Machine Translations

An investigation of interactive computer art works that incorporate physical and interactive aspects of pre-computer age machine devices.

by John Lycette

Submitted as a requirement for the Degree of
Master of Arts (by Research Project)
RMIT University

Student Number: 2100107A
Centre for Animation and Interactive Media
School of Creative Media
RMIT University

Supervisor: David Atkinson
© John Lycette, August 2007
Declaration

I, John Lycette, hereby certify that except where due acknowledgement has been made, this work is mine alone.

The work has not been submitted previously, in whole or in part, to qualify for any other academic award.

The content of this project is the result of work that has been carried out since the official commencement date of the approved research program.

Signed........................................... Date: / /
1  INTRODUCTION  

1.1  Methodology  
1.2  Historical Context (Professional Practice)  
   1.2.1  Papermachine  

2  PRE-COMPUTER AGE MECHANICAL DEVICES  

2.1  Collection of Mechanical Devices  

HUMAN INTERACTION WITH MECHANICAL DEVICES  

3  HUMAN INTERACTION WITH MECHANICAL DEVICES  

3.1  Mechanical Interaction  
3.2  Mechanical Characteristics  
   3.2.1  Function  
   3.2.2  Form  
   3.2.3  The Tactile  
   3.2.4  The Intangible  
3.3  The User Experience  
3.4  Body as Interface  
   3.4.1  Body Memory  
   3.4.2  Body and Mind  

4  COMPUTER INTERACTION  

4.1  Physical Interaction with Computer Devices  
   4.1.1  The "Desktop" Computer  
   4.1.2  The Hand-held Device  
   4.1.3  Gaming  
   4.1.4  Computer Control Devices  
4.2  Interaction with Computer Content  
   4.2.1  Virtual Screen Space  
4.3  The User Experience  

5  PRELIMINARY RESEARCH  

5.1  Soldering  
5.2  Suitable Input Methods  
5.3  Collections  
   Existing Artists and Artworks  

6  PROJECTS  

6.1  Project Concepts  
   6.1.1  Guest Book  
   6.1.2  Animation Machine
1 Introduction

This research is a practice led investigation of interactive computer artworks that incorporate physical and interactive aspects of pre-computer age mechanical devices.

1.1 Methodology

The method by which this research will proceed, is initially by looking at interactive productions (created as part of my professional practice) in order to identify any relationship to mechanical devices or factors that have influenced this field of enquiry. With the same purpose, I will document a selection of the mechanical objects I have collected during and in the years prior, to this research. These items will be analysed in terms of their mechanics as well as their visual and tactile form and its relationship with function. The mechanics of the typical human/computer user experience will be analysed and compared to that with pre-computer devices.

In order to consider and evaluate existing computer artworks that explore aspects of mechanical interaction, I will attend events, visit exhibitions and museums and identify practitioners in this field in order to gain inspiration and a context for the place of my own work. As a culmination of these activities, concepts for computer artworks that explore ideas or utilise methods of mechanical interaction will be considered and assessed. The findings from this analysis will inform the design and production of a number of interactive computer art works. The planning and production of the art works will be documented as well as the outcomes.

1.2 Historical Context (Professional Practice)

Aspects relating to the human/machine, human/computer relationships have existed in many of the previous works I have either created or been involved with. I think it is a natural progression for new mediums to reference aspects of form and function from proceeding ones and I believe this proved influential in my approach to computer interfaces and computer interaction. Even as the medium develops and matures, the tendency to reference other mediums continues and is evident. Within the context of my own professional practice, the representation of machine processes, their structures, internal and finite logics and repetition make them an ideal subject and influence for both function and form when producing multimedia works.
1.2.1 Papermachine

Figure 1: papermachine (1996)

The interactive work papermachine (1996) was conceived in the early years of my practice, with my brother Mark Lycette. At that time there was little common experience with interactive multimedia in the general public, and gaming was the main representation within everyday life. An interactive CD-Rom was not a commonly understood medium and the value of an interactive experience or learning method via the computer was not quantified. The 1.2 Megabyte floppy-disk was the primary method of file transfer and the World Wide Web was in its infancy.

Being new to this creative realm, Mark and I were trying to understand and quantify the interactive computer experience. As what might be a common response, we decided to look to the past to assist introducing this new technology, and decided to use our tactile and interactive relationship with paper as the bridge between a physical and virtual world.

The tactile nature of paper was represented on screen, it appears as an aged parchment with torn edges, textural and colour variations within the surface and stamps and printed marks upon the surface. Real world interactions with paper are referenced within the interactive work, the title 'types' into position from left to right, accompanied by the sound of a manual typewriter. A paper aeroplane can be 'folded' along a dotted line, wax can be 'dripped' on the page and a seal 'pressed' into it, tabs can be 'pulled' and the corner is 'flicked' in order to reveal a stick-figure animation.

The three dimensional nature of the paper was created in the virtual screen space with the use of texture upon the 'paper' background, with raised portions of paper picking up an imaginary light source and casting shadows into the lower sections. In addition to its texture, the paper has evidence of being previously folded and creased, discoloured through exposure to light, contact with fingers or accidents with water. Some of the edges have been torn or cut to expose secondary layers. The paper provides it a sense of scale and its aged appearance suggests it has been an object of function and use over some time.

The concept, central to papermachine, of linking aspects of paper interaction with computer interaction provides a point of reference for my research that aims to connect aspects of mechanical interaction with computer interaction and on-screen feedback.
2 Pre-computer Age Mechanical Devices

The pre-computer age mechanical devices this research will refer to have the potential to vary greatly in complexity, function in many different ways and with many different purposes. They could be considered a tool, a mechanism, or a machine and could be designed to operate in the realms of work, entertainment or leisure. No matter how complex they appear, most devices can be reduced down into simple mechanisms, which in Physics, are referred to as machines.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclined Plane</td>
<td>A flat surface with one end higher than the other.</td>
</tr>
<tr>
<td>Wedge</td>
<td>An inclined plane that is able to move.</td>
</tr>
<tr>
<td>Screw</td>
<td>An inclined plane wrapped around a central cylinder to form a spiral.</td>
</tr>
<tr>
<td>Lever</td>
<td>A rigid object that pivots about a fixed point.</td>
</tr>
<tr>
<td>Wheel &amp; Axel</td>
<td>Two circular or cylindrical objects that are fastened together and rotate about a common axis. Gears are two or more wheels linked by interlocking teeth.</td>
</tr>
<tr>
<td>Pulley</td>
<td>A grooved wheel around which is wrapped a rope, chain or cable.</td>
</tr>
</tbody>
</table>

A compound machine is a device that combines two or more simple machines.

According to this definition, the mechanical devices I am referring to in the context of this research are primarily compound machines. They can be very basic compound machines such as a hand lever, crank or wheelbarrow, or a complex one such as a pedal sewing machine or hand drill.
2.1 Collection of Mechanical Devices

Leading up to and throughout the duration of this research, I have documented mechanical devices in the form of photographs, sketches and diagrams. I have also collected many items that are in themselves compound machines or were parts of compound machines. The following selection represents a cross section of the entire collection presented within my web diary.

Spanners (Levers)

Cast iron 'box spanners'. These spanners are simply tools but when fixed around a nut or bolt, become simple levers. Their length and heft vary significantly, and this allows them to function according to the force and level of torque required in the task to which they are applied. The small spanner has a width and length suited for one hand while the larger one can accommodate two hands comfortably.

Steering Wheel (Lever)

A plastic steering wheel from a ride on mower. Although not aesthetically pleasing, it is a good example of the diverse form in which a lever can take. The regular bumps around the back of the steering ring are comfortable and practical for maintaining the position of the fingers while the depression that runs around the inner edge is designed for resting ones thumb at any rotation.

Punch Jig (Lever)

This purpose built tool features a lever that raises a weighted shaft that can be dropped onto an item positioned below. I assume this was used for accurately marking or puncturing one of many items in succession. The length of the handle is visibly longer on the users side of the fulcrum, this means the amount of force required to raise the weight is less than the weight itself. The wooden handle is discoloured slightly and has a polished patina through its repetitive use.
Shearing Shear Sharpener (Lever, Wheels and Axles)

A cast iron machine that clamps to the edge of a suitable bench. Through the use of a number of gears, the handle drives a grinding stone (no longer intact). The turned wooden handle is in fact a wheel and axle that is connected to a lever that is in turn connected to another wheel and axle with gears. The ratio of the gearing means that relatively slow cranking is translated to turn the stone at speed.

Hand Drill (Lever, Wheels and Axles)

This hand drill is similar to the shear sharpener above but it only consists of one level of gearing, that of the main wheel and two identical gears driving the main shaft with the chuck at one end. The angles of the spokes within the main wheel are of interest, as they allude to the direction of the tools operation. The shape and patina of the main handle suggest that it can be used with the hand around it or over the end when extra downward force is required.

Film Winder (Lever, Wheels and Axles)

This machine is also very similar in its mechanical make-up to the shear sharpener. But due to its less industrial nature, the iron finish is fine and detailed and its gears are contained within the casing. Also alluding to its function as a mechanism of relative precision, the size of the wooden handle is designed for a number of fingers rather than the entire hand.
3 Human Interaction with Mechanical Devices

3.1 Mechanical Interaction

When we interact with mechanical devices, particularly those with an industrial purpose or from the industrial age, we are more likely to engage in a large mixture of physical movements that vary in scale and force. If we were to start a vintage car using the crank at the front of the engine, we have to first bend at the waist and back, wrap our hands around the handle, manoeuvre our legs to achieve balance and provide enough purchase. We would have to use the muscles in our arms, shoulders, and back to turn the crank, while flexing the muscles in our stomach and legs to maintain a fixed position on the ground. Interaction with this type of machine device can be physically taxing, and repeated operation can increase physical fitness in the long-term and even cause physical damage in the short term.

Another mechanical device, but one that resides on the other end of the scale regarding degrees of movement and force, is a device such as a wind-up alarm clock. It is unlikely we could strain our muscles in the operation of such a device, and unlikely that it would provide an opportunity to exercise. But it is undoubtedly an activity that would engage our bodies in the physical sense. When I wind a clock I use my left hand to hold the clock, and the thumb and pointing finger of the right hand to grasp the key at the back. I then clasp the face of the clock in order to turn the key and wind the mechanism. In doing this, I feel the resistance created by the spring, and as I continue to turn the resistance increases until I feel it reach the extent of the mechanism.

