud’ is an ASCII format that can be translated into different 3D modelling formats such as *.STL, *.OBJ, *.VRML. These are common file extensions for 3D model programs such as Rhino, 3DMax and others. The before mentioned programs are all able to work with scripts and are therefore able to take the data from the ‘3D point cloud’, point by point with the exact coordinates for each point as a X,Y,Z value.

i  http://www.vitus.de/english/
Secondly, software called Open Scene Graphic will, in combination with a BATCH file, split the image into three to create the 3D effect, providing a format that can be displayed with a projector.

Thirdly, the hardware component 3D projector, here a projector like the InFocus™DepthQ™ 3D Video Projector, will be used for creating a 3D image. The InFocus™DepthQ™ 3D video projector is a lightweight single lens video projector capable of achieving true output frame rates of 120Hz. When used with a stereoscopic 3D image source and liquid crystal "3D" shutter glasses, InFocus™DepthQ™ will provide a stereo 3D experience (see Fig. 3).

Fig. 1: Vitrus ahead – 3D head scanner

Fig. 2: 3D model of scanned head

Fig. 3: InFocus™DepthQ™, a projector which can be used for 3D projection
Fig. 4: Principle of how a back projection works, the black line in the center is the projection plane

The projector creates a 3D image by using a process called back projection. As its name implies, back projection is the inverse function of projection. When an n-dimensional object is projected, each projection is an n-1 dimensional sum of its density along with the projection axis. Therefore, a sphere would have circles as its projections. A cube, on the other hand, would produce squares, diamonds or other intermediate parallelograms (see Fig. 4 top) depending on the direction of projection. The actual shape, of course, depends on the orientation from which the projection was made. The reverse function (see Fig. 4 bottom) is called back projection and regenerates the original object. Since a projection can be thought of as a "squishing" of the object, back projection is then the "smearing" of the projections back onto each other. The sum of the back-projected projections regenerates the original object. In the example above, a cube generated different parallelograms in projection. The image gets projected onto a transparent surface that functions as a medium in between the two projections.

Fig. 5: set up back projection with the projectors at the back and the projection plan in the front, the coloured image in the center represents the 3D projection

For further information about the products see following two homepages:

www.vitronic.com - for the 3D Head scanner
http://www.depthq.com/ - for the 3D projector
[4.3]

Result

The art installation was not accepted by the organisers, and unfortunately this proposal as well as in the first paper written for the UNESCO Digital Art Award, no results were provided. Therefore a reflection and evaluation based on thoughts and feedback by others has not been possible.

Nevertheless the project should be reflected on to investigate weak points when realising the project.

The project contained two elements which were crucial for the success of the project. The hardware, in this case the back projector and the 3D head scanner, and the software that would recognise the emotion expressed and then translate these into an architectural expression.

When looking at the hardware, the back projector should not have been a problem due to being a wide spread technology easy to access and purchasable off the shelf at any media rental company. An organiser focused on the development of digital arts should have heard and be aware of this technology. The 3D head scanner is certainly a technology not as common as a projector, though despite this the submitted information should have been adequate to gain an understanding of the technology and how it would work. Also the spatial arrangement of the 3D head scanner and projector was explained and did not contain any difficulties. Financial constraints could have been one reason for the lack of success as the submitted financial proposal asked for high financial participation of the organizers.

But the main issue would have been when dealing with software issues. The software required for the project does not yet exist and the paper could probably not convince the organizers of the possibility of developing a software that would recognise 3D data of a head in regards to emotion. This software would then focus on certain parts of the face and then display/represent these parts in the form of a certain colour, as seen at D-tower project in Doetinchem, and form of the surface due to the spatial arrangement of muscles on a face. Here a research conducted by others was found that proved the existence of software that will capture emotions from a 2D image. The NewScientist.com news service published on 17 December 2005 the following article
that discussed the possibility of recognizing human emotions just by looking at photographs or videos:

“Software decodes Mona Lisa's enigmatic smile

- 17 December 2005
- NewScientist.com news service

It’s official: Leonardo da Vinci’s Mona Lisa was 83 per cent happy, 9 per cent disgusted, 6 per cent fearful and 2 per cent angry.

Nicu Sebe at the University of Amsterdam in the Netherlands tested emotion-recognition software on the famous enigmatic smile. His algorithm, developed with researchers at the Beckman Institute at the University of Illinois, Urbana-Champaign, examines key facial features such as the curvature of the lips and crinkles around the eyes, then scores each face with respect to six basic emotions. Sebe drew on a database of young female faces to derive an average "neutral" expression, which the software used as a standard to compare the painting against.

Software capable of recognizing human emotions just by looking at photographs or videos could lead to PCs that adjust their response depending on the user's mood, as well as smarter surveillance systems."11

This software could be used as a component when writing a code for software that could fulfill the required task of recognizing the emotion of a 3D scanned face. As the above mentioned publication was in mid December 2005 the proposal for the ISEA conference had already been submitted and the development could not be considered. As a conclusion of the result a need for developing appropriate software to deliver media content seems essential. This will be the main issue to be considered when working as a curator for different media contents where one, a designer or artist, would have expectations in having a tool provided that would deliver ones media content.
Conclusion of Project 3: Effect and use – providing a media content

The third project has shown three different experiments in how a designed media content could be applied to different tasks. Due to the nature of the designed media content all three experiments had a cross-culture focus and all three experiments were chosen because they allowed the possibility of using the media content.

With the first experiment, the entry to the UNESCO Digital Arts Award, a theoretical framework was defined when submitting the conference paper. This paper was then used as the basis for translating the design from a theoretical stage to a practical application, using the idea and also the designed Spatial Dynamic Media System to create a host for the media content where the media content could be displayed.

This development then found an application in the second experiment, the entry for the Design competition Vivocity in Singapore. Not only could the media content be tested in this experiment, but also the system LED stick, through designing a box covered with the system and dealing with certain problems when using the LED sticks, and therefore having feedback on the design of the LED sticks. This has been a valuable experience for my research - seeing the designed media content as an opportunity to test the system again in light of the possibility of the design being installed and applied in a built environment.

The third experiment could then focus itself mainly towards the media content and not the system as such. Here, different characteristics of the spatial dynamic media system were applied in combination with the media content. This experiment also worked out most of the issues of realising an installation of the media content, by investigating all required hardware and to a certain extent the software. The software as a topic and its importance will be discussed further in the next chapter.

When evaluating Project 3 one conclusion can be made. It has been possible to design a space by a new form of design input. Even if it has been only one of many possible design options applicable for the system, the introduced media content of a relation between human and architectural expression has been possible only in its presented way when using a spatial dynamic media system. Other systems which work in a similar
field of shifting architecture towards an alloplastic, a concept introduced in the Chapter 3 [2.] would have been able to present the human expression only in either a spatial way, by altering space similar to movement of facial muscles, or by a change of colours to express emotions through the use of different colours. A transition from one human expression to another as explained in Chapter 4 Project 3 [4.2.4] Diagram timeline would also not have been possible.

The media content furthermore has included some of the particularities of the spatial dynamic media system, such as the decay function or a multilayered surface and could show here, with the design how the media content could be augmented through the system.

[5.2]
Step toward Project 4

The last of the three experiments, delivering an artwork for the ISEA conference 2006, has shown that one of the reasons why the applications has not been successful could be found in the lack of a provided and tested software. Having used mainly off the shelf hardware applications such as 3D head scanner and a back projector the software was the critical point where the realisation of the proposal failed.

When working as a curator for different media contents a lack of software will become an issue. Here certain considerations must be made as to what kind of media content could be provided by an artist or designer and what kind of creative input of a designer there could be.

These questions can be answered when working together with one artist or a group of designers through talking about their work and the requirements necessary to display their ideas with my researched system. Another option could be the provision of different softwares which would allow artists and designers to investigate the possibilities of a spatial dynamic media system.

Therefore different fields could be looked at, such as what input the system could receive to then transform this input into a spatial arrangement.

As a starting point a code should be developed that allows the display of any data collected by a sensor, such as temperature, wind speed, sound or other data. All these data have one thing in common, they all can be stored and analysed in a program.
Mostly the results will be captured and compared against each other, e.g. the temperature of a certain space or area over a period of time. A program able to process these data calculations is the Excel program provided by WINDOWS. The variety of data could be big, but they will ultimately provide all numbers which are fed into an Excel data sheet and from there be transformed with a code and then displayed in a three dimensional array.

Another code could look into the translation of images, pictures and movie clips into a spatial arrangement to investigate the possibilities of transforming the moving aspect of an object in a movie into a movement of a surface. Here for example a certain RGB value or black and white value could be connected to a spatial position in a third dimension, so the image becomes distorted not in a way that it would represent a three-dimensional image but a translation of the 2D image through a chosen parameter into a 3D form.

The above mentioned two examples should then offer the particularities of a spatial dynamic media system. They have been connected with media content in Subchapter [4.] in this project but should now be integrated as an option of the software. This collection of different codes should give my research the possibility to demonstrate what spaces could be delivered with the system.
2 Ibid., p. 23
4 Ibid., pp. 94-95
5 Ibid., pp. 116-117
[1.]
P4 /
Introduction Project 4

My work has taken me so far to this point, but I do not want to take the research done in Project 3 further in this regard, to free the research from focusing on only one media content. Having tested the possibilities of a designed media content in three different contexts, the potential, however, seems convincing, but this would have to be taken further in research beyond the scope of that which I have defined as my own. In Project 4, a number of exemplary codes were provided which created a dynamic space. The outcome of these codes are neither a form of art or communication there function is testing my researched system further. In comparison to the designed media content presented in the previous Project 3 I do not have the intention to create an art work or a form of communication with these codes. I want to hand over the design of the media content to other designers or artists in order to focus on curating supplied media content. To do so, I have written these sets of different codes in VB script/Rhino script to possibly allow artists or designers to work with the Spatial Dynamic Media System
and explore new possibilities. My intention at this point is the testing of the system with written codes.

To cover different ranges of possible media content the following codes were offered:

- A code to create a moving surface delivered through media content generated from digital input taken from the environment. With this proposed code the research offers artists the opportunity to use sensors as a method of capturing environment activity. Sensors here imply all kinds of recording devices that can measure temperature, wind speed, movement and humidity among others.¹

- A zone based on an image or a movie clip. Based on the colour information stored in an image, a code could use this information to generate a moving surface based on the movement within an array of images or a movie clip. Every image has an array of pixels in X and Y

¹ The function of sensors and the possibilities of sensors in architecture are based on a research using Smart Materials and Technologies by Michelle Addington and Daniel Schodek
direction that define its size and store colour information. The size of the image could be used to define the size of the zone in X and Y direction. The Z direction would then be driven by the colour. In the background discussion I talked about creating an amalgam of form and image, the code has been written with this interest in mind.

- A surface based on a scanned 3D form. Similar to the first step of the designed media content described in chapter [3.4.3.] a surface can be scanned in, such as a face. This scanned in surface is then displayed with light points, each light point being a different colour depending on its position in space. The previous Project 3 had a designed media content based on a 3D scan. The code written in this test wants to explore if it is possible to create a light point surface based on a scanned 3D form.

The general outcome of the tests conducted so far shows that it is possible to ‘inject’ information into the system to generate a moving surface in real-time. They can be used as tools for artists and designers utilising the Spatial Dynamic Media System, as described above, regarding tests such as the visualisation of information or the amalgam of form and image. In addition, the tests also proved propositions made in Chapter 3. Here the research discusses a multilayered surface and a decay function for a surface and the significance of the possibilities for architecture, as per the theoretical discussion in the background discussion, but the tests in this Chapter 4 Project 4: Effect and use – Working as a curator for different media content have demonstrated that it is possible to create such surfaces. Therefore, test series 5 and test series 6 investigates anomalies of surface in an intangible zone – the possibility to create a multilayered surface and the option of applying a decay function.

- To create a multilayered surface two types of discrete data stored in two remote Excel™ sheets are used and played simultaneously. These two data sheets create two surfaces, coloured differently. When both surfaces overlap their colour changes to a third colour. Here two surfaces can be perceived at one time, overlapping but still visible due to their incorporeal nature, and furthermore the two surfaces generate a third form or surface depending on the input of the two original surfaces. This has been
discussed as a possible significance in the theoretical framework and now been tested.

- The Plug-in for decay function also demonstrates a proposition made in the theoretical framework. A code has been written which will simulate a surface decay by giving single LEDs a brightness that varies from 0% till 100%. This creates the outcome of an after-effect of the façade that has just been, or will be in the future when the zone modifies itself through movement from its present state.

All these scripts have been loaded into and presented via Rhino.
The presented scripts can be seen as a first step to what is possible by creating a system such as the *Spatial Dynamic Media System*, and how artists and designers can be involved in the design of a surface. All the codes function as a tool set which can be developed further via outsourced ideas and media content.
Test Series I: 
Creating a surface based on an Excel datasheet input

To give artists a first tool to work with, a translation of data from an Excel sheet into a surface defined by light points should be scripted. The idea would be to create a program where the artist could use any kind of information translated into an Excel sheet and have this information displayed on the façade. Due to having no explicit data to be shown and not wanting to provide any meaningful content in this exercise, Excel will provide results with random data.

The RAND function in Excel “Returns an evenly distributed random real number greater than or equal to 0 and less than 1. A new random real number is returned every time the worksheet is calculated.” Based on this function a surface of no meaning can be produced as a test of the program and to analyse the outcome.

