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TITLE: The naturally imperfect form: Investigations of the application of digital sculpting methods - extracted art: incorporating and translating ‘found art’ into the medium of digital sculpture.

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STATEMENT OF ORIGINAL AUTHORSHIP

The work contained in this dissertation has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the dissertation contains no material previously published or written by another person except where due reference is made.

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This dissertation analyses how physical objects are translated into digital artworks using techniques which can lead to ‘imperfections’ in the resulting digital artwork that are typically removed to arrive at a ‘perfect’ final representation. The dissertation discusses the adaptation of existing techniques into an artistic workflow that acknowledges and incorporates the imperfections of translation into the final pieces. It presents an exploration of the relationship between physical and digital artefacts and the processes used to move between the two.

The work explores the ‘craft’ of digital sculpting and the technology used in producing what the artist terms ‘a naturally imperfect form’, incorporating knowledge of traditional sculpture, an understanding of anatomy and an interest in the study of bones (Osteology).

The outcomes of the research are presented as a series of digital sculptural works, exhibited as a collection of curiosities in multiple mediums, including interactive game spaces, augmented reality (AR), rapid prototype prints (RP) and video displays.
## Abstract


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CHAPTER 1:

1.0 INTRODUCTION.

This dissertation presents a reflection on a research practice, based on the use of a digital sculpting method in the creation of artworks which explore notions of perfection in physical and digital artefacts. Physical objects are translated into digital artworks through the use of photogrammetry\(^1\) and voxel\(^2\) sculpting techniques which can lead to ‘imperfections’ in the resulting models that are typically removed to arrive at a ‘perfect’ final representation.

Definitions of what sculpture can be has radically changed in the last two centuries, In Chapter 1 I discuss how sculpture is no longer bound to the physical. I document how digital sculpture came about from the automotive industries and how more recent processes in digital sculpture allow access to material based off the physical. Artistic influences are discussed with reference as to how they have influenced or reframed my artistic practice.

In Chapter 2, I reflection on how Western ideals of perfection have influenced 3D digital art, I reflection on perfection and how it is portrayed in current digital art. I then discuss that by integrating existing digital techniques into an artistic workflow that acknowledges and incorporates imperfections into the final pieces that these preconceptions on digital perfection can be avoided.

In Chapter 3, I present the technical processes used to create and display the artistic works. How my digital sculpting practice explores the process of translating the sculptural forms found in bones and how these forms are changed by the translation processes into the digital. The practice explores how the hand of the artist re-interprets these sculptural forms in the digital; how by utilising digital techniques can translate the natural imperfections of the original into the digital, at the same time allowing for distortions and additional imperfections caused by translation to be incorporated into the piece. I close the chapter with reflections on how the sculptural pieces are not only changed by their translation into the digital but also changed by the end mediums of display.

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\(^1\) Photogrammetry is the process of determining the geometric properties of objects from a series of photographic images, see chapter 3.1.3.

\(^2\) A voxel (volumetric pixel or, more correctly, Volumetric Picture Element) is a volume element, representing a value on a regular grid in three dimensional space. This is similar to a pixel, which represents 2D image data in a bitmap. As with pixels in a bitmap, voxels themselves do not typically have their position (their coordinates) explicitly encoded along with their values. Instead, the position of a voxel is inferred based upon its position relative to other voxels (i.e., its position in the data structure that makes up a single volumetric image). In contrast to pixels and voxels, points and polygons are often explicitly represented by the coordinates of their vertices. A direct consequence of this difference is that polygons are able to efficiently represent simple 3D structures with lots of empty or homogeneously-filled space, while voxels are good at representing regularly-sampled spaces that are non-homogeneously filled. For more information on voxels please see chapter 3.3.
In the closing Chapter 4, I discuss how the artistic practice grew out of the processes, mediums of display and reflect on how notions of ‘perfection’ affected my practice. I draw conclusions based on the outcomes of the works of this practice led research.
1.1. PERSPECTIVES ON SCULPTURE.

Sculpture is no longer restricted to existing in the physical. Conceptual developments from the early 20th Century along with increasing accessibility of technologies and new mediums of display are transforming the notion of sculpture.

Traditionally sculpture has always supposed a physical reality which dictates the outcome of the work; this reliance has traditionally linked the sculptor to the technical and artisanal practices of the craftsman. Technical restrictions, affordances of the medium and a reliance on techniques also exist when working in the digital medium. There is a relationship with the material and techniques used to manipulate it. These techniques can vary and are dependent on the final re-display or outcome of the work. There are similar reliance’s or affordances when working in the virtual medium of computer graphics (CG), As artists, we live in a world which is imperfect and use available technology to translate those imperfections into the digital.