The degree of forces we use, and the extent of our body we utilize while interacting with mechanical objects varies greatly. In one interaction we might use our entire body from our fingers to our toes, in an effort to exert a large amount of force in a controlled way. In another interaction we might use just the hand and fingers for minimal force or added precision.

3.2 Mechanical Characteristics

By first identifying characteristics of function, form, texture and sound that are embodied within the appearance and operation of machine devices, I will later be able to consider or attempt to include them into the design of interactive artworks.

3.2.1 Function

3.2.1.1 Weight & Resistance

There is a degree of weight or heft, involved in most machines. This is often due to their construction – made of steel or cast iron – providing them strength, durability and in effect a lifespan of use.

Weight creates a sense of value and importance. Any machine that requires an investment of effort to use or engage with, suggests an importance with the function it performs or with the weight with which it performs it, such as a steel press or guillotine. Nowadays, with the aid of hydraulics and power assisted interfaces – such as modern car steering – humans can become further disconnected from the task at hand. As such, weight and resistance have been “built in” to devices that no longer actually have it.
Beyond reflecting an aspect of the task being under-taken, resistance can provide important aspects of machine interaction, such as the level of engagement or end of engagement. When we can no longer move a handle in its mode of operation we deduce that its maximum or minimum setting has been reached. We know when winding an alarm clock that the resistance grows as the spring reaches its maximum compression, or when a vice is firming its grip upon an object. The resistance provides the operator “verification of engagement and completion”. [MacLean]

3.2.1.2 Weight & Momentum

Another aspect of weight - inherent within some mechanical devices – is the momentum it can provide. Within a mechanical environment, an obvious representation of which is the flywheel. A flywheel is a wheel of significant weight, that initially requires a good deal of energy to move, but creates a significant amount of momentum once spinning. A flywheel reduces the need to maintain a high or direct level of energy to drive, as is evident within a typical spinning wheel that incorporates a large wheel.

This large iron wheel has an approximate diameter of 150cm. It exists in a fixed position in a small farm shed (Portugal, 2004) and drives a piston connected to a chamber. It appears to be a pumping device, either turned via a crank opposite the wheel (no longer apparent) or by the wheel itself. The size and weight of the wheel provides a great deal of momentum when spinning and as such functions as a flywheel.

Momentum also plays a role when a mechanical device consists of components that move in a pendulous way or involve a rocking movement, such as a water pump. There are numerous devices that fall somewhere within the definition of machine and tool. And without exploring this definition further, the hammer is one such device that embodies weight at one end, and a handle to provide a swing and in turn momentum.

3.2.2 Form

3.2.2.1 Wear

Many mechanical devices appear to be old, well used or even worn out. When an object has an aged appearance due to rust or cracked paint, it suggests that its recent years have not been particularly active, and this is probably due to some level of obsolescence. When an objects aged appearance is due to wear, such as grooves in a bluestone staircase, shine on the handle of a scissor, or the handle of a spade worn by the shape of its users hand, then its appearance suggests an ongoing level of usefulness and relevance. Schutte refers to an objects "history-of-use" and believes this wear "adds authenticity, information, identity and social value". [Schutte] In practical terms this wear also helps describe the objects function and can "give signs of how (and how much) it's been used". [MacLean]
3.2.3 The Tactile

The ‘hands-on’ aspect of machines and machine interaction is common to most and plays a role in each mechanical characteristic whether of form or function. Most human interaction with machines occurs to a large part via the hands, delivering a level of physical, or haptic, feedback to the operator. Such tactile feedback provides information about the task, allowing the user to respond suitably or achieve a required level of precision.

3.2.4 The Intangible

An important aspect of machine interaction is the aural component. Much interaction can affect an item or material that exists outside of the device, such as a nail or wood being cut. When teamed with the existence of (or sudden lack of) resistance, the sounds can provide an important level of feedback announcing the end or extent of a certain interaction. The aural feedback can also provide useful as it can change according to the stage of the process at hand, such as the progression of sound associated with the driving of a nail.

Some interactions create an audible aspect within the compound machine or device itself, such as the sound of hub and axel, gears engaging or steel upon steel. While other audible elements somehow exist between that which is part of the machine and that which has being affected by it, such as the displacement of air within a piston or the release of steam.

Another sensory component of machine interaction is the olfactory. Wooden components often exude the smell of their timber or the varnish of which they were treated, or the oil by which they are maintained. Steel components are subject to rust and when moving, to friction. Anti-corrosive oils protect steel surfaces, grease reduces the friction and both provide an aroma to the user.

3.3 The User Experience

The many types of mechanical devices and the many types of interaction create as many different user experiences. Throughout history, humans have interacted with mechanical devices in order to complete tasks or participate within the realm of industry. We invest a certain level of our mental focus and varying degrees of physical energy and as such, expect an outcome of comparable worth.

Writers commonly refer to their tools as being integral to the flow of information and ideas from their mind to the page, Eno writes of how musicians have a similar relationship with their instruments and although impossible to separate and difficult for outsiders to understand, a dancers relationship with their body as their primary method of communication [Stevens].
3.4 Body as Interface

"All the information coming and all the information going out from the brain are filtered, if you like, via the body." [Haggard]

3.4.1 Body Memory

Brian Eno writes that "...familiarity breeds content. When you use familiar tools, you draw upon a long cultural conversation...".
The conversation Eno refers to is that which is had between the body and the tool. The tool feels familiar, the feeling reminds us of its purpose, we can visualise the movement, or more correctly we can 'visualise' the feeling of moving it. Our body remembers the tool and associations build from that memory.
The term "body memory" refers to the idea that there is an ability for the body to recall certain postures, positions and movements. The term "muscle memory" is also commonly used to mean the same thing. The memories specific to recalling a physical action of the body are called 'procedural memories' and assist us when driving a car, playing an instrument or riding a bicycle. After time, and often much repetition, these movements can become second nature and no longer controlled by a conscious decision making within the brain. The commonly held idea that once the feeling for riding a bike is gained, one never forgets, is a good illustration of body memory.

3.4.2 Body and Mind

Our physical knowledge of our bodies is integral in understanding concepts such as gravity, movement and momentum. Dreyfus believes that the shape and movement of our bodies helps us learn and make sense of the world and that a loss of embodiment (through an online existence) would lead to an inability to recognise relevance. [Dreyfus]

3.4.2.1 Sensations

Kinesthesia is the sense that detects bodily position, weight or movement of the muscles, tendons and joints. It is the sensation of moving in space. The knowing of a feeling is sometimes referred to as 'kinaesthetic awareness' and "operates through sensory receptors in the muscles and tendons that provide ... information on posture, movement, and changes in body equilibrium". [Seitz]. This sensory ability, called proprioception, can be illustrated by closing one's eyes and touching the tip of the nose with one finger [Haggard]. Proprioception is obviously integral in thinking about the feeling of certain actions or physically reproducing those actions in a satisfactory way, such as reciting a piano score, performing a choreographed work or even starting a lawn mower. Taction is the sensation arising from stimulus to the skin brought about by the act of touching or making contact. Obviously this is a factor in most forms of interaction and no doubt when interacting with mechanical devices.

3.4.2.2 Creativity

Brian Eno suggests that the level of comfort and content associated with interacting with a familiar tool provides an ability to be truly creative. Alternatively "...when muscular activity is rendered useless, the creative process is frustrated." [Eno]
When engaged in a comfortable and familiar task, the body is drawing from the primal regions of body memory and what feels “right” and is creating from another part of the brain.

3.4.2.3 Learning

There is evidence to suggest that 'procedural memory' (the ability to recall skills and procedures) is “more durable than the factual (brain) memory” [Wienke] used when recalling facts and events and referred to as ‘declarative memory’.

When cognitive exercise is teamed with physical movement, it becomes more engrained in one’s mind [Texas]. Students are encouraged to repeat new facts while jogging or swimming in order to assist in recalling them later. It is equally believed to be of use during intricate and small area movements such as writing or mouthing words. The physical movement, and one could extrapolate the associated body memory, of moving the mouth or arms and legs is placing the information in a region of the mind that can be readily retrieved for a long time.

4 Computer Interaction

4.1 Physical Interaction with Computer Devices

4.1.1 The "Desktop" Computer

On a day-to-day basis the extent of most physical interaction with computers involves a keyboard and a mouse. The mouse resides on a mouse mat and is often tethered to the computer by wire. The necessity to move ones “mouse hand” more than 30cm from the keyboard to the mouse is rare. The hand that remains at the keyboard rarely needs to move away and most of the physical movement is in our fingers, hands, wrists and lower arms.

The definition of computer is changing as is our use and relationship with it. The laptop allows us to move the computer with us. The mouse and mouse mat became unnecessary with the invention of the “track pad”, which allows a single finger to track a miniature touch sensitive quadrant like the mouse mat. While other laptop computers utilise other means of cursor navigation, with a “control stick” nestled in the middle of the keyboard. These methods reduced the operator’s physical movement even more than previously. Some might say that these solutions were particularly useful while being mobile, but the tendency for users to plug in an external mouse, suggests that the ease of use was questionable. In either case, when we relocate our computer workspace the realm of the physical area required to operate within rarely exceeds a square metre.

4.1.2 The Hand-held Device

Handheld computers, such as the pocket PC or palm device, are much more suited to the truly mobile worker. However, along with the increased portability of the device through miniaturisation of the hardware, the actual area for physical interaction has decreased. The lack of surface area on the device has demanded that other input methods be devised for the keyboard and mouse. The miniature keyboard was one answer, but the ease of use reduced with the reduction in size. The touch-screen and stylus has remained as one of the most successful methods of interaction for hand-held devices. A pen-like implement, the stylus, allows the user to drag and drop,
select, type, draw and write directly onto the screen. In the world of the miniature computer: the monitor, keyboard and mouse mat have become one.

Despite this revolution in handheld computers, the external monitor, keyboard and mouse remain the mainstays of most computer interaction.