The following script has been generated to achieve the translation of Excel data into a surface:

```
' CREATES A MATRIX OF POINTS BASED ON AN EXCEL DATA SHEET
' Script for Rhino 3.0
' Written by M. Hank Haeusler 13.01.2007
' Matthias.Haeusler@ems.rmit.edu.au
'
'DESCRIPTION: creates a matrix of points based on an image txt file
'STATUS: working
'TO DO: For this script to run, Rhino3 needs to be running first.
'
****************************************************************
Public Sub ImportPoints()
****************************************************************
' start of rhino connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
```

Microsoft Excel Help text for RAND
Dim RhinoScript As Object
Set RhinoScript = RhinoApp.GetScriptObject()
Dim arrOldObjects
'end of rhino connection

****************************************************************

SURFACE VARIABLES
Uvalue = 10 'surface height - number of rows
Vvalue = 10 'surface length - number of columns
arrCount = Array(Uvalue, Vvalue)
arrDegree = Array(2, 1)

SPHERE VARIABLES
myradius = 10

END VARIABLES

Loop for each sheet in the Excel book.
Dim Loop1(99) 'has to equal 0 + Uvalue*Vvalue

For j = 1 To Sheets.Count
    For j = 1 To 40
        EnableRedraw - switch of screen to start / finish script
        RhinoScript.EnableRedraw (False)

Removes all objects.
arrOldObjects = RhinoScript.AllObjects()
If IsArray(arrOldObjects) Then
    RhinoScript.DeleteObjects (arrOldObjects)
End If

loops to get XYZ from Excel spreadsheet
For i = 0 To UBound(Loop1)
    pointX = Sheets(i).Cells(i + 1, 1).Value
    pointY = Sheets(i).Cells(i + 1, 2).Value
    pointZ = Sheets(i).Cells(i + 1, 7).Value
    Loop1(i) = Array(pointX, pointY, pointZ)

Create a point
    RhinoScript.addpoint Array(pointX, pointY, pointZ) SWITCHED OFF

Next

Creating a surface of points from Excel
    mySrf = RhinoScript.AddSrfPtGrid(arrCount, Loop1, arrDegree) SWITCHED OFF

Creating sphere at each point with a function
    myspheres Loop1, myradius

EnableRedraw - switch of screen to start / finish script
    RhinoScript.EnableRedraw (True)

Next

Tells that script is finished
    MsgBox ("Script Finish")

End Sub

****************************************************************

Function myspheres(centres, radius)
    Function for Rhino 3.0
    Written by M. Hank Haeusler 13.01.2007
    Matthias.Haeusler@ems.rmit.edu.au
'DESCRIPTION: creates a sphere
'STATUS: working
'TO DO: add parameters required in the () out of sub main to run
****************************************************************
'start of rhino connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
Dim RhinoScript As Object
Set RhinoScript = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
'end of rhino connection
****************************************************************
' Loop for each point.
For j = 0 To UBound(centres)
    myspheroid = RhinoScript.AddSphere(centres(j), radius)
    myred = centres(j)(2)
'Variables for colour arrangement
Dim mycolourzero, mycolour02, mycolour03, mycolour04,
    mycolour05
Dim mycolour06, mycolour07, mycolour08, mycolour09, mycolour10
Dim TempColor
Dim limit1, limit2, limit3, limit4, limit5, limit6
'Colour definition for 10 different rows
mycolourzero = RGB(0, 0, 0)
mycolour01 = RGB(195, 32, 217)
mycolour02 = RGB(0, 0, 255)
mycolour03 = RGB(0, 132, 239)
mycolour04 = RGB(0, 240, 144)
mycolour05 = RGB(167, 252, 0)
mycolour06 = RGB(238, 246, 0)
mycolour07 = RGB(240, 202, 0)
mycolour08 = RGB(229, 114, 0)
mycolour09 = RGB(239, 41, 0)
mycolour10 = RGB(239, 59, 59)
'gets Z value from coordinate of sphere
    tempcoord = centres(j)
    tempz = tempcoord(2)
    If (tempz = 0) Then RhinoScript.ObjectColor myspheroid, mycolourzero
    If (tempz = 100) Then RhinoScript.ObjectColor myspheroid, mycolour01
    If (tempz = 200) Then RhinoScript.ObjectColor myspheroid, mycolour02
    If (tempz = 300) Then RhinoScript.ObjectColor myspheroid, mycolour03
    If (tempz = 400) Then RhinoScript.ObjectColor myspheroid, mycolour04
    If (tempz = 500) Then RhinoScript.ObjectColor myspheroid, mycolour05
    If (tempz = 600) Then RhinoScript.ObjectColor myspheroid, mycolour06
    If (tempz = 700) Then RhinoScript.ObjectColor myspheroid, mycolour07
    If (tempz = 800) Then RhinoScript.ObjectColor myspheroid, mycolour08
    If (tempz = 900) Then RhinoScript.ObjectColor myspheroid, mycolour09
    If (tempz = 1000) Then RhinoScript.ObjectColor myspheroid, mycolour10
Next
End Function

Certain lines have been switched off, having been written in the process of creating the script in helping to work with a methodology and then switched on after reaching the next.

These are the figures that have been used based on the random function explained earlier. The first column stands for the value generating the X coordinate, the second row for the value generating the Y coordinate and the third one the Z value. To create a surface as it could be perceived when using the system the values in column 3 have to be rounded due to having no position in a Z direction, for example a value of 755 will be rounded to 800, a figure that can be displayed in the 3D grid.

<table>
<thead>
<tr>
<th>Row defining position</th>
<th>X-Value</th>
<th>Y-Value</th>
<th>Z-value</th>
<th>Rounded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>755</td>
<td>800</td>
</tr>
<tr>
<td>100</td>
<td>0</td>
<td>0</td>
<td>184</td>
<td>200</td>
</tr>
<tr>
<td>200</td>
<td>0</td>
<td>0</td>
<td>829</td>
<td>800</td>
</tr>
<tr>
<td>300</td>
<td>0</td>
<td>0</td>
<td>673</td>
<td>700</td>
</tr>
<tr>
<td>400</td>
<td>0</td>
<td>0</td>
<td>228</td>
<td>200</td>
</tr>
<tr>
<td>500</td>
<td>0</td>
<td>0</td>
<td>164</td>
<td>200</td>
</tr>
<tr>
<td>600</td>
<td>0</td>
<td>0</td>
<td>797</td>
<td>800</td>
</tr>
<tr>
<td>700</td>
<td>0</td>
<td>0</td>
<td>239</td>
<td>200</td>
</tr>
<tr>
<td>800</td>
<td>0</td>
<td>0</td>
<td>954</td>
<td>1000</td>
</tr>
<tr>
<td>900</td>
<td>0</td>
<td>0</td>
<td>673</td>
<td>700</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
<td>0</td>
<td>259</td>
<td>300</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>0</td>
<td>430</td>
<td>400</td>
</tr>
<tr>
<td>200</td>
<td>100</td>
<td>0</td>
<td>808</td>
<td>800</td>
</tr>
<tr>
<td>300</td>
<td>100</td>
<td>0</td>
<td>796</td>
<td>800</td>
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<tr>
<td>400</td>
<td>100</td>
<td>0</td>
<td>602</td>
<td>600</td>
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<td>......</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This data continues until a surface with the dimensions 10 light points in X direction, 4 light points in Y direction and 10 light points in Z direction could be generated.
When running this script the following surface appears (Fig. 1 - Fig. 3: Images of the visualisation of script).

![Fig. 1: Images of the surface created by the script as a first step](image1)

![Fig. 2: This surface then gets translated into light points only](image2)

![Fig. 3: Light points then gets displayed in different colours regarding on their position on the Z axis](image3)

One can see that picture 1 creates a highly irregular surface. Due to the random function of Excel it is difficult to see more than an assembly of light points in picture 2. Since these images are only for visualisation of the script, this does not matter.
A collection of data for testing the script has been taken from the water levels of the dams around Melbourne.

“Melbourne gets its water supply by 9 different catchments located around Melbourne. Most of the catchments are located high up in the Yarra Ranges, north east of Melbourne. Traditionally these reservoirs were built to meet increasing demand for water, spurred on by population growth, dry spells and the inevitable drought. The last and largest of Melbourne's water storages, the Thomson Reservoir, was completed in 1984.”

The water levels of these dams are published daily on the homepage of Melbourne Water and the local newspaper. The data used for this research has been taken from the homepage of Melbourne Water, a homepage which details the water levels and several actions to preserve water and the water system in general. The water levels in the archives have been stored weekly and the levels from 5 January 2006 – 12 October 2006 have been used to create 40 sheets in Excel as an input for the script.

An example of how this data has been delivered is illustrated in the image below which represents the water level at the 24 January 2007. The Data sheet is attached in Chapter 6 Appendix: Appendix 2 – Tables.

One can see all 9 Reservoirs (Thomson, Upper Valley, O'Shanassy, Maroondah, Sugarloaf, Yan Yean, Greenvale, Silvan, and Cardinia) and the total water level. The percentage in % of these 10 figures has been used to run the script.

The following images illustrate the outcome of the script test when applying the water level input. All images have been taken straight from Rhino by taking screenshots while the script was running.

---

Fig. 4: Screenshot in Rhino which illustrates the environment the scripts is running at

The Image sequence P_2.3.2.B – E shows four zone arrangements as a result of the input data from a certain week out of the 40 weeks possible.

Fig. 5: Screenshot in Rhino of representation of information of water level at week 7

Fig. 6: Screenshot in Rhino, shows water level in week 18

Fig. 7: Screenshot in Rhino in week 27
Test Series II: Creating a surface based on a movie clip

The test should investigate another possibility in how media content could be presented. Here my research wants to offer the possibility for designers or artists to translate the movement represented in a movie into the movement of a surface. This translation should not be seen as a direct translation of the moving 2D image, i.e., a person walking from left to right on a screen into the same image but in 3D, but as a translation of the movement of pixels by their change of colour - colour information into a spatial movement.

Each moment in a movie, a certain pixel has different colour information. If pixel ‘A’ at position X = 0 and Y = 0 has at time T = 0 sec. the colour RGB = 0, 0, 0 for black and the movie has 25 frames per second it would be possible that the RGB colour information would change 25 times per second. This movement should be expressed by a spatial movement with the use of my researched system.

At present video artists are exploring possibilities such as creating different atmospheres within a movie when using different lights or colours, but so far none have made a movie considering how the effects of colours, light, movement and narrative will influence a surface. This is what my research wants to provide to artists when being the curator for different media contents.

The test is based on a function offered by the modelling software RHINO where one has the possibility to import an image into Rhino and alter the 2D image into a 3D surface. What the function does is analyse the colour of the image and give each colour a certain depth. The produced surface is therefore a result of what colours have been used in the image and how they have been arranged. One has the option to import *.bmp, *.tga, *.jpg, *.pcx, *.png, *.tif, *.tiff files into the function.
When following the program it first asks for the first corner and the size. It is therefore possible to define the size of the image, which is important because that will reflect later on the size of the screen available.

After defining the size the program asks for information about the number of sample points and height.

![Fig. 8: Program interface Rhino to create Heightfield function](image)

The number of sample points defines the angle from one level to another, and the higher the number the closer the angle gets to 90°, as better one pixel or colour information could get separated in 3D from another.

The height enables defining the depth of the surface, ie. when choosing 80 mm the surface will have a depth of 80 mm, and through this function the depth of the surface created with the LED sticks could be defined, as well as the number of colours existing in the movie.

If for example each single frame of a movie has 8 different colours per image, then each colour will stand for one depth level, so the total height of the surface will be a multiplication of 8 and the surface will have 8 depth level, with each depth level displayed by one LED within the LED stick.

To gain a better understanding of the Heightfield function and to optimise it for the translation of a moving image to a moving surface the following tests were conducted.
Firstly a white square was imported to Rhino with the Heightfield function to prove if an image with only one colour would create an even surface. This did happen - when importing the white square one could create a flat surface. See images below.

![White square](image01.png)

**Fig. 9:** White square, which will be altered in Rhino by the Heightfield function

![Result white square](image02.png)

**Fig. 10:** Result white square imported to Rhino altered with Heightfield function

As a next step a black and white image was imported, and here the number of sample points was tested. One could achieve the best results with a number of 200 sample points, which guaranteed, as mentioned earlier, the 90° angle between the surfaces.

![Black and white square](image03.png)

**Fig. 11:** Black and white square, which will be altered in Rhino by the Heightfield function
To test it further the square was divided into four pieces.

In the next step the two colours black and white are extended to four colours when two grey scales were also used. The two new colours were grey 50% and grey 75%.
Fig. 15: Four grey gradient square four pieces, to test how the Heightfield function reacts to different grey gradients

Fig. 16: Four grey gradients square imported to Rhino creating four different squares with a certain height level

The tests proved that different colours will create different heights. If one could see each of the four grey tones in the pictured square before as one pixel and each pixel produced by one LED stick one could create a surface with four different heights.

[3.2.3] Foundation studies with Photoshop

Adobe programs are commonly used for working with images. When having a movie clip of a certain length this movie can be altered to single images. If the movie has for example 25 frames per second, each second in the movie will result in 25 images, and the translation of the movie into single images could be done in Adobe After Effects or similar video editing programs. Each image could be then altered in Photoshop from the original image to an image suitable for my research purpose. What steps have to be done in Photoshop?
Firstly, the image tests with Heightfield from Image have shown that it is possible to create different heights from black and white images; therefore a colour image should be altered into a greyscale image.

After altering the image to a greyscale image, the resolution has to be altered in regards to the size of the spatial dynamic media system. If for example the screen would be 6m*4*m one would have 60 * 40 pixels, due to having 10 * 10 pixel per square metre. The test picture should therefore be altered to a resolution of 100 pixels in width and 66 pixels in height.

The image then would still have an undefined number of colours, but each colour would create in the Heightfield from Image function a position in the Z – plane,
therefore a specific number of colours have to be defined. When saving the image as ‘save for web’ one can define how many colours one will use. The range here is from 2, 4, 8, 16, 32, 64, 128, 256 possible colours. For Test image step 04 a range of 8 different colours will be used. The image would therefore have a depth of 8 light points on the LED stick.