The captured imperfections of the physical world are affected by errors in translation into the digital and rather than ignoring or removing these errors I allow for them in the digital medium.

My sculptural works are an exploration of *memento vita* (memento of life) – I see it as a way to re-experience my fascination with the remains of life. My work attempts to show inherent beauty of form in bones, without its associations with the macabre. My explorations of bones are not a fascination with death, but a fascination with what is the structure of life; bones hold us together as our most resilient structures.

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³ For more on affordance, see chapter 1.1.3 pg 12
1.1.1 DEFINITIONS OF SCULPTURE

Sculpture is the action or art of processing (through carving, modeling, or welding) plastic or hard materials into a three-dimensional work of art (as a statue) or as impressed or raised markings, a pattern (as a relief) (Merium-Webster 2010).

Sculpture initially served a religious or ritualistic purpose in society. Pieces such as the Venus of Willendorf, the Golden Calf of the Israelites (Exodus 32:4 New International Version) and ancient Greek sculptures of (perfect) gods all helped connect mankind with the unknowns of spiritual realm. The sculptures were representations or symbols of these deities.

The idea of sculpture being ‘art’ is a relatively modern concept. It’s only in the 15th and 16th centuries in renaissance Italy that the idea of an object being a ‘work of art’ emerges, along with the concept of the Artist (Witcombe, 1997).

Sculpture encompasses a wide range of three dimensional pieces, from the classical Greek obsession with the perfect human form, to the Modernists’ abandonment of man as the central image of sculpture. Abstractions of form, new materials and conceptual rationalizations; such as the practice of using tangible (found) objects as art materials have all become accepted explorations of sculpture (Butler, 1979). A recent British Council definition claims the term ‘sculpture’ can now be said to encompass installation, land art, body art, performance art, text-based work, photography and video, as well as the three-dimensional art objects (British Council, 2010).

This broadening of the definition of sculpture to include anything that is three-dimensional as long as it’s declared as art, stems from the found art works of Duchamp and Picasso.
1.1.2 SCULPTURE AS AN EXPRESSIVE MEDIUM.

This practice of found art (tangible objects) redefined as sculpture was initiated by Marcel Duchamp’s ‘readymades’\(^4\) and Pablo Picasso’s Cubist constructions of ‘assemblage art’\(^5\). Duchamp’s initial (1917) mockery of the established notions of art in the early 20th century resulted in Fountain (1917); and the earlier readymade work Bicycle Wheel (1913). Both Duchamp and Picasso explored the potential for sculpture as an expressive rather than descriptive art form, using unconventional materials and appropriating everyday objects in creating their sculptural works. These pieces have been accepted as legitimate art today. Duchamp’s fountain was chosen in 2004 as the most influential work of the 20th century and was awarded the Turner Prize by a poll of 500 art experts (Reynolds, 2004).

The concept of the readymade was explained in an anonymous article (reputedly by Duchamp himself) in the May 1917 issue of Dadaist magazine The Blind Man.

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\(^4\) Readymade is the term used by the French artist Marcel Duchamp to describe works of art he made from manufactured objects. - Tate Glossary definition source: [http://www.tate.org.uk/collections/glossary/definition.jsp?entryId=239](http://www.tate.org.uk/collections/glossary/definition.jsp?entryId=239)

\(^5\) Art made by assembling disparate elements often created as three dimensional works - Tate Glossary definition source: [http://www.tate.org.uk/collections/glossary/definition.jsp?entryId=34](http://www.tate.org.uk/collections/glossary/definition.jsp?entryId=34)
‘Whether Mr Mutt with his own hands made the fountain or not has no importance. He CHOSE it. He took an ordinary article of life, placed it so that its useful significance disappeared under the new title and point of view - created a new thought for that object.’ (Duchamp 1917)

In this statement attributed to Duchamp, published in the Blind Man in 1917, there are three points to note; one that the choice of object is the creative act. Two, that by removing the functionality of an object it becomes art. Three by giving it a new title and showing the object off in a different way gives the object a new meaning. Duchamp’s readymades showed that the nature of ‘Art’ can be defined by the artist (Seekamp, 2004). This redefinition of what art can be, or what a sculpture can be made up of, has subsequently allowed artists to appropriate and re-interpret pieces in whatever medium they choose.
1.1.3 THE MEDIUM

Traditionally, sculpture exists in a tactile (physical) three dimensional space. Often these sculptural works are transformed and realized by the limitations and structures of the materials of their production; both from a visual and tactile aspect. This reliance on the physicality of the medium has traditionally linked the sculptor to the technical and artisanal practices of the craftsman, (ignoring contemporary conceptual works) the medium dictated the form of the work. Classical Greek sculptors working in stone, restricted the posing of the sculpture\(^6\), used support props such as tree stumps, cloth and bridges of stone between limbs. (See Figure 2)

![Stone bridges and support columns used in Classical Greek sculpture.](image)

The physical reality of the medium guided the artist’s hand and defined the final outcome of the piece. Interpretations of the subject came about through working with the material of the piece, being fully engaging

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\(^6\) This topic of medium dictating outcomes is further explored in the Sculptural Practice chapters (Chapter 3.3).
in it and seeing the forms within it. This thought process of seeing in the material was described by Michelangelo as ‘freeing from the dead stone, the raw inert material, the beauty it imprisons’. (Butler 1979, p.3). Michelangelo saw the material he was working with, the stone, as alive, holding an inner form waiting to be brought out.