Mobile phone technology has been developing in parallel with personal computers. As their main purpose from the outset has been to make telephone calls, the basis to the mobile phone interface has been 10 digits and a number of function and navigation keys. As communication options evolved to include SMS functionality, “text messaging” has become a secondary form of mobile communication. The numeric keypad has been pushed beyond its primary function in an effort to accommodate the need to type. The mobile user has had to learn to type within a small surface area and the designers of the technology have had to arrive at new hardware and software solutions to aid ease of use. These developments have had obvious physical effects on frequent users of mobile phones. Thumb dexterity has improved throughout the world, particularly in the younger population that Sadie Plant refers to as the “thumb generation” [Plant]. This phenomena continues to evolve to the extent where there are numerous competitions to break the world record for typing text messages at speed. [textually]

The mobile phone has become a one-handed device, with a screen for reading, viewing information and entertainment. This development has informed the design of other technologies. The personal portable music player, has been with us for some time, in the form of the transistor radio or walkman. But it is only recently with the proliferation of digitised content such as music and video, that devices such as the iPod have increased in uptake and become a commodity to many. The ability to store, catalogue, distribute and share digital content in a very mobile fashion pushes the device into the realm of personal computer. As the inception and design of the iPod has occurred within the mobile phone era, its design has embraced the phones one-handed nature. It was designed with the inclusion of the scroll-wheel, and boasted that it "...makes it possible to hold and operate iPod with just one hand...." [Apple]. When teamed with other buttons (or indeed other interactions with the same input method) the scroll-wheel allows the user to toggle between functions while applying the same physical interaction technique. The success of the approach can be measured by it being replicated on similar devices such as the iRiver.

With Apple's launch of the iPhone we have seen a significant commercial move towards the use of virtual interfaces. Advances in the quality and functions of the touch screen have become possible, such as the ability to "multi-touch" by changing the relationship of two contact points (fingers in the case of the iPhone) in order to emulate concepts such as zooming, stretching and rotating. This interactive concept was represented within a science fiction context, in the movie Minority Report 2002. It has since been the focus for a number of researchers including the Multi-Touch Interaction Research of Jeff Han [Han] and that of John Underkoffler [Underkoffler] developing the concept for military application. These advances in the virtual interface mean that interactive computer devices can be less reliant on permanent physical fixtures such as the scroll wheel, in favour of virtual items that appear and vary according to the interaction required and the information represented. The central control panel of Volvo's concept car, the xc60 [Volvo] is an example of this type of adaptable interface that changes to suit the purpose. The inclusion of permanent tactile knobs, however suggests something of the inherent value embued within an actual interface button that one can hold and turn.
Additional functions such as the camera, video capture and microphone take the hand-held device from one where the central purpose is content sharing, to one that is capable of content generation. As with computers, the delineation between the medium and the message is becoming blurred. The capacity and capability of mobile devices and the networks will continue to grow, and ultimately rival desktop machines as the preferred and most commonly utilised computer device.

4.1.3 Gaming

The other realm of computer interaction that has developed largely in parallel to the personal computer, is gaming. As an entertainment industry, this is a realm in which there have been major explorations and developments in the way people interact with the screen content.

Since the early years of its existence, video games were available in the home by connecting an electronic box with one or more controllers to the television. Video games were also available in public outlets that provided purpose built cabinets that housed the electronic hardware, monitor and controllers.

Over the years the complexity and variation in the way games can be controlled has grown. Generally speaking; whether connected to a television via a console; a computer via the keyboard; or within a purpose built cabinet; the interaction method has increased in area, become more physical, and mirrored real world physical interaction and movement.

Real world aspects of machine interaction (as previously identified) such as heft, wear and resistance, are now being incorporated into computer games. These real world characteristics are relayed to the user via haptic gaming controls that use magnets to create various degrees and types of resistance. These characteristics have not been utilised to influence the design of the interface, but in order to more closely mirror reality and create a higher level of reality in the virtual realm.
More recently game controllers such as the Nintendo Wii, have incorporated inertia switches in order to track the position, angle and movement of the controller [STM]. The console tracks the users movement and translates real world gestures into the virtual space. As such users are required to swing a controller like a baseball, tennis racquet or boxing glove in order to operate the game. The computer control devices used in gaming continue to develop and continue to free the user from the keyboard/mouse “straitjacket”, as described by Alison Armstrong [Armstrong].

4.1.4 Computer Control Devices

Below is a collection of commonly used input devices or components listed in order of the degree of freedom they each provide.

<table>
<thead>
<tr>
<th>Input Device</th>
<th>Degree of Freedom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key, Button</td>
<td>finger/thumb</td>
</tr>
<tr>
<td>Scroll wheel (Mouse, iPod)</td>
<td></td>
</tr>
<tr>
<td>Keyboard</td>
<td>fingers</td>
</tr>
<tr>
<td>Switch</td>
<td></td>
</tr>
<tr>
<td>USB Knob</td>
<td></td>
</tr>
<tr>
<td>Track-pad (laptop, iPhone)</td>
<td>hand</td>
</tr>
<tr>
<td>Mouse</td>
<td></td>
</tr>
<tr>
<td>Track ball</td>
<td></td>
</tr>
<tr>
<td>Joy-Stick</td>
<td>hands</td>
</tr>
<tr>
<td>Touch Screen</td>
<td></td>
</tr>
<tr>
<td>Steering Wheel</td>
<td></td>
</tr>
<tr>
<td>Guitar</td>
<td></td>
</tr>
<tr>
<td>Steering Wheel &amp; Pedals</td>
<td>feet</td>
</tr>
<tr>
<td>Dance Mats</td>
<td></td>
</tr>
<tr>
<td>Nintendo Wii</td>
<td></td>
</tr>
<tr>
<td>Sony EyeToy</td>
<td>body</td>
</tr>
</tbody>
</table>

4.2 Interaction with Computer Content

Beyond our interaction with various computers or the hardware attached to computers, is our interaction with the content represented on the screen and within the perceived screen space. It is important to consider these aspects of the computer experience as it is closely linked with the method of input, level of interaction and perception of cause and effect.

4.2.1 Virtual Screen Space

To date, a large part of human/computer interaction has been dedicated to compiling, composing and distributing text information. A great many different types of software have been developed for this purpose and the primary hardware focus has been upon the desktop computer and keyboard and to a lesser extent the mouse. Typically the interaction with screen content has been somewhat analogous to interacting with real world documents, writing tools and processes upon a writing desk. Commonplace computer terms such as file, folder, document and indeed desktop are
remnant of this fact. Although the methods of interaction continue to develop and become less referential to real world objects and methods, the experience remains largely related to the two-dimensional qualities of the 'page'.

As the computers purpose has extended from being a work tool to include an entertainment device, the interactive space represented on the screen has become less derivative of the page in favour of the 3D space. The capacity to move one's viewpoint within a virtual space has meant that first person interaction has become widespread, particularly within gaming. When coupled with real-time feedback, such first person interaction provides an engaging and immersive experience. Advances in artificial intelligence, real-time animation, motion-capture and multiplayer networks continue to make this level of interaction and its visual appearance, extremely seductive. When teamed with tactile hardware, the on-screen representation can closely demonstrate real world interactions, along with mechanical affordances such as heft, resistance and momentum.

4.3 The User Experience

Humans interact with computer devices in order to create, extract or share information. These purposes might occur in the realm of work, education or entertainment and they will likely vary enormously in function and appearance. The interaction with a first person 'shoot-em-up' game will vary greatly when compared to that of a spreadsheet application, as will the users perception of the content as it exists 'upon' and/or 'beyond' the screen. Despite their differences, each interactive experience provides the user with an outcome they consider worthy of pursuit or, in the case of work, compelled to pursue.

When again considering my earlier work papermachine, the aim was for the user to refer to their experience of interacting with paper, in order to interact successfully. While the components within the work reference paper based symbols (such as dashed lines and scissors), marks (such as fold lines) and processes (such as 'flicking' the corner), the underlying drive or purpose appointed to the user is that of a puzzle. Pieces of a jigsaw must be uncovered and then correctly positioned in order to complete it.

Inherent to the make-up of a puzzle, is that the user is encouraged to engage with it, and continue to engage in order to reach its conclusion. A successful puzzle will require a certain degree of effort or challenge and a satisfactory outcome without creating too much frustration for the user. These aspects are similar to those associated with the "work" that is undertaken when we utilise machines or engage in machine interaction. When interacting with a machine, we invest our energy and focus, and expect an outcome we consider valid or worthy. This might be when we turn the handle of a mincer, pedal the cranks of a bicycle or push the piston of a pump.
5 Preliminary Research

5.1.1 Soldering

While at High school I had completed an electronics class, but any remaining practical knowledge was now no longer with me. I purchased a soldering iron and found a beginners guide to soldering [Winstanley]. I had a simple electronic kit that had remained unopened but would provide a suitable project to develop my soldering skills. I completed the project, which has resulted in a walking toy that responds to light.

![Electronic Robot](image)

Figure 13: Electronic Robot

This practical revision of knowledge will prove useful in repurposing electronic input devices and constructing alternative input methods.

5.1.2 Suitable Input Methods

In order to translate mechanical interactions in the real space into computer interactions in the virtual space, various peripheral computer devices and methods had to be considered.

In addition to the keyboard and mouse, there are numerous off-the-shelf devices that connect to a computer with a particular purpose, such as a game controller or joystick. There are also less common devices designed to accommodate particular needs such as head mounted pointing devices or pressure mats. As listed previously, the different input devices provide various degrees of freedom of movement for the user, but they also vary in the way they can be suitably applied to the input of mechanical movement.

At this early stage it is presumed that a degree of customisation will be required in order to re-purpose their particular functions or tailor their appearance. As such when considering the suitability of peripheral devices: the availability, simplicity of construction and capacity to be edited; will be taken into account.

5.1.2.1 Keyboard Hack

There are a number of online sources that describe the process of converting a standard computer keyboard, into an arcade game controller, with large robust buttons. When MAME (Multiple Arcade Machine Emulator) controllers are used to operate retro games, the user experience is similar to that from a previous era. There are a number of methods particular to certain types of keyboard or with outcomes specific to certain games.

In general terms when the key of a keyboard is depressed, it causes a connection between two pieces of plastic film. The film is laced with a circuit like grid connected to a line of inputs on a controller board. When a single key is pressed, two to three
inputs are triggered, and depending on the combination, the signal for a particular key is generated. The combination required to generate specific keys varies between keyboards, but it is commonly referred to as the 'keyboard matrix'.