![Fig. 20: Test image step 04 where the image only contains 8 different grey gradients](image)

When repeating these four steps for each single image a movie could be created which could be later translated to be displayed on a spatial dynamic media system screen with the dimensions of 100 pixel by 66 pixel and a depth of 8 pixel or, in metres, 10m * 6.6m * 0.8m. These dimensions have been chosen only for demonstration purposes and could be altered for all other dimensions as well depending on the existing dimensions of the spatial dynamic media system.

[3.2.4] Scripts to alter a surface to a light point grid

Based on the previous tests, a script should test what kind of result could be achieved when importing an image into rhino with the Heightfield from Image function. The resulting surface should then be divided by a point grid system; depending on their Z-value location each point on the surface should be stored in a separate layer. For a better visualisation each point should be changed into a sphere with different layer colours.

The image below has been altered from its original resolution and colour to an 8 bit image with a resolution of 20 pixels height and 26 pixels width.
When imported to Rhino with the Heightfield from Image function the following surface is the result when having a setup as explained in Subchapter [3.2.1.] with a number of sample points 200 x 200 and a height of 80 mm.

The following script has been then applied to arrange points on a surface:

```
'****************************************************************
' ArrayPointsOnSurface
' Script for Rhino 3.0
' Sample Script of Rhino 3.0 altered by M.Hank Haeusler 13.01.2007
' Matthias.Haeusler@ems.rmit.edu.au
```

**Fig. 21:** Test image for script

**Fig. 22:** Test image with a resolution of 20*26

**Fig. 23:** surface generated out of image with the Heightfield function
' DESCRIPTION: Creates an array of points on a surface.
' STATUS: working
' TO DO:

Option Explicit

Sub ArrayPointsOnSurface()
Dim strObject, nRows, nColumns
Dim U, V, i, j, arrParam(1), arrPoint
' Get the surface object
strObject = Rhino.GetObject("Select surface", 8)
If IsNull(strObject) Then Exit Sub
' Get the number of rows
nRows = Rhino.GetInteger("Number of rows", 2, 2)
If IsNull(nRows) Then Exit Sub
nRows = nRows - 1
' Get the number of columns
nColumns = Rhino.GetInteger("Number of columns", 2, 2)
If IsNull(nColumns) Then Exit Sub
nColumns = nColumns - 1
' Get the domain of the surface
U = Rhino.SurfaceDomain(strObject, 0)
V = Rhino.SurfaceDomain(strObject, 1)
If Not IsArray(U) or Not IsArray(V) Then Exit Sub
' Add the points
For i = 0 To nRows
    arrParam(0) = U(0) + ((U(1) - U(0)) / nRows) * i
    For j = 0 To nColumns
        arrParam(1) = V(0) + ((V(1) - V(0)) / nColumns) * j
        arrPoint = Rhino.EvaluateSurface(strObject, arrParam)
        If IsArray(arrPoint) Then Rhino.AddPoint arrPoint
    Next
Next
End Sub

The image below illustrates how the surface will look with points arranged on a surface.

Fig. 24: surface generated out of image with points on surface when using the script
The next step/script takes a collection of points of different heights and assigns them to different layers depending on a specified range and number of divisions. It is designed to work with a surface from Heightfield from Image and the 'array points on surface' sample script.

****************************************************************
ASSIGN LAYER BY HEIGHT SCRIPT
****************************************************************

Option Explicit

Sub assignlayerbyheight()

'define variables
Dim arrPoints, strPoint
Dim dblMinZ, dblMaxZ
Dim dblDivisions, i
Dim dblTotalRange, dblDivisionRange
Dim arrPtCoords, dblPtZ

'select points
arrPoints = Rhino.GetObjects("Select points to assign to layers", 1)

'define range of heights
dblMinZ = Rhino.GetReal("Define minimum z value", 0)
If IsNull(dblMinZ) Then Exit Sub
dblMaxZ = Rhino.GetReal("Define maximum z value", 10)
If IsNull(dblMaxZ) Then Exit Sub

'define number of divisions
dblDivisions = Rhino.GetInteger("Define number of divisions", 8, 2)
dblDivisions = dblDivisions - 1

'calculate range for each layer
dblTotalRange = dblMaxZ - dblMinZ
dblDivisionRange = dblTotalRange / dblDivisions

'add new layers
For i = 0 To dblDivisions
    Rhino.AddLayer "Layer " & (i+1)
Next
i = 0
'loop through all points
For Each strPoint In arrPoints
  'get z value of point
  arrPtCoords = Rhino.PointCoordinates(strPoint)
dblPtZ = arrPtCoords(2)
  'assign layer based on z value & calculate range dynamically
  For i = 0 To dblDivisions
    If dblPtZ > (dblMinZ + (dblDivisionRange*i)) And dblPtZ < (dblMinZ + (dblDivisionRange*(i+1))) Then
      Rhino.ObjectLayer strPoint, "Layer " & (i+1)
    End If
  Next
Next
End Sub

AssignLayerByHeight

****************************************************************

The image below illustrates the outcome of the script.

Fig. 25: surface generated out of image with points on surface and heights in different colours

For a better illustration and to generate a better render each point should have a sphere for clearer illustration. This should also be done with a script.

' AddSpheresToPoints
'Script for Rhino 3.0
'Written by M.Hank Haessler 13.01.2007
'Matthias.Haessler@ems.rmit.edu.au
'Description: Script to add a sphere to a series of points and add it on the same layer as the point.
'Status: working
'To Do:

****************************************************************
Option Explicit

Sub AddSpheresToPoints() 'Define Variables
Dim arrPoints, dblRadius, strPoint
Dim strPointLayer, arrPointCoordinates

'Get user inputs
arrPoints = Rhino.GetObjects("Select points to assign to layers", 1)
dblRadius = Rhino.GetReal("Define radius of spheres", 1)

Rhino.EnableRedraw vbFalse
'loop through all points
For Each strPoint In arrPoints
  'get layer of point
  strPointLayer = Rhino.ObjectLayer(strPoint)
  'set current layer to same as point
  Rhino.CurrentLayer strPointLayer
  'get coordinates of point
  arrPointCoordinates = Rhino.PointCoordinates(strPoint)
  'add sphere
  Rhino.AddSphere arrPointCoordinates, dblRadius
Next
Rhino.EnableRedraw vbTrue
End Sub

AddSpheresToPoints '****************************************************************

The image below illustrates the outcome of the script.

Fig. 26: surface generated out of image with points on surface and heights in different colours with points for better illustration
Before continuing with scripting a second look should be taken at the Heightfield function to explore possible problems.

Further tests with the Heightfield function should explore further if this function could be used for translating an image into a surface. With the results of the previous foundation study with Photoshop in mind an image containing 8 different colours should then be translated into a surface.
These 8 colours should then be mixed up to create different steps.
What has been noticed is the irregular distance between the gradients; even they had frequent gradient steps between them. It seems that the height between different colours varies depending on if they have a higher or lower level of black in them. The next image illustrates this with measured heights from one height to another height.

\[\text{Fig. 33: Different heights when using 8 colours grey gradient, which proves that the Heightfield function do not create an exact position depending on the colour value}\]

---

\[\text{[3.2.6] Conclusion}\]

Even if the Heightfield option would in principle do what is necessary to translate an image into a surface, it seems not ideal to achieve a clear image. This is due to the Heightfield function not being as precise as other options, which should be explored in the next chapter.

---

\[\text{[3.3] Tests with translating pixel information into an Excel data sheet]\]

\[\text{[3.3.1] Introduction}\]

When doing the foundation studies explained in Subchapter [3.2.3.] another option was discovered in how the colour information of an image could be translated into a surface. When recalling the Heightfield from Image function, one notices that the main role of this function is giving a colour a certain position in the Z – axis. This has been explained in Subchapter [3.2.2.] when analysing different colours and their position in the Z – axis. When using Photoshop the program offers an Info tool which tells the location of the pixel as well as the colour information in RGB and CMYK.
This kind of information could be used when finding a way to export the colour information of each pixel to an Excel data sheet. The datasheet would then feed a script which would translate the colour information into a Z – value. The size of the image would define the size of the surface in the X and Y plane and the colour information in the Z plane.

[3.3.2] ImageJ program

The ImageJ program allows its user to save an image file such as *.jpeg or *.tif into an *.txt file. The txt file could be then opened in Excel to create an Excel data sheet. The following steps illustrate what the program does:

When opening the image in ImageJ, ImageJ shows the pixel size, colour information and size of image in kilobit.
It is then possible to change the image to a ‘Text image’ which will produce the before mentioned *.txt file. This file will be then opened in Excel.
The following array of data is visible in Excel:

```
138  125  139  201  203
114  118  143  205  187
  58   82  154  215  191
111  114  147  237  226
143  126  131  219  208
```

Each of these numbers represents colour information in greyscale. Greyscale has a pixel value from 0 to 255, 0 meaning the darkest and 255 meaning pure white.

The following script makes it possible to convert the information stored in the Excel sheet into a surface. To illustrate the process a test images previous used in Subchapter [3.2.4] should be reused.

Fig. 38: Test image for script

Fig. 39: Test image with a resolution of 19*25

When saved as a text image in ImageJ and exported to Excel the following data array has been the result:
The script below would then be applied to alter this data into a surface generated by points:

```vba
Sub PointsFromImage()
    'start of rhino connection
    Dim RhinoApp As Object
    Set RhinoApp = CreateObject("Rhino3.Application")
    Dim Rhino As Object
    Set Rhino = RhinoApp.GetScriptObject()
    RhinoApp.Visible = True
    'end of rhino connection

    'gets information from excel
    Dim currentPoint
    Dim MyPointCount As Double
    Dim AllpointCoords
    Dim MyXRow
    Dim MyYRow

    'creates a matrix of points based on an image test file
    'Written by M. Hank Haeusler 13.01.2007
    'Matthias.Haeusler@ems.rmit.edu.au
    'DESCRIPTION: creates a matrix of points based on an image txt file
    'STATUS: working
    'TO DO:
```

200
MyYRow = Rhino.GetReal("How big is picture in X direction?")
MyXRow = Rhino.GetReal("How big is picture in Y direction?")

newPointCount = MyXRow * MyYRow
ReDim AllpointCoords(newPointCount)
For i = 1 To MyXRow
    For j = 1 To MyYRow
        Z = Cells(i, j).Value
        currentPointCoord = Array(i, j, Z)
        currentPoint = Rhino.AddPoint(currentPointCoord)
    Next
Next
End Sub

The image below illustrates the outcome of the script. One can recognize that each point has exactly the same distance to another point in all three axes. This is a main difference to the tests conducted with the earlier scripts, which were based on the Heightfield from Image function. The Heightfield function had differences in the distance from one point to the other in the Z-axis. This is much better controlled when altering an image with the ImageJ program.

![Image](image.png)

**Fig. 40:** surface generated out of feeding information provided by ImageJ into script

The next step is applying the script used before in Subchapter [3.2.4] **ASSIGN LAYER BY HEIGHT SCRIPT** this script will then pick all points and select them regarding the position in the Z-axis into different layers.

When applying the script and analysing the result, a few alterations and improvements of the script were necessary.

The image was upside down and also the surface height not displayed correctly with having white as the brightest colour close to the viewer and black as the darkest colour at the end. The first problem of the upside down image could be solved when altering the line:
currentPointCoord = Array(i, j, Z)

in the script above to:

currentPointCoord = Array(i, -j, Z)

to allow the image to be built up in Rhino not close to the location 0,0,0 in the coordination system and then moving towards +X und +Y direction, but in a same way one would read a page, starting at the top left corner.

The analysing the images created in Photoshop one important difference was noticed. When saving the image in Photoshop as a ‘save for web’ image the colours and the colour index have been in an order so that the colour index of the brightest colour (white) had the colour index 7 and the darkest (nearly black) the colour index 0. This was not the case when the image was saved and analysed again in Photoshop (see images P_3.4.1.B and P_3.4.1.C). The colour index was then mixed up. An effect of depth created through colour could not be achieved with a not-ordered colour index. This mix-up was corrected within the script when altering the colour index, which drives the Z – value, into a corrected new Z – value.

**Fig. 41:** Analysis of image with a black image
RGB value 4, 4, 4 having index 0

**Fig. 42:** Analysis of image with a black image
RGB value 250, 250, 250 having index 2
For this image following the alteration of the Z – value has been included in the script.

'New Z value to create a depth in regards to greyscale
If z = 6 Then MyNewZ = 0
If z = 3 Then MyNewZ = 1
If z = 5 Then MyNewZ = 2
If z = 2 Then MyNewZ = 3
If z = 0 Then MyNewZ = 4
If z = 1 Then MyNewZ = 5
If z = 4 Then MyNewZ = 6
If z = 7 Then MyNewZ = 7

This alteration has to be done for each picture series, or at least has to be controlled before applying an image to guarantee a gradient from black to white.

----------------------------------------------------------------------------------------------------------

[3.4.2]
Final script

Resulting on the above mentioned testings and alterations to work towards a final script, the following script is able to take a movie and translate movement happening within it into a movement of a surface. As an example, to test the script and demonstrate how the result could look, a movie showing a time lapse of clouds moving across a blue sky has been chosen.

Fig. 43: Image taken out of movie clip, which functions as a sample image for testing script

This image has then been altered into a greyscale 8 bit image and then into a text image as described in Subchapter [3.4.1].

'****************************************************************
' CREATES A MATRIX OF POINTS BASED ON AN IMAGE TEST FILE
'Script for Rhino 3.0
'Written by M. Hank Haeusler 13.01.2007
'Matthias.Haeusler@ems.rmit.edu.au
Sub PointsFromImage()

' start of rhino connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
Dim Rhino As Object
Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
' end of rhino connection

' Variables
Dim currentPoint
Dim MyPointCount As Double
Dim AllpointCoords
Dim MyRowX
Dim MyRowY
Dim arrAllPoints
Dim MyNewZ
Dim arrOldObjects
Dim MySheetCount
Dim Loop1
MySheetCount = 1

'define image size in pixel + size of sphere
MyRowY = Rhino.GetReal("How big is picture in Y direction?")
MyRowX = Rhino.GetReal("How big is picture in X direction?")
MyRadius = Rhino.GetReal("What is the radius of spheres?")