‘If sculpture is commonly understood to be a three dimensional artwork created by shaping or combining materials, then digital sculpture is one created using virtual sculpting environments (as there is no physical material). Artists must realise their works (or significant parts of their processes) through rapid prototyping (RP) prints or computer-numeric controlled milling.’ (Ganis 2005)

These technical qualities of sculptural production are also important in the development of sculpture in the digital medium. While there are no physical restrictions of creation when working in the digital, there are Human Computer Interface (HCI) affordances7 (Norman 1999) in the interaction with the medium; as well as restrictions in resultant mediums of display of the final pieces. Norman defined these perceived affordances as an indication on how something should be used; it’s perceived properties of function and use (Norman 1999). Knobs and door handles are for pulling in the physical, hammers are for hitting with – the feel and weight of them give one an indication of use.

However in the digital, icons in the user interface represent the chisels, sponges and the other real world tools of the sculptor, but their use is implicit and only learned through experimentation (and through a help manual). Unfortunately the use of real world metaphors in the interaction design of icons to represent tool functions can lock one into perceived affordances of the software. This can mean that one tends to rely on the ‘out of the box’ capabilities of the software, which can be restrictive. What I mean by ‘out of the box’, is the documented capabilities of the software as demonstrated by the developers and not as discovered through use by the users. Writing from my personal experiences in production one can discover techniques and workflows which are not documented by the developers; but are discovered by accidental use. Also, some icons in interface design can be so obscure as to not give any indication of their function.8

7 Norman now refers to them as perceived affordances when talking about HCI, i.e. non physical.

8 I still personally prefer a text based descriptor application button such as Soft Image’s interface design from 1995 – 98, while the interface may be seen today as archaic, there was no misconception of the button or tools function(as it was a text based description of its function). Maya’s current use of icon like shortcuts to represent tools and actions within the application are often (a) too small to indicate meaning, (b) so obscure as to have no indication of perceived application.
Interface issue aside, digital sculpture offers its users many affordances that its non-digital predecessor did not. For example, when working on a digital sculpture, scale is irrelevant, as objects can easily be altered and rescaled. Objects in the digital have no mass, which allows one to sculpt in ways impossible to do with a physical medium. Time is irrelevant, as one can undo one’s actions and correct one’s mistakes. This ability to undo is a reason for the resultant perception of the sterility of the digital medium. In the digital, one isn’t required to keep the errors that sometime occur in production when working with a physical medium. One can go back, refine and edit the work before one ‘made a mistake’ and go back again and refine a piece to such an extent that there seems to be no artistic hand involved, resulting in machine-like perfection.

1.2 DIGITAL SCULPTURE

1.2.2 HISTORY OF DIGITAL SCULPTURE

Digital sculpture is most often recognised in screen based media, such as the Visual Effects (VFX) seen in cinema and in computer games. The medium has its roots in the industrial design and automotive industries. Digital sculpture evolved in the late sixties and early seventies as computer and digital technologies entered the workplace. It was initially explored by engineers at the Renault Corporation who used their numerically controlled milling machines to create pleasing to the eye wooden pieces (Lavigne, 1998).

Lavigne defines the generic term, ‘Digital Sculpture’, to cover three different activities that can be complimentary.

1. The creation and visualization by computer of forms or constructions in 3-dimensions, or even 4, (including the evolution of time).

2. Digitizing real objects and their eventual modification made possible by computer calculations.

3. The production of physical objects by numerically controlled machines that are used to materialize the synthetic images (Rapid Prototyping techniques) by either subtraction or addition of material (Lavigne, 1998).

9 I discuss in detail subsequently, how the practice of digital sculpture has tended toward the perfect form.
The medium of digital sculpture has evolved, since Lavigne’s 1998 definition. Improvements in hardware and software are allowing for increased access to 3D scanners and rapid Prototype 3D (RP) prints. Experiments such as Willis’s Fabricate Yourself (2011) allow for rapid interactive fabrication; Willis used a Xbox Kinect to capture three dimensional images of participants which were then printed out as three dimensional pieces, demonstrating the possibilities for a more immediate interaction with the medium.