With my newfound insight into the workings of the modern keyboard, I dismantled the ones I had at my disposal, and identified the various components, the elements that could be utilized and the details that would provide a challenge. Certain types of keyboard were deemed unsuitable while others seemed ideal to 'hack'.

![Figure 14: Keyboards](image)

![Figure 15: Keyboard Hack](image)

![Figure 16: Hack Soldering](image)

When the plastic casing and keys are removed, the apple iMac keyboard reduces down to a long narrow circuit board. Wires were soldered to each track on the board, and connected to a block of junctions on the outside of the box. Individual switches could then be connected to the points without interfering or placing stress upon the internal electronics.

5.1.2.2 Mouse Hack

Through one of the MAME gaming websites, I found a reference to a "Mouse Spinner" [Strum], a mouse hack that emulates a certain type of arcade style input device that was suitable for using with a number of flying games or as a steering wheel for some racing games.

The hack involves reconfiguring the internal make up of a ball mouse. A typical ball mouse has one wheel that tracks the sideways movement of the ball and another that tracks its backward and forward movement. Each miniature wheel connects to a spoked disk that separates an LED and a light sensor. Each time the light sensor is interrupted, the signal is translated into cursor movement on the screen.

The Spinner Hack effectively isolates one of the sensor assemblies and makes a custom disk that connects to a vertically mounted wheel. When the user spins the wheel it translates into sideways cursor movement.

While this type of cursor movement might not translate particularly usefully into most software programs, it can be tailored to perform specific on-screen tasks.

![Figure 17: USB mouse](image)

![Figure 18: Mouse Wheels](image)

![Figure 19: Mouse Jig](image)

My research into input methods led me to dismantle the computer mice at my disposal. While I didn't construct my own mouse spinner I did utilise its theory in devising a simple prototype that translates rotation into computer input.
5.1.3 Collections

Since first entertaining the idea of producing interactive machines, I have collected machines, mechanical components or items that embody a patina of mechanical function. These items vary greatly and have been largely documented in my web diary, below are a selection of images and descriptions.
**Safe**
I originally created this work for an exhibition in 2000. It comprises of an aged wooden box with a lockable lid, a mounted fork and a section of text is contained within. While sculptural in form it has a limited interactive capacity, allowing the viewer to peer inside, unlock and open the box.

Figure 20: **Safe**

**Antique Door Handle**
Metal doorknob and brass locking assembly attached to a wooden portion of door. The exposed mechanism consists of a slide bolt and a rudimentary spring.

Figure 21: **Antique Door Knob**

**Ice-O-Mat**
A domestic ice-crushing device. Ice cubes are inserted at the top. By turning the handle a bladed axle crushes the ice allowing it to drop into a compartment below. The Ice-O-Mat has instructional details in the form of a 'C' and an 'F' referring to the 'Course' and 'Fine' mode of operation in accordance with the direction of rotation. In addition to its 'retro' aesthetic, the object is imbued with narrative and political concepts of domesticity.

Figure 22: **Ice-O-Mat**

**Decorative Steel Handle**
A groove around the outside of this wheel suggests it was connected to another wheel via a leather cord.

Figure 23: **Decorative Handle**

**Pedestal Wheel**
The tapered thread was likely for connecting various sanding or grinding attachments. As the central hub has a groove suitable for accommodating a drive belt, the decorative wheel would possibly function as a fly-wheel.

Figure 24: **Pedestal Wheel**

**Spool Box**
A number of remnants inside this blackened box suggest its original use somehow relating to film. The size and weight of the two handles allow for small and precise movements and the transfer of feedback to the fingertips.

Figure 25: **Spool Box**
Existing Artists and Artworks

5.1.3.1 Physical Computer Interaction

When a person interacts with interactive artworks via the keyboard or mouse, they are interacting in a physical way with a mechanical device. But there are many existing artists exploring physical computer interaction with tactile, gestural and mechanical interfaces. Many of these artworks cause the user to explore aspects of their bodies in space or the space around them. One of the common methods by which screen content and interaction allows the user to explore aspects of their body in space, is if there is a clear and immediate relationship between what is happening within the screen space and their physical space. This relationship between actual and virtual is common to what we understand as virtual reality. First person virtual reality artworks connect, reflect or respond to physical interaction in a direct and immediate way. Such artworks also speak of the real as much as the virtual, as Jeffrey Shaw put it, “virtuality is used as a strategy to reconstitute something essential about the real.” [Shaw]

Virtual reality artists and art works are often interested in leaving the body behind and temporarily suspending the users physical context. Maria Luisa Palumbo describes being in the virtual space as a “dislocation of the corporeal experience” [Palumbo]

Stelarc goes as far as saying “the body is obsolete” [Stelarc]. This is often achieved by creating an immersive experience, such as with the use of VR goggles and wrap around screens and dimensional audio. The work Ephémère, by Char Davies’, requires the user to be very conscious of their body, a user has to control their breathing in order to control movement in the virtual space. The visual component of the work transplants that person’s perception of self into another space. The out of body nature of this work make it a very seductive one and people describe the experience as being like scuba diving, where they are unencumbered in the virtual space. When I saw the work in 2002 [Deep Space], the silhouette of the user was cast on a screen, the cables and mask apparatus connected to them resembled that of a deep-sea diver. Similarly to the figure tethered to the information feed of the VR work, a flippered, weighted diver on dry land becomes a graceful practitioner underwater.

Virtual Reality works, such as Jeffrey Shaw’s, The Legible City gives the user a very real, very tangible device, the bicycle, with which to interact with the screen content. There is a direct and easily understood connection between the screen content and the physical interaction – when one pedals the bike, the virtual point of view moves forward; when one turns the handle bar, the point of view turns.

Also by Jeffrey Shaw, the work The Golden Calf is a virtual artwork that very much crosses the boundary between virtual space and physical space. Resting on a plinth (in the position it was left by the previous user) is an LCD monitor device with handles on each side and a large cable connected to it. When the user picks up the device they see that the screen is displaying the video image being captured by a camera pointing the opposite way. But when the device is held up to view the plinth, instead of it faithfully displaying an empty space, it displays what appears to be a metallic sculpture of a bull. The user can move the screen closer to the point atop the plinth to see the bull close up, or indeed view the sculpture from any position or angle in the room. The lighting within the sculptures virtual room, is designed to mimic that within the gallery, and as such, light is cast and falls across the sculpture as it would if it were on top of the plinth, in the actual room.
While interfacing with artworks such as Davies’ *Ephémère* and Shaw’s *The Golden Calf*, the user would undoubtedly be aware of their body and the space in which they stand. And while I would like to be able to create something as magical as either artwork, the sophistication of the interaction is at a higher level than would be necessary to reflect machine interaction.

The bicycle interface that Shaw created for *The Legible City* provides me a more suitable and realistic point of inspiration in developing an artwork. There are a number of factors that I believe not only make the work extremely successful but importantly point to aspects of my research.

- The components that make up the work are immediately apparent to the user; a screen and an upright bicycle.
- The bicycle is not a complex piece of equipment and the visual clues embodied in the mechanics of the bicycle are obvious to most. Their ‘behaviour’ is inferred by qualities of shape, weight, size and appearance, called their "affordances" [Norman]. They have “fundamental properties that determine just how the thing could possibly be used” [Norman]. One knows the seat is for sitting on, the pedals for peddling, the hand-grips for holding and the handle bar for turning. One also knows the conceptual extension to those mechanical devices, peddling creates movement and steering changes direction. And in a case where a prospective user is not familiar with the workings of a bicycle, it is not a complicated machine. It does not require fine motor skills or precise movement. Its operation is not reliant on a sequence of actions or complex methodology.
- The interface device is robust and nothing can be easily broken.
- The interface device isn’t an expensive piece of equipment.
- The screen content has a clear and complimentary relationship with the interface device. A bicycle allows for travel, the screen content allows for exploration.
5.1.3.2 Mechanical Artworks

Throughout modern times artists, such as Tinguely, have constructed machine inspired artworks. While not necessarily providing direct correlations with the final works, the research of existing machine artworks will likely provide inspiration and useful reference.

Arthur Ganson is an artist who has constructed a huge array of machines and mechanical artworks, many of which are constructed entirely from wire. They are often hand driven and consist of complex connections of cogs, wheels and shafts. In such examples, the level of accuracy, finesse and detail achieved with rudimentary machine components is remarkable.

Figure 28: Tinguely fountain  
Figure 29: Tinguely wheels

Figure 30: Meditation #1, Ganson  
Figure 31: Small Tower of 6 Gears, Ganson

A group of artists that explore aspects of the steampunk aesthetic, produce machine devices that are often recreations of computer devices. The design and foundation of the works, utilise or reference specialist mechanical tools such as typewriters and scientific equipment. Although the level of physical interaction we have with an old style typewriter could hardly be considered industrial, it does consist of components and materials that share characteristics of machine age devices.
The *Electroclerk* obviously draws upon a typewriter in order to reconstruct the computer keyboard. While typewriter keys are an obvious replacement for the keys on an extended computer keyboard.

This laptop has been rebuilt primarily with typewriter parts. The mouse button and track ball resemble a morse code or telegraph key.

Although utilizing antique keys this keyboard references the ergonomic profile of a Mac extended keyboard.

This keyboard demands little mechanical interaction beyond that of a modern keyboard but does incorporate an interactive lever for the function in the upper-right corner.

While there are many creative practitioners creating artworks that explore physical interaction with computers, much work is done in the realm of exhibition design for museums. These interactive exhibits have become common because they provide an entertaining and hands-on experience and they are often used to explain complex concepts and processes. They are often seen as places that provide informal learning activities that can enhance a formal education [Walton].

While these interactive exhibits utilise computer content to varying degrees, they provide a practical and inspirational guide to the design of interactive machines for public use. It could be argued that the interactive and tactile nature of such exhibits encourage people to engage with the content on display. While visiting the Natural History Museum in Vienna there were a number of such interactive exhibits worthy of further consideration.
Within this hexagonal wooden cabinet, numerous viewfinders are mounted vertically upon sliding panels, allowing users of different heights to vary the position of the viewfinder. This exhibit allows a number of visitors to view a large number of specimens at one time and in a relatively small area.

A number of individually mounted viewfinders provide a similar viewing experience, and one with a clear connection to that of a microscope. With the users ability to change their viewpoint and with the provision of a chair, the user is encouraged to engage with the content for a longer duration.