'redim code
newPointCount = MyRowY * MyRowX
ReDim AllpointCoords(newPointCount)

'Counts sheets in excel
For k = 1 To MySheetCount

'EnableRedraw - switch of screen to start / finish script
Rhino.EnableRedraw False

'Removes all objects.
arrOldObjects = Rhino.AllObjects()
If IsArray(arrOldObjects) Then
    Rhino.DeleteObjects (arrOldObjects)
End If

'Loop for creating an image of one sheet out of excel
For i = 1 To MyRowX
    'i gets X Value
    For j = 1 To MyRowY
        'j gets Y Value
        z = Cells(j, i).Value
        'gets Z Value
        z = Worksheets(k).Cells(j, i).Value
        'New Z value to create a depth in regards to greyscale
        If z = 255 Then MyNewZ = 0
        If z = 254 Then MyNewZ = 0
        If z = 253 Then MyNewZ = 0
        If z = 252 Then MyNewZ = 0
        If z = 251 Then MyNewZ = 0

        Rhino.AddMeshModel(MyNewZ)
If z = 249 Then MyNewZ = 0
If z = 248 Then MyNewZ = 0
If z = 247 Then MyNewZ = 0
If z = 246 Then MyNewZ = 0
If z = 245 Then MyNewZ = 0
If z = 230 Then MyNewZ = 1
If z = 229 Then MyNewZ = 1
If z = 228 Then MyNewZ = 1
If z = 227 Then MyNewZ = 1
If z = 226 Then MyNewZ = 1
If z = 225 Then MyNewZ = 1
If z = 224 Then MyNewZ = 1
If z = 223 Then MyNewZ = 1
If z = 222 Then MyNewZ = 1
If z = 221 Then MyNewZ = 1
If z = 202 Then MyNewZ = 2
If z = 201 Then MyNewZ = 2
If z = 200 Then MyNewZ = 2
If z = 199 Then MyNewZ = 2
If z = 198 Then MyNewZ = 2
If z = 197 Then MyNewZ = 2
If z = 196 Then MyNewZ = 2
If z = 195 Then MyNewZ = 2
If z = 194 Then MyNewZ = 2
If z = 193 Then MyNewZ = 2
If z = 175 Then MyNewZ = 3
If z = 174 Then MyNewZ = 3
If z = 173 Then MyNewZ = 3
If z = 172 Then MyNewZ = 3
If z = 171 Then MyNewZ = 3
If z = 170 Then MyNewZ = 3
If z = 169 Then MyNewZ = 3
If z = 168 Then MyNewZ = 3
If z = 167 Then MyNewZ = 3
If z = 166 Then MyNewZ = 3
If z = 145 Then MyNewZ = 4
If z = 144 Then MyNewZ = 4
If z = 143 Then MyNewZ = 4
If z = 142 Then MyNewZ = 4
If z = 141 Then MyNewZ = 4
If z = 140 Then MyNewZ = 4
If z = 139 Then MyNewZ = 4
If z = 138 Then MyNewZ = 4
If z = 137 Then MyNewZ = 4
If z = 136 Then MyNewZ = 4
If z = 120 Then MyNewZ = 5
If z = 119 Then MyNewZ = 5
If z = 118 Then MyNewZ = 5
If z = 117 Then MyNewZ = 5
If z = 116 Then MyNewZ = 5
If z = 115 Then MyNewZ = 5
If z = 114 Then MyNewZ = 5
If z = 113 Then MyNewZ = 5
If z = 112 Then MyNewZ = 5
If z = 111 Then MyNewZ = 5
If z = 90 Then MyNewZ = 6
If z = 89 Then MyNewZ = 6
If z = 88 Then MyNewZ = 6
If z = 87 Then MyNewZ = 6
If z = 86 Then MyNewZ = 6
If z = 85 Then MyNewZ = 6
If z = 84 Then MyNewZ = 6
If z = 83 Then MyNewZ = 6
If z = 82 Then MyNewZ = 6
If z = 81 Then MyNewZ = 6
If z = 60 Then MyNewZ = 7
If z = 59 Then MyNewZ = 7
If z = 58 Then MyNewZ = 7
If z = 57 Then MyNewZ = 7
If z = 56 Then MyNewZ = 7
If z = 55 Then MyNewZ = 7
If z = 54 Then MyNewZ = 7
If z = 53 Then MyNewZ = 7
If z = 52 Then MyNewZ = 7
If z = 51 Then MyNewZ = 7
If z = 30 Then MyNewZ = 8
If z = 29 Then MyNewZ = 8
If z = 28 Then MyNewZ = 8
If z = 27 Then MyNewZ = 8
If z = 26 Then MyNewZ = 8
If z = 25 Then MyNewZ = 8
If z = 24 Then MyNewZ = 8
If z = 23 Then MyNewZ = 8
If z = 22 Then MyNewZ = 8
If z = 21 Then MyNewZ = 8
If z = 10 Then MyNewZ = 9
If z = 9 Then MyNewZ = 9
If z = 8 Then MyNewZ = 9
If z = 7 Then MyNewZ = 9
If z = 6 Then MyNewZ = 9
If z = 5 Then MyNewZ = 9
If z = 4 Then MyNewZ = 9
If z = 3 Then MyNewZ = 9
If z = 2 Then MyNewZ = 9
If z = 1 Then MyNewZ = 9
If z = 0 Then MyNewZ = 9

'creates point in Rhino
currentPointCoord = Array(i, -j, MyNewZ)
'creates sphere in Rhino
currentSphere = Rhino.addsphere(currentPointCoord, MyRadius)
'call colour function
MyChangeColor currentSphere, currentPointCoord(2)
Next 'next for (i)
Next 'next for (j)
'EnableRedraw - switch of screen to start / finish script
Rhino.EnableRedraw True
'call screengrab function
screengrab (k)
Next 'next for (k)
'Tells that script is finished
MsgBox ("Script Finish")
End Sub
The script also has a function which will capture an image at the end of each loop to illustrate the result and the changes of the surface while running the script.

```vbscript
' Function screengrab(i)
' Function for Rhino 3.0
' Written by M. Hank Haeusler 23.01.2007
' Matthias.Haeusler@ems.rmit.edu.au

' DESCRIPTION: Incremental Screen Capture to file location
' STATUS: working
' TO DO:

' start of Rhino Connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
Dim Rhino As Object
Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
' end of Rhino Connection

' function screengrab
Dim sPath

' Specifies Path location and file type
sPath = "S:\Students\Hank\01_RESEARCH\Surface scripting\02_PICS\screengrab of multilayered surface" & i & ".jpeg"
Rhino.Command "-_ScreenCaptureToFile " & Chr(34) & sPath & Chr(34) & " Enter"

End Function
```

When altering the images generated from the cloud movie into txt files and then importing them into Excel, Excel limited the amount of columns one could have to 255. Therefore the image had a pixel resolution of 255 * 200. Furthermore Photoshop had difficulties when saving the images as a *.gif file and altered some of the colours. As a result of this the images were not saved with the ‘save for web’ command but with the ‘Posterize’ command, which allows the user to define how many colours one would like to have in an image. I have limited the number to 10 colours, which has been as the excel data sheet later proved, more then exact 10 colours, it produces a range of 10 very colours with having each single colour with some same variations. This have been considered in the script and altered to a total of 10 colours which feed into the script.
The following 10 images have been selected to represent how the result could look. Due to there being nearly 600 single images not all of them could be displayed here.
Picture Series 1: Sequence of images first 10 of 589 the information of the cloud movie which were fed into the script

[3.5]
Conclusion

It has been possible to provide future artists with a tool that would allow them to explore the potential of a Spatial Dynamic Media System when coming from a film or image based background. The code also allows the user to set certain parameters such as the number of colours or how these colours are then translated.
P4 / 4.1 Introduction

Test Series III:
Creating a surface based on a 3D form

This test addresses a solution for an application similar to that in the designed media content in Project 3 where human faces were scanned in order to analyse their emotions. Here a 3D surface, that being the face, has been scanned and displayed via a 3D light point matrix. This will be achieved by using the following script, where any surface could be analysed and separated in a grid of point. Each point should then have its own colour depending on its Z position. Surfaces to be scanned are not always in a rectangular form, as a standard Spatial Dynamic Media System Hardware configuration would be, and assuming that the screen on which any kind of animation or movement is to be displayed is in a rectangular form the surface must be trimmed and altered to fit. Therefore the user has the option of defining the size of the screen before translating the scan into a 3D light point matrix.

[4.2] Set up

[4.2.1] Test surfaces

Once again, the surfaces used for the test are examples only and have no significance in of themselves. More than one example should be used to prove that the script functions with a variety of surfaces. Here two different test surfaces are used:

- a simple 2D plane, further called Surface 1
- a surface generated through the Heightfield from image function, further called Surface 2
The following two images are used for the tests:

**Fig. 44:** 2D plane surface as test surface for script

**Fig. 45:** Surface generated of a heightfield from image as a second test surface for script

The following script is able to divide a surface into a resolution of light points required by the user.

```
' **********************************************
' CREATING A SURFACE GENERATE OF LIGHT POINTS OUT OF A 3D FORM
' Script for Rhino 3.0
' Written by M. Hank Haeusler 07.02.2007
' Matthias.Haeusler@ems.rmit.edu.au

' DESCRIPTION: selecting surface and alter surface into a 3D pint grid with different colours for different heights
' STATUS:
' TO DO:

Sub SurfaceOut3DForm()
```
'****************************************************************
'start of rhino connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhin03.Application")
Dim Rhino As Object
Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
'end of rhino connection
'****************************************************************

'SELECT SURFACE**************************************************
'variables SELECT SURFACE
Dim strObject
Dim arrDomainU
Dim arrDomainV
Dim arrParam(1)
Dim arrpoint
Dim MyFirstPt
Dim MyResolution
Dim AllPts()
Dim arrPointGridOnsrf
Dim MyBasePoint

'******************************************************************************
'get resolution
dblres = Rhino.GetInteger("Resolution?")

'Get the surface object
strObject = Rhino.GetObject("Select surface", 8)
If IsNull(strObject) Then Exit Sub

'Get the domain of the surface
arrDomainU = Rhino.SurfaceDomain(strObject, 0)
arrDomainV = Rhino.SurfaceDomain(strObject, 1)

'Turn off redraw function
'Rhino.EnableRedraw vbFalse

'Add the points
If Rhino.IsSurface(strObject) Then
    arrParam(0) = arrDomainU(0)
    arrParam(1) = arrDomainV(0)
    arrpoint = Rhino.EvaluateSurface(strObject, arrParam)
End If

'Array points with equal distance
counter = 0
For i = 0 To arrDomainU(1) Step dblres
    arrParam(0) = i
    For j = 0 To arrDomainV(1) Step dblres
        ReDim Preserve AllPts(counter)
        MyFirstPt = Array(arrpoint(0) + i, arrpoint(1) + j, 0)
        AllPts(counter) = MyFirstPt
        counter = counter + 1
    Next
Next
ReDim arrPointGridOnsrf(UBound(AllPts))
counter = 0
For Each pt In AllPts
    tempPtOnSrf = Rhino.SurfaceClosestPoint(strObject, pt)
Next

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When testing the script on Surface 1, the script generated the following result with the resolution set to five, which is equal to a distance of 5 cm from LED stick to LED stick.

![Surface 1 divided in points by the script](image1)

**Fig. 46: Surface 1 divided in points by the script**

Applying the same script on Surface 2 with a resolution of 5 generated the following result:

![Surface 2 divided in points by script](image2)

**Fig. 47: Surface 2 divided in points by script**

Here the script did not create an array of points and the points were not spread evenly over the surface. This uneven spread is due to Rhino script getting the first point at the fringe of the surface arraying them and then creating surface closest point on the surface based on the U and V value of the surface. This surface closest point is not projected parallel to the surface, therefore the distortion.
This error is corrected in the following script.

```vba
Sub SurfaceOut3DForm()
'****************************************************************
'start of rhino connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
Dim Rhino As Object
Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
'end of rhino connection
'****************************************************************

'SELECT SURFACE**************************************************
'variables SELECT SURFACE
Dim strObject
Dim arrDomainU
Dim arrDomainV
Dim arrParam(1)
Dim arrPoint

'get resolution
dblres = Rhino.GetInteger("Resolution?")

'Get the surface object
strObject = Rhino.GetObject("Select surface", 8)
If IsNull(strObject) Then Exit Sub

'Get the domain of the surface
arrDomainU = Rhino.SurfaceDomain(strObject, 0)
arrDomainV = Rhino.SurfaceDomain(strObject, 1)

'Turn off redraw function
Rhino.EnableRedraw False

'Get min u/v domains
If Rhino.IsSurface(strObject) Then
    arrParam(0) = arrDomainU(0)
    arrParam(1) = arrDomainV(0)
End If

'converts u/v parameter into X,Y,Z parameter
arrpoint = Rhino.EvaluateSurface(strObject, arrParam)
```
' create point matrix
  MyMatrix = PointGrid(arrDomainU, arrDomainV, arrpoint, dblres,
                      strObject)

'Turn on redraw function
  Rhino.EnableRedraw True
End Sub

'****************************************************************
Function PointGrid(arrDomainU, arrDomainV, arrpoint, dblres,
surface)
****************************************************************
'start of rhino connection
  Dim RhinoApp As Object
  Set RhinoApp = CreateObject("Rhino3.Application")
  Dim Rhino As Object
  Set Rhino = RhinoApp.GetScriptObject()
  RhinoApp.Visible = True
'end of rhino connection
****************************************************************
Dim allPoints()
Dim arrPoints()
newcounter = 0
For i = 0 To arrDomainV(1) Step dblres
  counter = 0
  For j = 0 To arrDomainU(1) Step dblres
    'add points in u direction
    coordPoint = Array(arrpoint(0) + j, arrpoint(1) + i, 0)
    arrStart = Array(coordPoint(0), coordPoint(1), -1000)
    arrEnd = Array(coordPoint(0), coordPoint(1), 1000)
    sampleLine = Rhino.AddLine(arrStart, arrEnd)
    stringy = ("intersect SelID " + surface + " SelID " +
               sampleLine + " enter")
    tempIntersect = Rhino.Command(stringy)
    If tempIntersect = True Then
      ReDim Preserve arrPoints(counter)
      strPoint = Rhino.LastObject
      tempPoint = Rhino.PointCoordinates(strPoint)
      arrPoints(counter) = tempPoint
      counter = counter + 1
    End If
  Next
  ReDim Preserve allPoints(newcounter)
  allPoints(newcounter) = arrPoints
  newcounter = newcounter + 1
Next
PointGrid = allPoints
End Function

The following images show Surface 2 with a resolution set to 10:

Fig. 48: Surface 2 divided in points with improved script
Test Series IV: Creating a multilayered surface

The codes written earlier for sensor input, image, video or 3D form should now be mixed with each other to create a multilayered surface. Here two or more surface movements should be displayed at the same time. The surfaces should be stored in separate files and not in the Excel sheet as has been the case earlier. With having the data stored in one location and the running code in another location, one has the option to upload data by simply altering the name of the file location which inhabits the stored information. Both of the used input surface movements are for representation purposes only and are rather simple movements. Nevertheless they can demonstrate how such a surface could look. Furthermore the crossing point of both surfaces should be illustrated in a different colour and the two original surfaces in a second and third colour.