A hand-cranked zoetrope allows the user to see the inner sequence of images from above, and also to look through the vertical slits in order to experience the desired effect. A simple interactive device that illustrates and also demystifies a process.

The height of this device is under one metre and provides an indication of the perceived age of the audience for this exhibit. But as is the case in the photo, adults can bend down and engage with the content.

While not strictly machines (and not connected to computer content) these devices resemble scientific tools and entertainment devices that require a degree of physical interaction, and also embody physical characteristics that assist the users interactive experience.
6 Projects

6.1 Project Concepts

The following are project concepts that were devised during the research period, but have not been realized.

6.1.1 Guest Book

A customised trolley with a computer screen exists within the gallery space. On the screen is an information interface including a digital keyboard and a cursor. When the trolley moves, the cursor moves also. When a handle of the trolley is engaged the trolley can be moved independently from the cursor. The trolley effectively functions like an oversized mouse, and a handle on the side operates as a large button. By physically navigating the trolley around the gallery space, the user can enter their name in a virtual guest book, 'type' their thoughts or read the comments of others. The trolley would be forced to use the space of the gallery like an oversized mouse mat. They might project their concept of a keyboard onto the floor and have to move 'over there' in order to reach the letter 'A'. At times they would have to 'lift' the mouse in order to reach an item in the virtual space that is obstructed by something within their physical space.

I am intrigued by the fact that the user would be engaging with two spaces simultaneously, a virtual one and their physical one. As the screen component of the work would appear as a typical computer interface, employing interface conventions presumably familiar to the user, the screen content would appear quite 'normal'. But the act of pushing a screen around on the back of a mouse, would take what is experienced as a seated act, with limited hand-arm movement, into a full body exercise. The increased level of movement and amount of space required to move the cursor would magnify the distortion of scale. The act of walking in order to move a cursor would exaggerate the idea that the cursor itself is representative of one's identity within the virtual space. In all, I believe the distortions of scale tempered with that of expectation would create an interesting and unique user experience.

6.1.2 Animation Machine

Mounted at the top of a pedestal is a device with a viewfinder and a handle at one side. When the user bends forward to look through the eye-piece, they see an image of the device that they are currently engaged with. The images change one at a time as the user turns the handle and an animation of the machine in motion results. As the animation is representative of the device itself, I think this would focus the users perception upon the object, the method of interaction and the kinaesthetic awareness associated with the interaction.

6.1.3 POV

A small wooden box sits on the floor and projects an image on the wall. There are two small handles at the front of the box. As the user turns a handle, the internal workings of the interactive box appear silhouetted on the wall and the sound of the internal mechanics can be heard. The internal workings respond as the user changes the direction or speed of the turning. The initial perception of the screen content is that it is a literal representation of the inside of the box. But as the user continues to interact they discover it is actually a
less literal view of the internal space. Turning one handle moves the projected viewpoint horizontally and the other moves it vertically. While exploring the inside of the box with the two handles, silhouetted inhabitants of the box appear or become apparent; animals, objects, words and plants.

I believe the viewer would initially perceive the projected image as being what is actually within the box in front of them, they would be considering practical aspects regarding the purpose of a wheel, the source of the light or the scale of the gears. The users perception would then be torn between the real and unreal. While the tactile, visual and aural feedback would suggest the user is engaging with a real device with very real mechanical characteristics, it would simultaneously suggest one was interacting with an impossible object with little connection to the real world.

Other aspects of interest are:

- The user is physically connected with the movement of the screen content.
- The interaction and screen content refers to the object in front of the user and not beyond it.
- The user would likely have to kneel down on the floor beside the device in order to operate it.
- The level of engagement would likely be thumb and finger and the motion would be limited to very small circular movements.
- The user would be moving into an unfamiliar position and interacting in a very intimate space.

6.1.4 Curio

![Curio Concept Diagram]

A rectangular wooden object stands in the gallery space, at its top is a glass pane similar to that of a display case in a museum. There are three hand cranks, one at the top, one at the front and one at the side. An adult can stand looking down at the case, in comfortable reach of the three handles. A blurred image would be apparent within crosshairs on a black screen below the glass. The cross-hairs move sideways by turning the handle at the left, and backwards or forwards when turning the handle at the front. The handle on the top of the box moves the viewpoint up and down, causing the image to blur or sharpen as it falls in and out of focus. Many curious objects would populate the virtual cabinet. The space would be navigable by the user and on occasion objects would navigate the space itself, allowing the user to follow their progress as they traverse across the space or vertically through the space. Particular regions 'within' the cabinet would become recognized as where certain items reside or appear.

I believe that the appearance of the object, coupled with the interactive experience, would create the sensation that the physical space within the cabinet is populated. I believe that the user would feel as if their actual viewpoint was moving within three
dimensions, and that their interaction would be coupled with a kinesthetic awareness of position and space, relating to the actual cabinet rather than in their mind. As such the user would likely use spatial concepts of position and depth (such as; here, there, further, closer, down, higher, deeper) teamed with physical gesturing around the box itself.
6.2 Project 1: Orbiculum

6.2.1 Call for Entries

In September 2002, Experimenta put out a call for entries for its biannual exhibition, to be held during September 2003 in Melbourne. The House of Tomorrow exhibition was an opportunity to create an artwork that explores aspects of my research

6.2.2 Response

One of the initial difficulties that presented itself in defining the response to the brief, was the inherent idea that the future is likely to be somehow “polished” with the use of sleek and highly designed lines and forms and smooth and reflective surfaces. The retro “Jetson's” like aesthetic embraced within the House of Tomorrow “Sky Pad” identity was a continual reminder to this concern. And while attempting to explore ideas of mechanically inspired physical interaction this would be a difficult aesthetic to achieve with my limited ability in construction. The constraints of a limited budget were also important to consider while contemplating a suitable and realistic response.

Figure 44: Experimenta House of Tomorrow – “Sky Pad” identity

It became apparent to me that it would be necessary to redefine the concept of 'tomorrow'. And in acknowledgment of the 'futures' represented in Gilliam’s Brazil and Jeunet and Caro’s The City of Lost Children, decided the 'tomorrow' to be a post apocalyptic one, where components appear to have been resurrected from scrap yards and materials sourced from redundant machinery - edited for a new purpose. On a practical level, this future would afford an achievable aesthetic with the use of second hand materials, limited tools and limited know-how. It would be a mechanical device with digital components, cobbled together, re-contextualized and reconfigured for some future purpose.

“...(in) the post-apocalyptic Australia of the future, suburban life no longer exists” but has “...become etched in folklore and ... nostalgically recreated with the available materials.”

“a virtual snow-dome” containing “…a stylised representation of a suburban backyard; a garden shed, barbeque, lemon tree and concrete path leading to a centrally located Hills Hoist”.

6.2.3 Concept

The artwork is to utilise pre-computer machine interaction as its method of input, while exploring the relationship between computer content and mechanical interface. This work will consist of a physical, mechanical device that employs aspects of machine and tool interaction. It will allow the user to interact with computer generated content while in some way acknowledging the physical, tactile, visual and kinetic aspects of their actual space.

6.2.4 The Physical Interface

“On a computer screen, mounted on a rotating arm, is a stylised representation of a suburban backyard” ... “As the user rotates the screen, their vantage point moves around the space, moving a handle to the left of screen moves the vantage point in and out of the scene.”

As stated in the proposal document outlining Orbiculum, the finished artwork would "allow the user to explore a virtual space in the first person, while having to physically move around their immediate actual space."

In order to encourage the 'correct' type of interaction and for the physics of the interface function to meet expectation, it was important from the outset that aspects of rotation, forward and backward movement and, to a lesser degree, tilt be embodied in the design.

The “center around which something rotates” [Websters] is called the axis, and as such, the axis was to be the most primary mechanical characteristic of the Orbiculum. It would not necessarily be the most visually obvious characteristic, but it would form the central shaft from which the monitor would turn and tilt. It was important to me that the Orbiculum looked like an object that turns and tilts, its basic structure resembles a see-saw, its cantilevered screen is not dissimilar to the “lamp style” Apple iMac.

6.2.5 Design & Construction of the Physical Interface

6.2.5.1 Prototype

The initial design stage began by roughly sketching potential mechanical solutions. These sketches were gradually refined while considering mechanical objects that were available and interactive processes that I considered desirable. An early requirement was to identify and purchase a flat screen monitor of suitable proportions and function. The selected flat screen monitor was a Sharp 26cm VGA which weighed 700g.
A wooden prototype was constructed at the outset, as it was important to understand the basic dynamics of the device. It consisted of an adjustable cantilevered arm that supported an item equivalent in weight and size to the LCD screen. The wooden prototype provided a guide to the overall dimensions and weight, and the position of items within its makeup. It was constructed so that pivot points could be adjusted, or dimensions varied to change the relationship between length, weight and balance. The prototype highlighted the need for each end of the monitor assembly to amount to about 2 Kg. However when tilted in one direction the majority of the weight would shift to that side, and in order to prevent the object from toppling while being tilted, the base would either have to be very heavy or be fixed to the pedestal. As it was to meet public safety requirements, I decided the *Orbiculum* would be fixed to the pedestal, which could be weighted accordingly.

Another design consideration became evident at this early stage, the incline of the device and its effect upon the virtual space. Would the height of the person viewing the monitor affect the height of the camera in virtual space, or would it effect the angle from which the camera emanates out from the centre? As either approach would increase the variation of user experience quite markedly, I decided for the tilt of the monitor to not have a bearing on the virtual space. The monitor would still be able to be raised or lowered to suit the users ergonomic preference.

### 6.2.5.2 Construction

If a particular type of item, shaped item or functional item was required, it was either made from components or sourced from scrap heaps and junkyards. This production method meant that the process was one of contemplation, trial and error.

After dismantling the prototype, construction of the *Orbiculum* began by effectively replacing components one at a time. This had to begin with the monitor surround as its weight and dimension would have a bearing on the length of the monitor arm. The workshop was populated by tools as well as a growing number of machine parts and
industrial objects that were considered for inclusion and often utilised in the construction of prototype components or the final components.

In order to decide on aspects such as dimension, height, position and other ergonomic factors, the *Orbiculum* was regularly mocked up and user tested. It was decided that the position of the zoom handle and the handles on the monitor would reflect the relationship between gear stick and steering wheel of a typical right hand drive vehicle.