To illustrate the code two simple movements should be generated. These movements are expressed in Excel due to this being the program used so far mainly as an input source for the codes. The information for this surface movement is stored in a remote data sheet and will run using a code stored in a separate sheet.

Both images are 20 * 20 pixels in size and have either a depth of 7 or 10 pixels. The Excel datasheet therefore contains 38 spreadsheets with 20 columns and 20 rows, with the numbers arranged in a way that it either creates a wave form or a drop form and changes from value 0 to 7 (10) to create a surface movement.

The code is similar to those created earlier, for example when creating a surface out of an image. Here the surface is still in different colours; in the final demonstration it will be in one colour only.
The following images (Picture Series 1) illustrate the movement of the surface with a wave form:
Drop form

The following images (Picture Series 2) illustrate the movement of the surface with a wave form:
(Picture Series 2: Screenshots of surface movement when running script to generate surface Two)

[5.3]

Final script

Following is the code for creating a multilayered surface based on the two surfaces introduced in the previous Chapter. As mentioned in the introduction of this chapter both sets of data for creating the surface are stored in a remote file, and the location of
the file could be changed within Window Explorer when creating a multilayered surface based on other data.

```
'' CREATING A MULTILAYERED SURFACE OUT OF A REMOTE EXCEL SHEET

'Script for Rhino 3.0
Written by M. Hank Haeusler 04.02.2007
Matthias.Haeusler@ems.rmit.edu.au

'DESCRIPTION: looping through x amount of sheets in a remote excel worksheet and create a multilayered surface

'STATUS:
'TO DO:

Sub MultilayeredSurface()

'start of rhino connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
Dim Rhino As Object
Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
'end of rhino connection

'variables
Dim SurfaceFolderOne
Dim SurfaceFolderTwo
Dim MyXRowSurfaceOneAndTwo
Dim MyYRowSurfaceOneAndTwo
Dim arrOldObjects
Dim MyMultiSurfaceColor
Dim MyWorkSheetCountSurfaceOne
Dim objXLOne, objWBOne, objSHOne
Dim MyWorkSheetCountSurfaceTwo
Dim objXLTwo, objWBTwo, objSHTwo

'define image size in pixel + size of sphere
MyYRowSurfaceOneAndTwo = Rhino.GetReal("How big is picture in Y direction?")
MyXRowSurfaceOneAndTwo = Rhino.GetReal("How big is picture in X direction?")
MyRadius = Rhino.GetReal("What is the radius of spheres?")

'SURFACE_ONE_EXCELCONNECTION***************************************

'defines number of worksheets for SurfaceOne
MyWorkSheetCountSurfaceOne = 38
For m = 1 To MyWorkSheetCountSurfaceOne
'start of connection to Excel for SurfaceOne
Set objXLOne = CreateObject("Excel.Application")
Set objWBOne = objXLOne.Workbooks.Open("S:\Students\Hank\01_RESEARCH\Surfacescripting\08_SCRIPTS\MS_Wave_070205.xls")
```
Set objSHOne = objWBOne.Sheets(m)

'*************************************************************
'SURFACE_TWO_EXCELCONNECTION************************************
*************************************************************

defines number of worksheets for SurfaceTwo
MyWorksheetCountSurfaceTwo = 3
'For n = 1 To MyWorksheetCountSurfaceTwo

'start of connection to Excel for SurfaceTwo
Set objXLTwo = CreateObject("Excel.Application")
Set objWBTwo = objXLTwo.Workbooks.Open("S:\Students\Hank\01_RESEARCH\Surfacescripting\08_SCRIPTS\MS_drop_070205.xls")
Set objSHTwo = objWBTwo.Sheets(m)

'*************************************************************
'Removes all objects.
arOldObjects = Rhino.AllObjects()
If IsArray(arOldObjects) Then
    Rhino.DeleteObjects (arOldObjects)
End If

'makes a wireframe viewport
Rhino.Command("_WireframeViewport")

'EnableRedraw - switch of screen to start / finish script
Rhino.EnableRedraw False

'SURFACE_ONE_CREATE_POINTS******************************************
*************

'loop1 to create SurfaceOne out of txt file
For i = 1 To MyXRowSurfaceOneAndTwo
    For j = 1 To MyYRowSurfaceOneAndTwo
        ZSurfaceOne = objSHOne.Cells(j, i).Value()
        'creates sphere surface in Rhino for SurfaceOne
        currentPointCoord = Array(i, j, ZSurfaceOne)
        currentSphereOne = Rhino.addsphere(currentPointCoord, MyRadius)
        'Color For SurfaceOne
        Rhino.ObjectColor currentSphereOne, RGB(255, 0, 0) 'red
    Next
End If

'SURFACE_TWO_CREATE_POINTS******************************************
*************

ZsurfaceTwo = objSHTwo.Cells(i, j).Value()

'creates sphere surface in Rhino for SurfaceTwo
currentPointCoord = Array(i, j, ZsurfaceTwo)
currentSphereTwo = Rhino.addsphere(currentPointCoord, MyRadius)

'Color For SurfaceTwo
Rhino.ObjectColor currentSphereTwo, RGB(255, 0, 255) 'purple
If ZSurfaceOne = ZsurfaceTwo Then
    'Function Multilayered surface colour
    Overlapping currentSphereOne, ZSurfaceOne, currentSphereTwo, ZsurfaceTwo
End If
Next 'next for (i)
Next 'next for (j)

' makes a shaded viewport
Rhino.Command("ShadedViewport")

' EnableRedraw - switch of screen to start / finish script
Rhino.EnableRedraw True

' call screen grab function
screenGrab (m) ' value out of MySpreadSheetCount

' Next for getting data of remote Excel data sheet for SurfaceOne
Next 'next for (m)

' Quite the connection with the remote excel data sheet for
SurfaceOne
objXLOne.Quit

' Quite the connection with the remote excel data sheet for
SurfaceTwo
objXLTwo.Quit

'Tells that script is finished
Rhino.MessageBox "Script Finish"
End Sub

******************************************************************************
Function myColor(strObject, RGB)
' Function for Rhino 3.0
' Written by M .Hank Haeusler 13.01.2007
' Matthias.Haeusler@ems.rmit.edu.au

'DESRIPTION: create the colour for surface 2
'STATUS: WORK IN PROGRESS
'TO DO:
******************************************************************************
' start of rhino connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
Dim Rhino As Object
Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
' end of rhino connection
******************************************************************************
Rhino.ObjectColor strObject, RGB
End Function

******************************************************************************
Function screenGrab(m)
' Function for Rhino 3.0
' Written by M .Hank Haeusler 23.01.2007
' Matthias.Haeusler@ems.rmit.edu.au

'DESRIPTION: Incremental Screen Capture to file location
'STATUS: working
'TO DO:
******************************************************************************
' start of Rhino Connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
Dim Rhino As Object
Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
'end of Rhino Connection

'function screengrab
Dim sPath
'Specifies Path location and file type
sPath = "S:\Students\Hank\01_RESEARCH\Surface scripting\02_PICS\screengrab of multilayered surface\" & m & ".jpeg"
Rhino.Command "-_ScreenCaptureToFile " & Chr(34) & sPath & Chr(34) & " Enter"
'****************************************************************
End Function

Function Overlapping(currentSphereOne, ZSurfaceOne, currentSphereTwo, ZSurfaceTwo)
' Function for Rhino 3.0
' Written by M.Hank Haeusler 23.01.2007
' Matthias.Haeusler@ems.rmit.edu.au
'DESCRIPTION: Incremental Screen Capture to file location
'STATUS: working
'TO DO:
'****************************************************************
'start of rhino connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
Dim Rhino As Object
Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
'end of rhino connection
****************************************************************

'ruler for overlapping points out of surface 1 and surface 2
Rhino.ObjectColor currentSphereOne, RGB(0, 255, 0) 'green
Rhino.ObjectColor currentSphereTwo, RGB(0, 255, 0) 'green
End Function

----------------------------------------------------------------------------------------------------------
[5.4]
Images
The following images show a multilayered surface generated from the two surfaces introduced in the previous Subchapter [5.2.1]. This time they have been unicolour with the drop form in purple and the wave form in red. When both surfaces overlap, the colour changes to green to symbolize where the connection of surfaces occurs.
Conclusion

When discussing a multilayered surface in Chapter 3 [3.3] the idea and notion of a multilayered surface stayed on a theoretical level, but here a multilayered surface can be presented when applying two surfaces. These two surfaces with their determinate movements give an idea of what could be done with a multilayered surface. The
potential of this has not been fully explored, but it was not the intention to deliver a state of the art multilayered surface installation in this exercise. The main focus has been on providing an artist or designer with a tool to create multilayered surfaces and for them to explore new methods of how to design multilayered surfaces.
P4 /
Introduction

Test Series V:
Plug-in for decay function

The script will function as a plug-in to create a decay function. Furthermore it will function as a prove if it is possible to create a decay function as it has been discussed in Chapter 3 in Subchapter [3.3.3.]. The decay function will be simulated with the size of a sphere which will symbolise the light and its colour.

Final Script

Following is the code for creating a decay function.

Sub PointsFromImage()
    Dim RhinoApp As Object
    Set RhinoApp = CreateObject("Rhino3.Application")
    Dim Rhino As Object
    Set Rhino = RhinoApp.GetScriptObject()
    RhinoApp.Visible = True
End Sub

'Description of script
'CREATES A MATRIX OF POINTS WITH A DECAY FUNCTION
'Script for Rhino 3.0
'Written by M. Hank Haeusler 05.04.2007
'Matthias.Haeusler@ems.rmit.edu.au
'Description: creates a matrix of points and give them a decay function
'Status:
'To Do:

Sub PointsFromImage()
    Dim RhinoApp As Object
    Set RhinoApp = CreateObject("Rhino3.Application")
    Dim Rhino As Object
    Set Rhino = RhinoApp.GetScriptObject()
    RhinoApp.Visible = True
End Sub

Variables
'currentPoint
'MyPointCount As Double
'AllpointCoords
'MyRowX
'MyRowY
'allAllPoints
'MyNewZ
'allOldObjects
'MySheetCount
'Loop1
MySheetCount = 38

'define image size in pixel + size of sphere
MyRowY = Rhino.GetReal("How big is picture in Y direction?")
MyRowX = Rhino.GetReal("How big is picture in X direction?")
dblRadius = Rhino.GetReal("What is the radius of spheres?")