With the addition of springs running up each side of the central shaft (like those found on a desk lamp), the weight of the screen assembly could be accounted for by the tension within the spring. The inclusion of the springs provides a visual suggestion of resistance and/or “return”. The visual weight at opposite end would re-enforce this idea.

The base of the Orbiculum had to add visual weight and appear broad and heavy which would help give it an appearance of stability. The handle surround was designed to suggest the degree of movement possible.

6.2.5.3 Testing

Strength tests occurred regularly throughout the construction process, some items and methods were discarded due to their fragile nature.
The testing of ergonomics and usability occurred at regular intervals and often occurred in an incidental and anecdotal fashion by analysing how individuals engaged with elements of the object or the object itself. During a visit by one of the curators of the show, it was identified that there were certain aspects of the design of the *Orbiculum* object that might pose a level danger to the user or bystander. As curator Liz Hughes stated, the device was to be "no more dangerous than a door". As it was at a relatively early stage of the construction process it, it was timely feedback that could inform the design direction rather than warrant a redesign. Of particular concern was the possibility that the monitor could be slung at speed and collide with someone standing in its vicinity. It was suggested that the monitor should have enough resistance within its mechanics to render it difficult to swing freely or at speed. The method of resistance would ideally be resilient and require very little maintenance, I decided to add the large circular cog around the base of the device which would provide a regular surface to create friction against. This friction came with the help of two rubber wheels that press against each side of the wheel. The wheel assembly itself had to be treated in a way that would not allow people to harm their fingers.

The cog and wheels also provided an amount of visual width and aided the solid appearance of the device.

### 6.2.6 Design & Production of the Input Method

In parallel with the visualisation of the physical interface was the method by which the physical and virtual content would be connected. One of the earliest experiments was to construct a meccano device around the inner workings of a computer mouse.

A handle extended out from a central base, its axis connected to a directional wheel of the mouse. A rudimentary 'application' was developed that turned a virtual object on screen according the horizontal position of the cursor. The on-screen image was designed to appear 3 Dimensional, but as opposed to a real time 3D engine, it was created with a finite number of pre-rendered frames that were displayed according to the cursor position. When using this prototype, one could imagine rotating a screen around a central axis and effectively viewing the object from different directions.

This early prototype was helpful in proving the concept and also that even simple immersive experiences require a high level of real time interaction. Real time interaction would require that both small and large actual physical movements be translated accurately on screen. It also requires that the user be able explore a simulated space from any and every position. The level of accuracy and sensitivity to movement within a mouse is quite low, it would have to be teamed with a gear system to increase its sensitivity and provide a potential input solution. In addition to limitations within the device itself is the way a mouse signal is translated into the
computer, a customised software solution might be required to convert mouse movement from cursor control into something else. The final production would likely require a much more complicated and capable input method than a mouse, to provide the desired level of user experience.

Figure 51: Griffin Powermate

The Griffin Powermate device, a USB Knob, was one such off-the-shelf product that appeared to offer a solution. It is a programmable knob that connects to the computer and affixed to the desk. The knob was designed to allow users a more tactile relationship with their on-screen content, such as those familiar with the shuttle control of video editing devices now using desktop computers. This in itself is an acknowledgment of the value of physical interaction when working with computer devices, and is obviously relevant to my research. But the device itself offered limited options for hardware or software customisation at an exorbitant price.

A conversation with colleague Kenneth Mok raised another possible solution and one that he had previously utilised. It involved teaming Macromedia Director's new 3D engine with a gaming controller such as a joystick or steering wheel. The make-up of a steering wheel game controller is typically the wheel itself (with a number of buttons) a brake pedal and an accelerator pedal, each of which has a small rotational knob, called a potentiometer at its foundation. As the steering wheel assembly could be dismantled and each of the potentiometers and buttons extracted, this would offer a broad and adaptable solution with a number of options to be reconstructed within a customised mechanical interface.

6.2.7 Design & Production of the Virtual Content

"A 3D representation of a suburban backyard within a snow dome. The backyard consists of items such as a garden shed, barbeque, lemon tree, concrete path and centrally located Hills Hoist. The backyard is a static snapshot of suburbia, with snowflakes falling throughout the space."

Conceptually I didn't want the virtual space to look photo realistic, but rather as if it had been produced in a low polygon fashion with obvious image mapping. As the machine itself was to appear as if constructed from first world refuse, I decided the virtual space should look similar in that its make up be equally obvious to the user. I created a rough 3D representation of how the screen content might appear.
I approached another colleague Lucas Licata to consider developing the 3D component of the project. Lucas had previously demonstrated a capacity in 3D animation with a particular interest in low polygon modelling and realtime game graphics. The three of us discussed the process by which the visual and interactive methodology could be designed initially by myself, and then further developed and produced by Ken and Lucas. The process began in parallel, where I devised the contents of the backyard space and provided simple elevation diagrams to both parties. Lucas constructed a rudimentary version of the space Lightwave and provided it to Ken in a generic 3D format to be imported into Director. With the basis of the process defined, Ken developed the 3D engine, Lucas and I continued to refine the detail within the virtual space and provided regular updates to Ken for performance testing.

The production of the 3D content began by sourcing reference images of the various objects, providing them to Lucas to construct. The liaison continued in order to assess and refine the models in terms of appearance and functionality.

The low polygon rendering and low resolution image mapping provided the desired appearance of a first person game. While navigating the space: artefacts, rendering
glitches and modelling oversights were evident. In an effort to clarify to the user that
the virtual content was a constructed reality, these elements were emphasised and in
addition a 'glitch' was created in order to momentarily display the scene in wireframe.
These momentary glances of construction lines and polygons made the software
appear as if it was struggling to maintain the display quality and level of movement.
Conceptually this referred back to the maker of the *Orbiculum*, their tools and level of
skill and motivation.

6.2.7.1 Testing

The software was continually tested on a laptop PC, to see how it functioned over
long durations of inactivity, occasional activity and frequent activity. This testing
highlighted an issue with the signal generated from each potentiometer switch, their
signal level did not remain constant, even while remaining still. This caused the
numbers that were being sent to Director to assess their position, were bouncing up
and down. Sometimes these numbers spiked up to such a level that caused the
application to crash. A number of different potentiometers were tested which resulted
in the same problem. It was decided to incorporate a software solution within the
application that was to ignore data spikes that were above or below a certain
percentage of the previous signal. This solution proved successful and significantly
reduced the likelihood of crashes.

6.2.8 Final Outcome - Orbiculum

6.2.8.1 Physical Description

It stands atop a white plinth that places it around chest height to an adult. Its monitor
 pivots from a central, forked column and is countered by a weighted box. Two
tendon-like springs reach down the sides of the device that broadens to become the
base.

The base is composed largely of a squat cast iron object. With three sturdy feet like a
potbelly stove, each visibly secured to the plinth on which it sits. The base is
encircled by a multi teethed flywheel which is suspended out from the base by three
brackets. The area of open space allows light to pass between the forms creating a
ring of negative space and the tendency to cast characteristic shadows across the
white surface of the plinth. One end of a car alternator forms an aluminium collar that
concludes the extent of the base and from where the column rotates. This collar
appears to house the electronic workings of the *Orbiculum*, coloured wires are visible
through the various openings.

The short, thick forks of a BMX Bicycle are the central component of the column.
They have large, uncomplicated curves and no apparent attention has been spared
on anything other than strength and function.
From the forks, a buttressed arm reaches out beyond the perimeter of the base and
suspends a pairing of wheels that sandwich the opposing sides of the flywheel. The
wheels, which appear to have been sourced from a skateboard or skates, press
against the high tensile steel. Their pink rubber contrasts with the surrounding
material while also creating enough friction to slow its rotational movement. A thinly
barred chrome grate guards fingers from the wheel assembly.
Bolted in the end of the forks is the spoke-less hub of a bicycle. A large colourful knuckle – the “goose neck” (also sourced from a BMX bike) clasps the hub and is bolted to the pivot arm, allowing the arm to rock up and down. Suspended between the arms of the bicycle fork column is a tilted rectangular frame. The two shortest ends limit the amount the pivot arm can be tilted and the rubber blocks absorb the impact at each end point. Two extension springs reach at angle out from the arms of the forks. These springs pull the pivot arm back to a central location while providing assistance in lifting the monitor and resistance in pulling the monitor downwards.

The pivot arm is capped at one end by a mount for the monitor assembly and at the other end disappears into a small steel box. The box acts as an actual and visual counterweight to the opposing monitor assembly. The distance the box extends from the column is less than that of the monitor, but this imbalance is compensated by tension in the springs.

The monitor assembly leans forward from the bulk of the device. The luminous nature of an LCD image, sets it at odds to the heavy steel that frames it. Other than at the corners, where the weld has oxidised, the steel around the screen is covered in surface rust. The back of the monitor has a cool white glow and light pushes out through its perforated framework.

Two chrome handles, mounted at the bottom and right edges of the rectangular screen, have a matt black inlay recessed slightly into them. They would have been at home on the cupboard doors of a kitchen from an earlier era, but here they provide options for positioning hands in order to control the orientation of the screen. Suspended behind the monitor and reaching out from the left of screen, is a section of bicycle frame. From an axle extends a crank with a turned wooden handle. It is framed on either side by a semi-circular bracket, which limits the extent to which the handle can be rotated. Whether the monitor is being tilted or turned, the distance and orientation between the handle and the monitor remains the same and allows users of varying height to operate it comfortably.

The wires that twist throughout the framework, connecting the monitor and the handle to the base, unite the various portions of the Orbiculum.

6.2.8.2 Physical Mechanics

There are a number of characteristics contained within the Orbiculum that assist in communicating its method of usability.

In contrast with the rusty steel frame, the handles around the monitor appear smooth, reflective and suitable to touch. The weight of the screen is light and can be easily manoeuvred with one hand. In the absence of a symmetrically placed handle for the left hand, the handle of a crank is provided instead. A circular portion of a bracket frames the crank-shaft and suggests that there is a limit to the angle it can be rotated in each direction. This limit or “verification of engagement and completion” [MacLean] can be felt when the handle hits a shaft at each end point.
6.2.8.3 Audible Mechanics

Some of the design components within the make-up of the *Orbiculum* create sounds similar to those generated when interacting with machines. These sounds add to the feeling of familiarity with the object and assist in our understanding of its dynamics and processes.