'redim code
newPointCount = MyRowY * MyRowX
ReDim AllpointCoords(newPointCount)

'Counts sheets in excel
For k = 1 To MySheetCount

'EnableRedraw - switch of screen to start / finish script
Rhino.EnableRedraw False

'Removes all objects.
arrOldObjects = Rhino.AllObjects()
If IsArray(arrOldObjects) Then
Rhino.DeleteObjects(arrOldObjects)
End If

'Loop for creating an image of one sheet out of excel
For i = 1 To MyRowX 'i gets X Value
For j = 1 To MyRowY 'j gets Y Value
    z = Worksheets(k).Cells(j, i).Value
    MyNewZ = 0
    If z = 0 Then MyNewZ = 0
    If z = 1 Then MyNewZ = 1
    If z = 2 Then MyNewZ = 2
    If z = 3 Then MyNewZ = 3
    If z = 4 Then MyNewZ = 4
    If z = 5 Then MyNewZ = 5
    If z = 6 Then MyNewZ = 6
    If z = 7 Then MyNewZ = 7
    If z = 8 Then MyNewZ = 8
    If z = 9 Then MyNewZ = 9

'creates point in Rhino
currentPointCoord = Array(i, -j, MyNewZ)
MyRadius = ChangingRadius(MyNewZ, dblRadius)

'creates sphere in Rhino
currentSphere = Rhino.addsphere(currentPointCoord, MyRadius)

'call colour function
MyChangeColor currentSphere, currentPointCoord(2)
Next 'next for (i)
Next 'next for (j)

'EnableRedraw - switch of screen to start / finish script
Rhino.EnableRedraw True

'call screengrab function
screengrab (k)
Next 'next for (k)

'Tells that script is finished
MsgBox("Script Finish")
End Sub
Function MyChangeColor(strObject, ColourIndex)
' Function for Rhino 3.0
' Written by M. Hank Haeusler 05.04.2007
' Matthias.Haeusler@ems.rmit.edu.au
' DESCRIPTION: Changes the color of the layer
' STATUS: working
' TO DO: add parameters required in the () out of sub main to run
'******************************************************
'start of rhino connection
Dim RhinoApp As Object
Set RhinoApp = CreateObject("Rhino3.Application")
Dim Rhino As Object
Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
'end of rhino connection
'******************************************************
'Color definition for 10 different rows
Dim mycolour00, mycolour01, mycolour02, mycolour03,
mycolour04, mycolour05,
mycolour06, mycolour07, mycolour08, mycolour09, mycolour10
'enhance with making it dependent on variable
mycolour00 = RGB(0, 0, 255)
mycolour01 = RGB(25, 25, 255)
mycolour02 = RGB(50, 50, 255)
mycolour03 = RGB(75, 75, 255)
mycolour04 = RGB(100, 100, 255)
mycolour05 = RGB(125, 125, 255)
mycolour06 = RGB(150, 150, 255)
mycolour07 = RGB(175, 175, 255)
mycolour08 = RGB(200, 200, 255)
mycolour09 = RGB(225, 225, 255)
mycolour10 = RGB(255, 255, 255)
'gets Z value from coordinate of cell and give it colour
If ColourIndex = 0 Then
Rhino.ObjectColor strObject, mycolour00
Exit Function
ElseIf ColourIndex = 1 Then
Rhino.ObjectColor strObject, mycolour01
Exit Function
ElseIf ColourIndex = 2 Then
Rhino.ObjectColor strObject, mycolour02
Exit Function
ElseIf ColourIndex = 3 Then
Rhino.ObjectColor strObject, mycolour03
Exit Function
ElseIf ColourIndex = 4 Then
Rhino.ObjectColor strObject, mycolour04
Exit Function
ElseIf ColourIndex = 5 Then
Rhino.ObjectColor strObject, mycolour05
Exit Function
ElseIf ColourIndex = 6 Then
Rhino.ObjectColor strObject, mycolour06
Exit Function
Else
End If
Exit Function
ElseIf ColourIndex = 7 Then
    Rhino.ObjectColor strObject, mycolour07
End Function

ElseIf ColourIndex = 8 Then
    Rhino.ObjectColor strObject, mycolour08
End Function

ElseIf ColourIndex = 9 Then
    Rhino.ObjectColor strObject, mycolour09
End Function

End Function

Function screengrab(i)
    ' Function for Rhino 3.0
    ' Written by M. Hank Haeslener 23.01.2007
    ' Matthias.Haeusler@ems.rmit.edu.au
    ' DESCRIPTION: Incremental Screen Capture to file location
    ' STATUS: working
    ' TO DO:

    '****************************************************************
    ' start of Rhino Connection
    Dim RhinoApp As Object
    Set RhinoApp = CreateObject("Rhino3.Application")
    Dim Rhino As Object
    Set Rhino = RhinoApp.GetScriptObject()
    RhinoApp.Visible = True
    ' end of Rhino Connection
    '****************************************************************

    'function screengrab
    Dim sPath
    ' Specifies Path location and file type
    sPath = "S:\Students\Hank\01_RESEARCH\Surface
    scripting\02_PICS\screengrab of multilayered surface" & i & 
    ".jpeg"

    Rhino.Command "-_ScreenCaptureToFile " & Chr(34) & sPath & 
    Chr(34) & " Enter"
    '****************************************************************

    End Function

Function ChangingRadius(MyNewZ, dblRadius)
    ' Function for Rhino 3.0
    ' Written by M. Hank Haeslener 05.04.2007
    ' Matthias.Haeusler@ems.rmit.edu.au
    ' DESCRIPTION: Change of radius to simulate decay function
    ' STATUS: working
    ' TO DO:

    '****************************************************************
    ' start of rhino connection
    Dim RhinoApp As Object
    Set RhinoApp = CreateObject("Rhino3.Application")
    Dim Rhino As Object
    Set Rhino = RhinoApp.GetScriptObject()
RhinoApp.Visible = True
'end of rhino connection

'*gets Z value from coordinate of cell and give it a size

If MyNewZ = 0 Then
    ChangingRadius = 0.1 * dblRadius
    Exit Function
ElseIf MyNewZ = 1 Then
    ChangingRadius = 0.2 * dblRadius
    Exit Function
ElseIf MyNewZ = 2 Then
    ChangingRadius = 0.3 * dblRadius
    Exit Function
ElseIf MyNewZ = 3 Then
    ChangingRadius = 0.4 * dblRadius
    Exit Function
ElseIf MyNewZ = 4 Then
    ChangingRadius = 0.5 * dblRadius
    Exit Function
ElseIf MyNewZ = 5 Then
    ChangingRadius = 0.6 * dblRadius
    Exit Function
ElseIf MyNewZ = 6 Then
    ChangingRadius = 0.7 * dblRadius
    Exit Function
ElseIf MyNewZ = 7 Then
    ChangingRadius = 0.8 * dblRadius
    Exit Function
ElseIf MyNewZ = 8 Then
    ChangingRadius = 0.9 * dblRadius
    Exit Function
ElseIf MyNewZ = 9 Then
    ChangingRadius = 1 * dblRadius
    Exit Function
End If
End Function

[6.3]
Images

Following a series of screen shots captured while running the script to simulate a decay function by altering the size of a sphere.
(Picture Series: Screenshots of surface with a simulated decay function by changing the size of a sphere)
Conclusion of Project 4: Effect and use – working as a curator for different media contents

Project 4 is the last of the four projects, providing a number of codes written in VB script in order to curate different media content designed by others. All these codes are written on an Excel platform and mainly use data fed from an Excel data sheet, with the exception of Test Series 4 where the input has been generated from a 3D scan. The use of Excel, a Windows program which enables the storing, working and analysing of data, shows the origins of potential media content. The Spatial Dynamic Media System is when using scripts able to visualize information as a spatial arrangement, viewable for the beholder and understandable in its spatiality. Excel as an input source was used when providing a script in Test Series I, which allowed the user access to all kinds of data which could be stored and saved in Excel. This includes input from various sensors such as temperature or wind among other allowing the system to react to changes in the environment, as shown by the example of water levels of reservoirs in Melbourne.

The tests have also, by the creation of a surface based on a movie clip as in Subchapter [3.] of Chapter 5 Project 4, proven that it is possible to weave together architecture and image with a result closely related to the original image but is more than barely a 3D representation of the image. Here again a code is provided for the artist to create movies and video clips by focussing on a new way of conducting a movie narrative. With a film tailor-made for the Spatial Dynamic Media System, the translation of the movement within the film will be the main focus. As my research in Test Series II has shown, when the position and colour information of a pixel is altered, the ability to create movement of a surface is enabled. It will not provide a straight translation of 2D form into a 3D form, ie. a 2D object in the movie such as a person will not be directly translated into a 3D object, but the colour information stored in the 2D object can be used to transform it into a 3D object. Thus the altering of a pixel’s colour information consequently creates a movement.
The test in Test Series III originates in the proposition made in Chapter 5 Project 3, where the designed media content was based on the 3D scan of a face and the human emotion expressed via the face. Essentially the conducted five tests have provided two general types of results: that it is possible to inject information into the system, and also to generate a moving surface in real-time. The written codes can be used as tools for ideas by artists and designers using the Spatial Dynamic Media System, as described above when discussing different tests such as the visualisation of information or the amalgam of form and image.

In addition the tests proved propositions made in Chapter 3. Here my research discussed a multilayered surface and a decay function for a surface, and the significance of these possibilities for architecture. Both options were discussed on a theoretical level in Chapter 3 Subchapter [3.3.], but the tests in this Chapter 4 Project 4 have proven that it is in fact possible to create such surfaces.

Appendix

Appendix 1 – Plans

Plans Mercedes-Benz booth Auto Salon Geneva 2004
(CHAPTER 01_Research background: [1.1.1.])

Plans Mercedes-Benz booth Auto Show China Beijing 2004
(CHAPTER 01_Research background: [1.1.2.])

Plans Model set up of P1
(CHAPTER 03_Project work: Project 1: Experiment Series
III: Chapter [5.2.2.])

Plans Model outcome Final Prototype
(CHAPTER 03_Project work: Project 1: Experiment Series
VI: Chapter [9.3.1.])

Plans Bld 91 RMIT University City Campus
(CHAPTER 03_Project work: Project 2: Design façade
Building 91 RMIT University City Campus: Chapter
[2.2.1.])

Plans option 1
(CHAPTER 03_Project work: Project 2: Experiment III:
Plans Option 1 [5.2.2.])

Plans option 2
(CHAPTER 03_Project work: Project 2: Experiment III:
Plans Option 2 [5.2.3.])

Plans option 3
(CHAPTER 03_Project work: Project 2: Experiment III:
Plans Option 3 [5.2.4.])

Detail
(CHAPTER 03_Project work: Project 2: Experiment III:
General Plans [5.2.5.])

Poster 1 Vivocity Competition
(CHAPTER 03_Project work: Project 3: Design of
installation [3.2.1])

Poster 2 Vivocity Competition
(CHAPTER 03_Project work: Project 3: Design of
installation [3.2.2])

Poster 3 Vivocity Competition
(CHAPTER 03_Project work: Project 3: Design of
installation [3.2.3])

Poster 4 Vivocity Competition
(CHAPTER 03_Project work: Project 3: Design of
installation [3.2.4])

Poster 5 Vivocity Competition
(CHAPTER 03_Project work: Project 3: Design of
installation [3.2.5])

Poster 6 Vivocity Competition
(CHAPTER 03_Project work: Project 3: Design of
installation [3.2.6])

Floor Plan set up Installation ISEA 2006
(CHAPTER 03_Project work: Project 3: Design of art
installation [4.2.1.])
ground floor level 0
Presentation of Mercedes-Benz on the Salon d’Automobile in Genf 2004
ground floor level +1
Presentation of Mercedes-Benz on the Salon d'Automobile in Genf 2004
Presentation of Mercedes-Benz on the Salon d’Automobile in Genf 2004
INTRODUCTION LED STICK:
Section / Elevation / Perspective

DETAIL SPECIFICATION
1 - HINGE
2 - RGB LEDs
3 - PLUG
4 - FASTENER
5 - GROMMET
6 - BASE TO HOLD ELECTRONIC
RMIT BUILDING 91
FLOOR 1
SCALE 1:200
LIGHT ANIMATED HYPERSURFACES

My project proposal is an investigation into the perceptual boundaries between the virtual and physical world and how to break them. It asks how architecture can creatively adopt a fourth dimension, in this project a dimension provided through the use of digital technologies. The project draws from two examples of existing buildings / installations are used to demonstrate how movement and light colour have been used in architecture with the participation of the public.

The first exemplar project is the physical movement of a full-size wall surface: ‘Aegis Hyposurface’ (DECOi Architects+ Deakin University / Mark Burry).

The second project expresses a town’s collective emotions through dynamic change in architecture via the use of colours: The D-tower (QS Serafijn & Lars Spuybroek/NOX).

SEARCH FOR AN INTERACTIVE 3D DYNAMIC SYSTEM

Three discrete considerations are required in order that such a system achieves its full potential.

Firstly how are forms received and can they be defined with the use of light? The illumination of the city gives the beholder a notion of space at night time, where they can locate the city and its buildings in relation to his own position - something one could not do if there had not been any light in forms and therefore the possibility to define space with the use of light.

Secondly, I want to investigate the potential existing media technologies beyond their typical application to architecture. Currently the typical application of arrays of lights (Times Square for example) can only offer the display of apparent 3D images and forms – but these ‘3D forms’ are never actually 3D, they only become 3D when one ‘moves’ it with a computer mouse. The reason for this is the 2D nature of the display. Extended beyond their typical 2D application set to give an illusion of 3D is my proposed façade built with a 3D grid of lights each with X,Y,Z coordinates with point lights at each intersection of the grid.
This façade will be erected by a number of 'sticks', attached in a 90 degree angle to the existing façade, and each of these sticks contains an array of LEDs in certain distances to each other along the stick. An equal resolution could be achieved in all three axes; images displayed in the X, Y, and Z planes and more importantly as 3D objects. Through their 'non-physical' existence, it can change its image and its spatial boundaries over time and therefore allow a strong relation between time and space and create new concepts of space, time, and social relationships in an urban environment.

Thirdly, interactivity will be achieved through the 3D 'façade' and smaller image capturing 'stations' placed in the immediate vicinity. These stations contain 3D face scanners that are open to the public. Face expression will be scanned in at these stations; collected and displayed on the facade.

A REDEFINITION OF 'PLACE'

Why do I want to do this? One of my core questions is to reconsider what new relationships are possible between place and media, and the consequences for interactive projects that result. 'Place' is a term that has a variety of meanings in a dictionary sense, but which is principally used as a noun to denote location, and primarily in the sense of what is actually within that location. By using 'place' in architecture, it defines 3D static objects that create the urban landscape and therefore notion of space and density. Media in a place on the other hand, is a two dimensional dynamic element mainly added on a 3D form, i.e. a building.

This leads to the result that the 'user' of the place only being able to consume its surface/media appearance, without allowing participation. Can these two elements be combined to create a three dimensional dynamic element enabling participation by the city's inhabitants and if so, in what ways could people participate and play within the urban environment in the dynamic formation of cities?
THE SET UP OF FACE / FAÇADE

My proposal includes an examination of new kinds of public participation in urban environments. I intend to set up the proposed system, with movement and human expression being compared to conventional architectural ‘expression’, which will be considered together with how different cultural groups can be involved in this arrangement. Bergson discusses a relative movement when he talks about: “the movement of an object in space. My perception of the motion will vary with the point of view, moving or stationary, from which I observe it. “William F. Allman argues that communication between humans can be held verbally but at the same time non-verbally by miming and gestures. Non-verbal communications are generally easier to understand. This non-verbal understanding has found its artistic expression in the performance art of a mime artist. Allman states, “Emotional cues are so important to human survival that a “universal grammar” has evolved in human facial expression. The human facial expression that spring from feelings [...] is universal among all human societies.” Communication through mime has therefore been an important part in our daily life, but what is miming in a spatial sense? When one moves ones face to express something the surface of ones face changes and therefore creates a changing surface. These expressions can be digitised and reproduced in a façade that allows the display of 3D images. So far architecture has been determined mainly by the education and the cultural background of the architect. A light-animeted surface that is defined by the captured similar emotions – the participation of the beholder in a cross-cultured form of expression – ensures an exclusion of one or more culture does no longer exist.