Mounted between the pivot arm and the base, is an aged brass tube that resembles a hand pump. The pump is incorporated as a safety measure and provides a small degree of resistance that makes it impossible to move quickly or swing freely. In addition to slowing the potential acceleration and deceleration it creates a pneumatic hissing sound as the air is drawn in or released.

When the monitor is tilted to various angles the tension in the two springs changes. As the springs twist on the steel mounts at each end it sends a pang through the spring and it reverberates through the whole work.

When the monitor assembly is turned around the central column, resistance is created by the wheels that run around the fly-wheel sprocket. While preventing the monitor from being swung violently (and gaining momentum before reaching its rotational limit), the wheels create a rubber squeak that varies according to the speed at which it is turned.

6.2.8.4 The Virtual Space

The physical aspect of the *Orbiculum* allows the user to navigate the virtual backyard. They are able to circle the space and traverse in and out of it. The position furthest away, allows the user to see the 'glass' shield that contains the virtual snowdome, while the other extreme places the viewpoint at the base of the clothesline at the absolute centre of the space. The Hill’s Hoist provides a central point of focus when the viewer navigates the back yard, as well as a central point to view from when viewing from the centre of the yard. The user can control the viewpoint in an effort to view items in detail or to break through an objects virtual skin. Virtual snowflakes fall through the space, rather than respond to their surrounds, the blocks of snow dissect the objects they come in contact with and fall through the ground rather than upon it.

The image on the monitor is frozen in time. It has the sterile and contrived appearance of virtual spaces, and as such, is at odds with the physical interface. As with all computer screen interfaces, the content exists in a space beyond the front of the screen. The virtual content draws the users eye and perception past the device that frames it, while navigating the space the physical object becomes temporarily irrelevant.
6.2.9 Exhibition

The *Experimenta – House of Tomorrow* show premiered in Melbourne on the 5th of September and continued until the 3rd of October 2003. Components of the show then toured regional and capital centres around Australia and was viewed by more than 161,000 people. From Melbourne, *Orbiculum* travelled to Perth, Gippsland and Bendigo.

![Figure 60: Experimenta House of Tomorrow](image1)

![Figure 61: Experimenta House of Tomorrow](image2)

6.2.10 Conclusion

6.2.10.1 General

The Orbiculum proved to be approachable and engaging and I witnessed many individuals interacting with it. I am comfortable deducing that it succeeded as a physically un-daunting and intuitive interactive experience.

The Experimenta - House of Tomorrow show was extremely successful and the number of visitors to the Melbourne show was over 40,000.

The curators considered *Orbiculum* to be one of the more successful and maintenance free artworks in the selection. As such, was included in the travelling show to Brisbane, Perth and Bendigo.

Soon after exhibiting *Orbiculum*, Mothers’ Art approached Lycette Bros. to devise a technical solution for an interactive exhibit at (the yet to be opened) AFL World.

The attached DVD contains footage of the *Orbiculum* in use.

6.2.10.2 Problems & Improvements

The main problem with the *Orbiculum* was its occasional tendency to crash. A number of times during the exhibition the screen content would freeze and an error would appear. On such occasions the PC had to be restarted, which meant opening the plinth, and pressing the restart button on the computer.

Efforts to recreate the bug failed, but it seemed to be a problem with the way the controller software communicated with the Director Plug-in. At the end of the exhibition the Operating System and controller software was updated and reinstalled. We had noticed the software was getting widely varying numbers from the potentiometers. And even while the potentiometers were physically static, the numbers they were outputting were wavering and occasionally dipping or spiking.

Although it was not necessarily the source of the problem, I replaced the potentiometers with new ones but this failed to change the situation or indeed reduce the concern.
Although quite simple in its make-up, I believe the complexity of the computer components of the Orbiculum posed a problem. There are many aspects in the process that could break or have conflicts, the variables are great and the problems are difficult to diagnose. The reliance on specialist software, plug-ins and peripheral devices would be better avoided in future projects.

One of my initial concerns for the exhibition of Orbiculum was that it would physically stand up to rough and repeated activity. But as I had tested it thoroughly beforehand, my concerns moved from the strength of the construction to the strength of some of the small mechanical components. Of particular concern was the physical interface between the rotation of the pillar, and its connection to the potentiometer – namely, a rubber band! The band had previously lost traction with the aluminium wheels connected to each shaft, and after a number of hours small slippages could potentially become major disparities in alignment. This disparity would in effect reduce the scope of the on-screen rotation, and limit the viewer to one corner of the virtual space. After the first full day of operation, I opened up the Orbiculum to see if this had occurred, I was pleased to see that it had either not moved at all, or moved a similar amount each way and amounted to a negligible disparity. In hindsight, I would design future objects so that 'problem areas' or 'maintenance zones' could be accessed easily by one person and without having to dismantle a large portion of the machine.

Figure 62: Orbiculum mechanism
6.3 Project 2: Cubby House Robot

6.3.1 Brief

In April of 2004, I was contacted by Michelle Glaser of Awesome Arts, an arts organization in Perth that run an arts festival for young people. Within the festival program they run an initiative called Cre8tive Challenge that places artists in schools and communities across Western Australia to produce site-specific artworks. Lycette Bros. was asked to function as "lead artist" and create an overarching work inspired by the various artworks exploring the common theme, "cubby". The work was to have a prominence for the duration of the festival and to engage young people and the broader community.

I decided that this presented another opportunity to create an interactive installation artwork in keeping with my research.

6.3.2 Response

The brief proved itself to be very difficult and a number of responses and iterations were delivered to Awesome in a period of weeks. The difficulty was creating a conceptually robust artwork that explored a single theme while drawing from 15 very different artworks. The broad aims were to: engage an audience (allowing multiple users & viewers); represent the 15 artworks/communities in one context; and allow the participants to see themselves and/or their work.

It was decided that the artwork was to "... facilitate a connection between the creative participants while also documenting a broad and varied collection of content." (Concept Proposal Document). Photographic content depicting the art, artists and schools or communities would provide the basis to the artwork, be projected onto the gallery wall and affected by interacting with a mechanical interface.

6.3.3 Concept

As the prime audience of the festival and the artwork, are young people, the physical interface will need to be intuitive and accessible to people ranging from 8 to 15 years of age. The work will also need to be engaging on a number of levels as well as robust and require minimal maintenance.

When people interact with computer exhibits, Ben Gammon identifies three main modes of behaviour; purposeful use, exploratory use and play [Gammon]. Early in the process, it was decided that the artwork be capable of providing satisfaction on each of those levels. And that it remain playful, unthreatening and, in keeping with the Cre8tive Challenge, allow participants a level of self-expression and creativity.
6.3.4 The Physical Interface

A small figure stands on a pedestal looking toward a projected image. The figure is brightly coloured and has a simple geometric form, it has the graphic appearance of an icon in 3 Dimensions. From its back protrude a number of handles and buttons.

![Cubby House Robot](image1)

Figure 63: Cubby House Robot

6.3.5 Design and Construction of the Physical Interface

In the process of sketching and considering various robot designs, I decided it would be problematic if the robot were too different from the on screen content, I also did not want it to compete visually with the on screen artworks and images from the communities.

Informed by my experience in producing and exhibiting *Orbiculum*, a number of other factors were identified as being desirable or important. The final installation had to be robust, easy to maintain and free of hazards such as sharp edges or "finger pinches" as the British Interactive Group call them [Simmons]. Early sketches show the data projector incorporated in the head of the robot but this would be easily interfered with and raise issues of security and safety regarding heat and ventilation. It would also mean the artwork would require a specific projector with specific design features or dimensions. I decided to keep the projector mounted externally where it could remain safely from reach and not be limited by design specifics.
The robot was designed with a steel frame onto which particle board could be affixed. The body would contain the keyboard, switch assembly and speakers. The handles use springs and weights in order to return them to the central position.

The four handles pivot along a length of 'all thread' steel and are held in position with lock nuts. This allows the tension of the handles to be adjusted as they experience wear.

Pairs of switches are positioned above and below the handle and are triggered when it reaches either extent. A panel of steel and rubber cushions the handles and prevents them from damaging the switches. The 'keyboard' assembly is mounted within the head and can be accessed easily by lifting it off.
The robot has two cables that run through its leg and into the pedestal. The keyboards USB cable which connects to the laptop and a cable connecting the speakers to the subwoofer.

The handle and switch assembly can be accessed through entry plates either side of the robot.
6.3.6 Design & Production of the Virtual Content

"A dynamic generative art piece that combines word and image associative sequences, presenting both a live art exhibit and navigable record of the processes and outcomes undertaken by the students."

Proposal Document, April 2004

The representation of content on the screen was developed in conjunction with the physical interface. The earlier versions consisted primarily of a face of a robot that was made up of images that could be switched by the user. In addition to the work being image oriented, we proposed that it have a textural element. Allowing words to be presented alongside images, as such they would likely provide interesting connections, comparisons or contrasts. Single keywords would be attributed to individual images, as well as the relevant name of the school or community.

During the refining process, I decided the robot should speak the words rather than present them on screen. This would make the robot a more engaging character and also make its presence felt within a gallery space.

6.3.6.1 Prototypes

A number of simple interactive prototypes were created using Flash. By pressing certain keys of the keyboard the user could change the individual parts of the image.

![Concept 1](image1.png)  ![Concept 2](image2.png)  ![Concept 3](image3.png)

Figure 76: Concept 1  Figure 77: Concept 2  Figure 78: Concept 3

In an aim to make the designs more visually dynamic and less 'blocky', the photographs were masked within forms that could be used to construct a face. Although these faces were more characteristic and dynamic, they were less successful at utilising the photographic content as the focus, therefore treating the images of the children and their artworks merely as raw material for an artwork.

By cutting visual elements out of the photographs and composing them as entire figures, the resulting images were successful at highlighting the artworks and could also appear dynamic and characteristic while also providing a comical element.

6.3.6.2 Production

Once a visual direction had been defined, the application had to be developed so that it could be customised and refined further. In addition to the user being able to change the individual body parts, a separate button changes the background colour. Another button generates a random selection of a head, body, arms, legs and background. When a body part is changed, the robot 'speaks' the word associated with two of the objects, followed by the word 'robot'. This causes the Cubby House Robot to
announce names like "Toy Zebra Robot", "Camera Box Robot" or "Crazy Plastic Robot". In order to identify the source of the images, they are each accompanied by the name to the school or community that animates out from the relevant body part.