CONCLUSION

Through having a system that can display the time dimension within a spatial construct, the focus of the project will be the subject of interactivity. How this concept allows the participations of the public and its cultural-sociological meaning will be examined. This will be a far reaching proposition of how the public will be included in the decision process of defining space, through expressing our innermost feelings through an architectural medium. Thus emotions of the individual have a platform and can be brought indirectly to the public, and in turn open up discussions about the state of the community through the state of the façade. An alliance of media and place in an urban context can be achieved and created, with the participation of its inhabitants, along with a new perception of how media and architecture can together shape and inform-spatial relations.

The system contains three major items, the Hardware (LED sticks, Control unit, and 3D bodyscanner) and the Software that runs the system.

Firstly, the Hardware component LED stick is under development in cooperation between Industrial Designers, Electro engineers and the Author. These sticks function as single elements. The electronic is held in the base, made from shock absorbing raisin material, so is the stick that contains RGB LED’s with reflectors to achieve a illumination in a 275 degree dome. I am working on that development and see it as an enhancement of existing systems such as the BARCO MiPix-20 in a spatial way, where pixels are arranged onto a surface in a defined pattern with the control unit knowing where they are located and what kind of information they have to get at which time.

A 3D bodyscanner, e.g. the Vitrus ahead – 3D head scanner, “three dimensional scanning is as easy as can be: a person stands in the center of the measuring portal and the laser light sources (which are not harmful for the eyes) are switched on. [...] A few seconds later, the necessary data is collected. A so-called ‘3D point cloud with colour overlay’ composed of several million 3D measuring points has been generated. A virtual duplicate of the person has been created with maximum precision. Due to its high resolution the 3D head scanner VITUS ahead is able to scan even delicate details of the face. The products generated with the scanned 3D data show an amazing similarity to the real object. The non-contact measurement is carried out by 8 triangulation cameras with a resolution of approx. 1 mm within less than 10 seconds.

[…] The data can be used for animations as well as for medical purposes. The chain of hardware elements goes from the 3D bodyscanner to the control unit and finally to the LED sticks. Secondly, the software translates the data provided by the 3D bodyscanner to the sticks. The data will be changed in the controllers, by having spatial model information into a scripted version with X, Y, Z coordinates, as well as an RGB information to allow different colours and an opacity function. With this information each LED got at all times the necessary information to create a picture. The system is an addable element that can be attached on any existing building façade, due to being built up by single elements that can be attached to a substructure. Because of the flexible angle in X and Y plane the same element can define corners of different shapes on a building.
Due to the unspecified location of the interactive installation, these plans are held quite general and will be adopted with the site. The plans are generated as a parametric CATIA model to allow changes to a later stage. This allows to alter the size, as shown in plan 1 (floor plan) and in plan 2 (section) to any required size. The facade is built of LED sticks that are identical in construction, and can be altered to the required position via a hinge to achieve different positions.

**DETAIL SPECIFICATION**

1. HINGE
2. RGB LEDs
3. PLUG
4. FASTENER
5. GROMMET
6. RASF TO HOH ELECTRONIC
**Appendix 2 – Tables**

Table of SMARTSLAB comparing different system
(CHAPTER 03_Embedding media in architecture: cultural and technical implications [1.4.2.])

Table of Data sheet JAYCAR
(CHAPTER 04_Project work: Project 1: Model Five – Nine [4.6.2.])

Table Renderings of Surface I
(CHAPTER 04_Project work: Project 2: Renderings of Surface II Chapter [3.2.4.])

Table Renderings of Surface II
(CHAPTER 04_Project work: Project 2: Renderings of Surface II Chapter [3.2.5.])

Table Data Sheet ALTOONA
(CHAPTER 04_Project work: Project 2: Explanation Data Sheet Chapter [4.2.1.])

<table>
<thead>
<tr>
<th>Feature</th>
<th>SmartSlab</th>
<th>Plasma</th>
<th>LED walls</th>
<th>Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loadbearing</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>N/A</td>
</tr>
<tr>
<td>Impact resistant</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>N/A</td>
</tr>
<tr>
<td>Waterproof</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Graffiti cleanable</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Scratch repairable</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Suitable for floors</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Class 'W' fire resistance</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>N/A</td>
</tr>
<tr>
<td>Modular repairable</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Thin display</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Modular display tile</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Large &amp; giant format</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Full viewing angle</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Close-up viewable</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Lifetime 100,000 hours</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Millions of colours</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cost</td>
<td>low-med</td>
<td>low-med</td>
<td>high</td>
<td>low-med</td>
</tr>
<tr>
<td>Brightness</td>
<td>med-high</td>
<td>low</td>
<td>high</td>
<td>v.low</td>
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<tr>
<td>Power consumption</td>
<td>low-med</td>
<td>low</td>
<td>high</td>
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**5mm Standard**

<table>
<thead>
<tr>
<th>Colour</th>
<th>Cat No.</th>
<th>Qty 1</th>
<th>Qty 10+</th>
<th>Qty 25+</th>
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<tbody>
<tr>
<td>Red</td>
<td>ZD-0100</td>
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<td>ZD-0101</td>
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<td>Green</td>
<td>ZD-0103</td>
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**5mm High Brightness**

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<td>Green</td>
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**5mm Flashing**

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<td>Orange</td>
<td>ZD-0202</td>
<td>$0.25</td>
<td>$0.22</td>
<td>$0.17</td>
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</table>

**5mm Flashing Tri Colour High Brightness**

An ideal LED for eye catching displays. The lens is moulded in yellow. The LED produces an arresting chasing pattern through red, green and blue.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Cat No.</th>
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<th>Qty 10+</th>
<th>Qty 25+</th>
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</thead>
<tbody>
<tr>
<td>Red/Green/Blue</td>
<td>ZD-0204</td>
<td>$5.95</td>
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**5mm 12 Volt Flashing Red**

Al low 1.25W. The LED can be used in a circuit that does not need a resistor.

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<td>ZD-0205</td>
<td>$0.45</td>
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**5mm UV**

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<td>ZD-0206</td>
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**10mm Standard**

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**10mm High Brightness**

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<td>Yellow</td>
<td>ZD-0305</td>
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<td>$0.25</td>
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</table>

**5mm RGB**

Build your own custom multicoloured displays or even a video screen for the more adventurous.

- **White diffused**
- **High brightness**
- **4 legs**

<table>
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<th>Colour</th>
<th>Cat No.</th>
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<td>Red/Green/Blue</td>
<td>ZD-0207</td>
<td>$5.95</td>
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**10mm Flashing**

Red 3mm (2A)
- Voltage 3.5 mm. 9 volt typical
- Intensity not 120lmcd
- Use with 2A.

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<th>Colour</th>
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<td>Red</td>
<td>ZD-0208</td>
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**JAYCAR ELECTRONICS 2004**

Want it fast? How about next day delivery - see order section.
# LED SPECIFICATIONS

<table>
<thead>
<tr>
<th>LED Emitter Colour</th>
<th>Lens Colour</th>
<th>Wave Length (nm)</th>
<th>IV (mA)</th>
<th>IV (V)</th>
<th>View Angle</th>
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<tbody>
<tr>
<td><strong>3mm</strong></td>
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<tr>
<td>Bi-Colour</td>
<td>Red/Green</td>
<td>625</td>
<td>400</td>
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<tr>
<td>Tri-Colour</td>
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<td>3.2</td>
<td>1.3</td>
<td>1.4</td>
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<td><strong>5mm</strong></td>
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<td>Tri-Colour</td>
<td>Red/Green/Orange</td>
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<td>500</td>
<td>3.2</td>
<td>1.3</td>
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</table>

*All prices in Australian Dollars*
<table>
<thead>
<tr>
<th>Name</th>
<th>Emitting Colour</th>
<th>Wave Length</th>
<th>nm</th>
<th>Pd W (mW)</th>
<th>If mA</th>
<th>If mA (peak)</th>
<th>Min</th>
<th>Vf (V)</th>
<th>Max</th>
<th>IV min</th>
<th>Brightness mcd</th>
<th>Type</th>
<th>View Angle</th>
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<tbody>
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<td>5 mm LED water clear (ZD-0152)</td>
<td>Red</td>
<td>660</td>
<td>90</td>
<td>110 mW</td>
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<td>200</td>
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<td>1.8</td>
<td>2.2</td>
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<td>500</td>
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</tr>
<tr>
<td>5 mm LED water clear (ZD-0154)</td>
<td>Red</td>
<td>625</td>
<td>20</td>
<td>120 mW</td>
<td>50</td>
<td>100</td>
<td>1.5</td>
<td>2.0</td>
<td>2.6</td>
<td>3000</td>
<td>4000</td>
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<tr>
<td>5 mm LED water clear (ZD-0156)</td>
<td>Red</td>
<td>625</td>
<td>20</td>
<td>130 mW</td>
<td>50</td>
<td>150</td>
<td>2.0</td>
<td>2.3</td>
<td>2.6</td>
<td>7000</td>
<td>10000</td>
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<tr>
<td>5 mm LED water clear (ZD-1790)</td>
<td>Red</td>
<td>616</td>
<td>18</td>
<td>135 mW</td>
<td>50</td>
<td>1000</td>
<td>-</td>
<td>2.1</td>
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<td>20000</td>
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<tr>
<td>Rectangle 5x2mm (ZD-0230)</td>
<td>Red</td>
<td>700</td>
<td>90</td>
<td>45 nW</td>
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(Source: Data table by JAYCAR ELECTRONICS 2004)
**Multi-Color Flashing LED**

**F45B**

**Multi-Color Flashing 5mm LED**

**Specification**

**ELECTRO-OPTICAL CHARACTERISTICS : (Ta=25°C)**

<table>
<thead>
<tr>
<th>Emitted Color</th>
<th>Material</th>
<th>λ (μm)</th>
<th>V(V)</th>
<th>Lf(mA)</th>
<th>I(t) (mA)</th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>Red</td>
<td>AlGallnP</td>
<td>635</td>
<td>1.9</td>
<td>2.1</td>
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<td>Green</td>
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<td>3.1</td>
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<td>Blue</td>
<td>InGaN</td>
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</table>

© I.C. ENGINEERING LIMITED
BLK.B, 12 FLOOR, UNIT 23, HI-TECH IND. CENTER 491-501 CASTLE PEAK RD., TSUEN WAN, N.T.
TEL. NO.: (852)2414 9121 , (852)2414 9149 FAX. NO.: (852)2412 2879
E-mail: icinfo@fbice.com
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# Camera position in 1.50 m height and 10° to surface

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<td>75°</td>
<td>90°</td>
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<td>Option 1</td>
<td>100 Sticks / sqm</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>-----------</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option 2</td>
<td>75 Sticks / sqm</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Option 3</td>
<td>67 Sticks / sqm</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Option 4</td>
<td>50 Sticks / sqm</td>
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Camera position in 1.80 m height and 1.00 m distance to surface

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<tr>
<th>0°</th>
<th>10°</th>
<th>20°</th>
<th>30°</th>
<th>40°</th>
<th>50°</th>
<th>60°</th>
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Camera position in 1.80 m height and 2.00 m distance to surface

<table>
<thead>
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<th>Option 1</th>
<th>100 Sticks / sqm</th>
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<tr>
<td>Option 2</td>
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<td>Option 3</td>
<td>67 Sticks / sqm</td>
</tr>
<tr>
<td>Option 4</td>
<td>50 Sticks / sqm</td>
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<tr>
<td>Camera position in 1.80 m height and 5.00 m distance to surface</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| **Option 1**  
100 Sticks / sqm  
| **Option 2**  
75 Sticks / sqm  
| **Option 3**  
67 Sticks / sqm  
| **Option 4**  
50 Sticks / sqm  
<p>| 0° | 5° | 10° | 15° | 20° | 25° | 30° |
|---------------------------------------------------------------|
| 35° | 40° | 45° | 50° | 55° | 60° | 65° |</p>
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<th>Option 2</th>
<th>Option 3</th>
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<td>100 Sticks / sqm</td>
<td>75 Sticks / sqm</td>
<td>67 Sticks / sqm</td>
<td>50 Sticks / sqm</td>
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Camera position in 1.80 m height and 10.00 m distance to surface
## ALTOONA - TECHNICAL CHARACTERISTICS & CALCULATOR

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<tr>
<th>Pitch</th>
<th>PV 5 SMD</th>
<th>PV 7 SMD</th>
<th>PV 7</th>
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<th>PN 16 SMD</th>
<th>PN 20</th>
<th>PN 31</th>
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<td>5 mm</td>
<td>1PG+1B+2R</td>
<td>1PG+1B+2R</td>
<td>1PG+1B+2R</td>
<td>1PG+1B+2R</td>
<td>3 in 1</td>
<td>1PG+1B+1R</td>
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<td>3PG+2B+4R</td>
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<td>7 mm</td>
<td>120°</td>
<td>120°</td>
<td>120° / 60°</td>
<td>120° / 60°</td>
<td>120°</td>
<td>120° / 60°</td>
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<td>7,000</td>
<td>4,500</td>
<td>6,500</td>
<td>6,500</td>
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<tr>
<td>Pixel / Sq. M²</td>
<td>40,000</td>
<td>20,400</td>
<td>20,400</td>
<td>10,000</td>
<td>3,900</td>
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<td>625</td>
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<td>Max Power Cons./Sq. M² (kW)</td>
<td>1.5</td>
<td>0.6</td>
<td>1.1</td>
<td>0.8</td>
<td>1.2</td>
<td>0.7</td>
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<tr>
<td>Pixels/Module Wide</td>
<td>32</td>
<td>64</td>
<td>128</td>
<td>128</td>
<td>64</td>
<td>64</td>
<td>32</td>
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<td>Pixels/Module High</td>
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<tr>
<td>Module Size (mm)</td>
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<td>448</td>
<td>896</td>
<td>1280</td>
<td>1024</td>
<td>1280</td>
<td>992</td>
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<td>448</td>
<td>640</td>
<td>512</td>
<td>640</td>
<td>992</td>
<td>1280</td>
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Guideline Cost per Sq.M. (£):

- For Proposed Screen Size w:
  - £24745
- For Proposed Screen Size h:
  - £15143

**Cost of screen £k (Up)**

|           | £25,339 | £15,728 | £22,418 | £12,688 | £12,799 | £10,397 | £8,948 | £6,711 |

October 2004 - Data can change without notice
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<th>Reservoir</th>
<th>Capacity (ML)</th>
<th>Current Volume (ML)</th>
<th>% Full</th>
<th>Change since Yesterday (ML)</th>
<th>Rainfall (mm)* to 8:00am</th>
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<td>Upper Yarra</td>
<td>200,000</td>
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<td>2,110</td>
<td>70.3</td>
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<td>Yan Yean</td>
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<td>6,111</td>
<td>20.4</td>
<td>-39</td>
<td>0.0</td>
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<tr>
<td>Greenvale</td>
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<td>22,245</td>
<td>82.4</td>
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<td>36,089</td>
<td>90.2</td>
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<td>Cardinia</td>
<td>287,000</td>
<td>191,098</td>
<td>66.6</td>
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<td><strong>657,648</strong></td>
<td><strong>37.1</strong></td>
<td><strong>-1142</strong></td>
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</table>
Appendix

Appendix 3 – Images

CHAPTER 1 Research background
Pictures Mercedes-Benz booth Auto Salon Geneva 2004
(CHapter 1 Research background: [1.1.1])
Fig. 6 – Fig. 11

Pictures Mercedes-Benz booth Auto Show China Beijing 2004
(CHapter 1 Research background: [1.1.2])
Fig. 12 – Fig. 15

CHAPTER 04_ Project work
Picture of model experiment series I
(Chapter 5 Project work: Project 1 [2.2.2])
Fig. 6

Picture of Model Set up
(Chapter 5 Project work: Project 1 [5.4.1])
Fig. 83

Picture Enlargement of Model Set up
(Chapter 5 Project work: Project 1 [5.5.1])
Fig. 204

Picture first rendering of LED stick model
(Chapter 5 Project work: Project 1 [9.2.1])
Fig. 148

Picture form test in wood
(Chapter 5 Project work: Project 1 [9.2.2])
Fig. 150

Picture Rendering
(Chapter 5 Project work: Project 1 [9.3.2])
Fig. 180

Picture Model LED Stick
(Chapter 5 Project work: Project 1 [9.3.3])
Fig. 181

Picture Model LED Stick
(Chapter 5 Project work: Project 1 [9.3.3])
Fig. 183

Picture Model LED Stick
(Chapter 5 Project work: Project 1 [9.3.3])
Fig. 184

Picture Model LED Stick
(Chapter 5 Project work: Project 1 [9.3.3])
Fig. 186

Picture Model LED Stick
(Chapter 5 Project work: Project 1 [9.3.3])
Fig. 187

Picture different resolutions of letter ‘R’
(Chapter 5 Project work: Project 2 [3.2.1])
Fig. 3
Fig. 6: Main elevation of media façade of the VIP cafe
Fig. 7: Main elevation of media façade of the VIP café within booth opening hours, with different content

Fig. 8: Main elevation of media façade of the VIP café within booth opening hours
Fig. 9: View from the top

Fig. 10: Detailed view of façade and the play between people in the café and the content displayed on the façade
**Fig. 11:** Detailed view of façade

**Fig. 12:** Elevation from entrance exhibition

**Fig. 13:** Vista of first ramp
Fig. 14: View from ramp to main stage

Fig. 15: Elevation entrance area Maybach

CHAPTER 04_ Project work

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Fig. 6: Surface manually distorted, with lights switched on

Fig. 83: Model with switched on LEDs
Fig. 104: Enlargement of Test set up

Fig. 148: First rendering of LED stick
Fig. 150: Picture of form test in wood

Fig. 180: Rendering of an array of LED sticks
Fig. 181: Prototype side view

Fig. 183: Prototype perspective view
Fig. 184: Prototype perspective back view

Fig. 186: Prototype side view
**Fig. 187:** Prototype perspective view

**Fig. 3:** Letter in different resolution
Fig. 27: Surface view 1
Appendix

Appendix 4 – Documents

Confirmation from VIVOCITY
(CHapter 5 Project Work: Project 3 [3.2])

Email from Martina Eberle
(CHAPTER 4 Conclusion)
11th October, 2005

Matthias Haeusler
matthias.haeusler@ems.mit.edu.su

Dear Matthias,

**VivoCity Student Design Contest**

Congratulations! I am pleased to inform you that you have been selected as one of the 20 semi-finalists in the VivoCity Student Design Contest.

As a semi-finalist, your design will be developed into scale prototypes and displayed in an exhibition as part of the Singapore Design Festival. Four finalists will then be short listed by our panel of judges during the exhibition to participate in a mentorship program in Tokyo with Mr. Toyo Ito, to refine their designs. Upon re-submission, the judges will categorise the final entries as gold, silver, bronze and merit prizewinners. Should an entry meet the criteria to win a gold prize, the piece will be produced and displayed at VivoCity, alongside the VivoCity International Art Collection.

To further your chances of excelling in this contest, we are enclosing comments from the judging committee regarding your design. You will be given till **14th October 2005** to refine and resubmit your designs to us, before the prototyping process commences.

In order to do the prototyping, all semi-finalists are required to submit the following:

1. **Drawings of the designs in Rhino, Autocad or Solidworks (3dm, dwg, dxf) formats.** All drawings must be three-dimensional. Should a semi-finalist be unable to submit the above, two-dimensional drawings are acceptable, but only if clear illustrations of the top view, side view and front / end view are provided.

2. **All dimensions should be given in millimeters (mm).** Measurements / dimensions and the material of the art piece should be clearly stated in the drawings.
   
   *Note: Semi-finalists may submit the drawing files in 1:1 scale, but the actual prototype will be scaled down for display at the Singapore Design Festival exhibition.*

3. **Semi-finalists are encouraged to submit a rough model made from materials like paper, plaster etc, which will help explain the design and its intention.**
Note: The organiser maintains the absolute right to produce the prototypes according to the prototype-maker's best ability, and where production processes require, slight modifications or changes in dimensions may be necessary, although the design intent will be taken into the highest consideration throughout the process.

We also request that you fill in the attached contestant background form and send it back to meiyong.leong@141worldwide.com, together with a résumé of your past and present design achievements. This will help us in compiling a publicity package.

Please contact us at enquiries@vivocity.com.sg should you have any questions regarding the contest. On behalf of the organisers, I wish you all the best in this contest.

Sincerely,

Susan Sim (Ms)
Senior Vice President, Marketing

You are required to submit all revised designs to

VivoCity Student Design Contest Re-Submission
1 Maritime Square
#13-01, HarbourFront Centre
Singapore 099253

or submission@vivocity.com.sg (please include the header “VivoCity Student Design Contest Re-Submission”) by 14th October 2005, failing which, the prototype will be produced based on your original submission, which may affect the final score given by the judging committee to your design. Due to the tight schedule, you may choose to submit electronic drawings via email by the above deadline and follow up with the actual drawings.
Light Animated Hypersurface
By Matthias Hank Haeusler

Comments from Judges
General Comments from Judges: All entries need to submit detail explanation on how your designs interact with people/viewer
Answer:

__________________________________________________________________________________________

Specific comments from Judges:
"Lighted Animated Hypersurfaces" by Mr Matthias Haeusler

Comment: To consider a tunnel shape instead of a block
Answer:

__________________________________________________________________________________________

Comment: Production cost is limited, therefore to review how design can be done within a budget
Answer:

__________________________________________________________________________________________

Comment: Safety of display piece should be thought through carefully
Answer:

__________________________________________________________________________________________

Comment: Will be good to build in some functionality
Answer:
References

Booklist

Here all books, articles, essays, conference papers, etc. direct used for this research got listed by the name of the author in an alphabetical order.

Books influencing the research, but not directly quoted

Here all books, articles, essays, conference papers, etc. which have an influence onto this research but have not been direct quoted in the research are listed by the name of the author in an alphabetical order.

Image Index

The author wants to express explicit that all images are for representational reason only, and the author do not own any copyrights. All resources have its source stated with the exception of the images of in following chapters:

- CHAPTER 3 Embedding media in architecture: cultural and technical implications [1.3.2.] Fig. 16 – Fig. 26, these images have been sent to me from Japan with out a reference of ownership.

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Booklist


Alliez, Eric and Feher, Michel, “Notes on the sophisticated city”, Michel Feher and Sanford Kwinter (eds), The contemporary city (New York: Zone Books 1/2, 1987).


Fest, Joachim, *Speer, the final verdict*, (Berlin: Alexander Fest Verlag, 1999).


Slaatta, Tore, *Urban screens: Towards the convergence of architecture and audiovisual media*,

Snoonian, Deborah, P.E., “Digital Practice”, in: *Architectural Record*, 03/2003 The magazine of the AIA.


CHAPTER 1 Research Background

[Fig. 1] http://www.ctgermany.com/de/mipix.php
[Fig. 2] All rights Kauffmann, Theilig & Partner, Stuttgart, Germany
[Fig. 3] All rights Kauffmann, Theilig & Partner, Stuttgart, Germany
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[Fig. 15] All rights Kauffmann, Theilig & Partner, Stuttgart, Germany

CHAPTER 3 Embedding media in architecture: cultural and technical implications

[1.] The historic, technologic and content background of media in architecture

[Fig. 1] www.galinsky.com/buildings/pompidou/pompidou1.jpg
[Fig. 2] www.galinsky.com/buildings/pompidou/pompidou1.jpg
[Fig. 3] All rights Warner Bros
[Fig. 4] All rights Warner Bros
[Fig. 5] All rights Warner Bros
[Fig. 6] ToyoIto.Phaidon.Press.Milan2001 (book3)
[Fig. 7] ToyoIto.Phaidon.Press.Milan2001 (book3)
[Fig. 8] www.shoplet.com
[Fig. 9] http://en.wikipedia.org/wiki/Image:Verschiedene_LEDs.jpg
[Fig. 10] http://en.wikipedia.org/wiki/Image:Fremont_show3_051205.jpg
[Fig. 11] http://www.crutchfieldadvisor.com/ISEO-rybtsppd/reviews/20051220/bravia.html
[Fig. 12] http://www.rentacomputer.com/PR/iece.asp
[Fig. 13] http://www.asiatech.com.hk
[Fig. 14] http://www.jahsonic.com/42ndStreet.html
[Fig. 15] http://www.aquaphoenix.com/doc/nyc/page6.html
[Fig. 16] Source not identified
[Fig. 17] Source not identified
[Fig. 18] Source not identified
[Fig. 19] Source not identified
[Fig. 20] Source not identified
[Fig. 21] Source not identified
[Fig. 22] Source not identified
[Fig. 23] Source not identified
[Fig. 24] Source not identified
[Fig. 25] Source not identified
[Fig. 26] Source not identified
[Fig. 27] http://www.ctgermany.com/images/portfolio/specsheet_lightguide_2004.pdf
[2.] A discussion of works by others in my research domain

Fig. 46: http://www.greyworld.org/?the_source_i2
Fig. 47: http://www.greyworld.org/?the_source_i2
Fig. 48: http://www.greyworld.org/?the_source_i2

Fig. 49: http://www.sial.rmit.edu.au/Projects/Aegis_Hyposurface.php, credit: Mark Burry
Fig. 50: http://www.sial.rmit.edu.au/Projects/Aegis_Hyposurface.php, credit: Mark Burry
Fig. 51: http://www.sial.rmit.edu.au/Projects/Aegis_Hyposurface.php, credit: Mark Burry

Fig. 52: http://new-art.blogspot.com/2005_07_01_new-art_archive.html
Fig. 53: http://www.archidose.org/writings/blur.html

Fig. 54: http://architettura.supereva.com/architettura/20041013/index.htm
Fig. 55: http://www.banquete.org/banquete05/visualizacion.php?id=125

Fig. 56: http://www.oosterhuis.nl/quickstart/index.php?id=116
Fig. 57: http://www.vitruvius.com.br/arquitextos/arq000/es136.asp

[3.] Possible significance of the spatial dynamic media system for architecture

Fig. 58: E.H. Gombrich, The story of art, 16th edition Phaidon Press Limited, London; Picture 45
Fig. 59: E.H. Gombrich, The story of art, 16th edition Phaidon Press Limited, London; Picture 48
Fig. 60: E.H. Gombrich, The story of art, 16th edition Phaidon Press Limited, London; Picture 52

Fig. 56: http://www.erusg.cz/era21/index.asp?page_id=97
Fig. 57: http://www.rousseauprojectdurham.com/slides/S_sargadelos.jpg
Fig. 58: http://www.nationalgallery.org.uk/cgi-bin/WebObjects.dll/CollectionPublisher.woa/va/work?workNumber=ng1314
Fig. 59: http://en.wikipedia.org/wiki/Image:Skull-Ambassadors.jpg
Fig. 60: http://www.oosterhuis.nl/quickstart/index.php?id=122