Through user testing and to increase its suitability for exhibition, a number of features were added. If left dormant the robot repeats its 'title' every ten seconds, after two minutes a random robot is generated, and after another ten minutes it defaults to its initial graphic state. This means that the work announces itself aurally to visitors and garners interest. It also increases the chance that people will approach the work in its beginning state when the virtual robot mirrors the actual robot.

6.3.7 Final Outcome

Figure 79: Start-up Screen
Figure 80: Robot 1
Figure 81: Robot 2
Figure 82: Robot 3
Figure 83: Robot Controls
Figure 84: Robot in Gallery

An interactive installation that enables viewers to configure an on-screen robot. Each "Cubby House Robot", created either randomly or interactively, is a new singular identity collaged from photographs of the students, schools, artists, communities and art works from the Cre8tive Challenge.

A small orange robot, with a house shaped head, stands on a pedestal in front of a projected image. At the back of the robot are a number of levers and buttons. The projected image is a two dimensional representation of the robot with head, body,
arm and leg components. The body components can be substituted with photographic images of pieces of artworks, or portions of scenes, objects or people. The four handles on the back of the robot correspond with each of the components of the body and allow the user to cycle through the many body parts representing each component. As new robots are recomposed with the different body parts, a new name is generated from a descriptive keyword attached to each of the images. The robot regularly calls out a triple barrel title, such as "bubble brush robot" or "square scissor robot".

6.3.8 Exhibition

_Cubby House Robot_ was exhibited from 19th–28th November 2004. The general public and numerous school groups visited the gallery and the _Cubby House Robot_ proved to be a popular focus. It was relayed to me that a number of school groups wanted to capture and document what they had created with the _Cubby House Robot_. Their solution was to pose and be photographed in front of their projected designs. I found it very pleasing that the audience were engaging with the creative aspect of the artwork and were using it in a fashion not expected. As an extension to the work in the gallery context, the interactive component was packaged on CD ROM and distributed to all the schools and artists involved.

The attached DVD contains footage of the _Cubby House Robot_ in use.
6.3.9 Conclusion

6.3.9.1 General Conclusion

The Creative Director of the Awesome Arts Festival was very pleased with the Cubby House Robot. It became the central focus of the exhibition space and was enjoyed by the visitors to the gallery. When a school group arrived in the gallery, the group would gather around the Robot and as many children as possible would interact at one time. Teachers most often told the children to line up and interact individually or in pairs, which often meant one child had control of the two handles on the left and the other child controlled the two on the right. The simple mechanics and straight-forward interactive nature of the Robot made it intuitive to use and gratifying to users of different ages. The fact that it was constructed upon a keyboard, and did not require specialist inputs or software, made it robust, reliable and easy to set-up. Lycette Bros. has been invited to take part in the 2007 Awesome Arts Festival.

6.3.9.2 Problems and Improvements

One of my main desires at the outset of the design and construction process, was to make the Cubby House Robot much less complicated than the Orbiculum and with a simpler and more robust technology at its foundation. The main motivation behind this decision was to take the focus off the robot itself in favour of the artworks upon the screen and the creative task of creating an original composition upon it. While I believe these aims were achieved, I think the final outcome might have been too simple an interactive device and in terms of a rich physical or tactile experience, the robot interface itself did not engage for very long. Another method for engaging the user might have been for the Robot to have more character. This might have been achieved by making it appear as more of an individual and less iconic, or by incorporating more personality in its voice or manner.

Another desire for the Cubby House Robot, was for it to require less maintenance. I am pleased that this was largely achieved, as no maintenance was required after 5 days of frequent use. There were however a number of details that I would design differently in order to make it more robust and less likely to require maintenance after much longer periods of use.
7 Conclusions and Findings

My research has led me to conclude that the tool and the mechanical device consist of characteristics that aid and inform the user. These characteristics might be signs such as design, shape, scale, position, material or wear. When a user approaches an interactive artwork or installation object with such a mechanical presence, they can be presented with visual clues and suggestions as to the type of interaction required, the expected level of engagement and for whom the work is designed. A mechanical interface can also provide valuable and functional feedback throughout the duration of the interaction. Machine interaction also makes it possible to exercise, develop and utilise body memory.

When mechanical interaction is teamed with that of a computer, it can assist in the success of interaction and aid understanding within the virtual space.

As computers develop, each iteration of the various control devices becomes less connected to the device and in general, become more oriented towards gesture and physical movement. Via the Sony EyeToy, the Nintendo Wii and the Apple iPhone, we have seen the gestural interface grow from a science fiction fancy into a commercial reality. The space between user and computer has become a 3 Dimensional interactive zone. The surface of a screen has become a stage for ones fingers or hands to perform in a fluid and expressive way. The added involvement of the body increases the likelihood of exercising as well as drawing upon ones body memory, therefore increasing ease of use, productivity and potentially, expression.

While the modern interface is moving towards gestural and physical movement, it is moving away from the mechanical interface. More succinctly, many computer interfaces have a virtual representation of a mechanical interface in favour of a real world physical or tactile element. These virtual screen elements have however not yet abandoned the visual representation of the mechanical interface. The 'lock' of the iPhone is a good example of a virtual mechanism that references the real world device for visual and functional inspiration. Aided by the use of light and shadow, the button of the lock appears contained within a countersunk trough. The trough provides a suggestion of the possible direction of its movement as well as the limit of its movement. The slide responds in a way that a similarly designed mechanical device in the real world would respond. If the user releases their finger while partially toward the unlock position, the slide snaps back to the starting position. The importance of the task at hand is representative in the way the slider requires a conscious and concerted effort to become fully engaged. Any partial movement resulting from an accidental or misguided touch is unlikely to start the function. There is potential for such virtual mechanisms to represent the real world more closely. Aspects of wear and patina could be represented on the screen or even 'integrated' into the software so an element could age over time as a reflection of its value. Such additions might function as an aid or guide to streamline interactions. Mechanical characteristics such as weight, friction and momentum could be applied to virtual interfaces. Major functions might require a slower, more concentrated effort to enact, while small changes could be easily triggered and respond in a light and immediate way.

Something I experienced first hand in the production of the artworks was the pleasure that is associated with making things with ones hands. Whether rubbing ones hand across a newly sanded surface or feeling a grinder resist biting into a ridge of steel, there is obvious value in gauging and quantifying the task at hand.
This is a largely unexpected element of my research that might also support the importance of physical, gestural and tactile interaction that can be experienced while engaged in pre-computer age mechanical devices.
8 Bibliography


Available at: http://www.wired.com/wired/archive/7.01/eno.html

Gammon, B. 1999, How do visitors use computer exhibits? British Interactive Group
http://www.big.uk.com/knowledgebase/exhibits/computer_based_exhibits_v1.htm

Hayles, N. K. 1999, How We Became Posthuman; Virtual Bodies in Cybernetics,

Available at: http://www.abc.net.au/rn/science/mind/stories/s1323547.htm

Han, Jeff. Jan 2006. Multi-Touch Interaction Research [Online]


MacLean, K. Physical Interaction Design: Haptic and Multimodal Interfaces [Online]
Available at: http://www.cs.ubc.ca/~maclean
Available at: http://www.cs.ubc.ca/labs/spin/publications/local.html


London.

HarperCollins. New York


News

Palumbo, Maria Luisa. 2000 New Wombs - Electronic Bodies and Architectural Disorders.


Shaw, Jeffrey. 2001 *Jeffrey Shaw: Virtual Melbourne*, Realtime 41 [An Interview by Dean Kiley] [Online] Available at: http://www.realtimearts.net/rt41/kiley.html


http://www.volvocars.com/corporation/NewsEvents/XC60Concept.htm

Walton, R. *How should we analyse learning in Interactive Centres?* [Online]
Available at:
http://www.big.uk.com/knowledgebase/research/learning_and_research.htm

Websters. Online Dictionary [Online]
Available at: http://www.websters-online-dictionary.org/definition/english/ax/axis.html

Wienke, B.R. The Head Games of Diving. UK Divers [Online Article]
http://www.ukdivers.com/info/head_games.asp

Wimborne Publishing Ltd., UK
9 Appendix

9.1 Image Reference

Figure 90: Minority Report, 2002
http://www.imdb.com/title/tt0181689/
20th Century Fox and DreamWorks L.L.C. All Rights Reserved.

Figure 91: Perceptive Pixel (Jeff Han)
http://www.perceptivelpixel.com/

Figure 92: Volvo Control Panel
http://www.volvocars.com/corporation/NewsEvents/XC60Concept.htm

Figure 93: Apple iPhone
http://www.apple.com/iphone

Figure 94: The Golden Calf, Shaw.
Figure 95: The Golden Calf (Detail), Shaw.
http://www.jeffrey-shaw.net/html_main/frameset-works.php3

Figure 96: Meditation #1, Ganson
http://www.arthurganson.com/pages/Sculptures.html

Figure 97: Small Tower of 6 Gears, Ganson
http://www.arthurganson.com/pages/Sculptures.html

Figure 98: Electroclerk
Figure 99: Electroclerk (Detail)
A.H Leman
http://www.ahleman.com/ElectriClerk.html

Figure 100: Steam Laptop
Figure 101: Steam Laptop (Detail)
http://ironwork.jp/monkey_farm/computer/pc2.html

Figure 102: Steam Keyboard
Figure 103: Steam Keyboard (Detail)
The Steampunk Workshop
http://steampunkworkshop.com/keyboard.shtml

Figure 104: Leather Keyboard
Figure 105: Leather Keyboard (Detail)

Figure 106: Experimenta House of Tomorrow – “Sky Pad” identity

Figure 107: Griffin Powermate
http://www.griffintechnology.com/products/powermate/
9.2 Resources

Strum, N. *How To Build the Cheep Spinner*
http://www.arcadecontrols.com/arcade_spinners.shtml

*Keyboard Hack*
http://dragonsden.emunu.com/ddkeytutl.htm

9.3 Research Diary

Please view my Research Diary at the following URL

http://infotyte.adc.rmit.edu.au/john/
9.4 Visual Documentation

Please see the attached DVD which documents the development and exhibition of the interactive artworks.