Current digital sculpting tools, such as Mudbox, Zbrush and 3DCoat have evolved to fill a gap for a more organic and traditional (sculptural) approach to modeling, as compared to the 3D modeling CAD based tools such as Maya and 3DSMax.
Digital sculpture and 3D creation software has become mainstream; both professional and amateur artists are using commercially available digital sculpting software, such as ZBrush, and Mudbox in their workflows. These technologies are being integrated into computer aided design (CAD) centric software, such as Modo and Blender; both applications have integrated polygonal digital sculpting into their tool sets. The techniques and workflows of digital sculpting are becoming ubiquitous – and is now even accessible on hand held formats. Developers are working on iPhone and iPad versions of digital sculpting software such as iSculptor as well as freeware digital sculpting software programs such as Sculptris.

Many users still rely on a CAD centric approach to digital sculpting; using polygonal primitives such as the cube, sphere or cylinder, to build complex shapes, creating what is termed a base mesh. Petroc (2007) uses this base mesh method to create an anatomically correct, idealised and perfect male for his DVD lecture on digital sculpting.

The CAD centric process of using a geometrically perfect primitive, simplifies the creation of forms in the medium of the virtual. The technique of using a three dimensional shape as the base form guides the artists’ eye allowing them to better see and emulate the underlying forms of the original object. This method of working from a stock shape is similar in technique to the simplifications that traditional drawing techniques rely on.

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10 A base mesh is a low-resolution polygonal model that can be used as the starting point for digital sculpting.
The tradition of modelling from a primitive (simple) as a guide to a complex form is well documented in artistic training books. In Bridgman’s Life Drawing, Bridgman notes that simplifying forms aids memory, he then defines the processes of ‘seeing’ the masses of the human body in a two dimensional medium, Breaking down the masses of the human body into square and round shapes (Bridgeman, 1924). Loomis, a student of Bridgeman suggests that all drawing stems from the forms of the round [sphere], square [cube], cylinder, cone and pyramidal (Loomis, 1951).

![Diagram showing round, square, and cylindrical shapes.](Image)

**Figure 4**- Loomis, A. (1951). Successful Drawing [Image] New York: Viking Press. Primitive objects used to define forms pg. 10.

However, the use of the geometrically perfect primitive as a starting point in Computer Graphics (CG) means that the artist then has to create the patina and history through successive modeling and texturing¹¹ additions.

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¹¹ Texturing or texture mapping, is a method of applying a 2D bitmapped image of the texture used to represent the surface colouration), called a "texture map," which is then "wrapped around" the 3D object.
These techniques of conceptual simplification have been adopted by artists working in the digital. The production of CG is currently dominated by these artisanal atelier techniques. As a medium, CG has become locked into what could be seen as simplified ‘visuality’ (Rose, 2007). Rose defines the difference between vision (what the human eye is capable of seeing) and visuality (the way we see), what we see and how we see it are always culturally constructed. (Rose, 2007).

McCloud describes these cultural constructions of visuality in his triangle of communication types in his book Understanding Comics (1994). McCloud defines a way to classify comics allowing for what degree they relate to realistic representation and abstract concepts. McCloud’s triangle of communication displays the relationships between images; ranging from realism on the far left, to the written word on the right and abstractions (icons) on the top (Figure 5).

Figure 5- McCloud Understanding comics (1994) p.52-53
From a CG production standpoint this visuality, the traditional simplification of the forms was not a conceptual or aesthetic choice, but initially a technical one. Rendering techniques, both real time and pre-rendered rely on optimised geometries’ to reduce rendering times. Additionally managing an overly complex virtual scenes, with its associated increased file sizes, negatively affects the performance of CG tools. To render more complex scenes in real-time, currently relies on surface rendering methods which emulate more complex surface shapes, over optimised geometry using both texture and normal mapping techniques.\textsuperscript{12}

\textsuperscript{12} For more information on normal mapping and its use in real time 3D displays please see Re-Display Interactive: Game Space chapter (Chapter 3.4.1 p.66).
1.2.4 IMPERFECTIONS OF THE NATURAL

The digital medium can provide for a far more interesting starting point for the artist than is currently being utilised. By using directly digitised elements of real objects combined with sculpting tools such as a voxel sculpting application 3DCoat now affords one the free form manipulation of complex geometry. Polygonal applications can also be used to manipulate the geometry but require further manual adjustments to allow manipulation of scanned data. Recently affordable technological developments now allow the digital sculptor/artist to capture and adapt digital ‘ready made’ objects. Artists such as Dan Collins, Robert Lazzarini, Íñigo Bilbao and Brody Condon have been using technologies to integrate digital readymades in their practice. This has been done either through use of scanning technology (Collins 2003, Lazzarini 1999 and Bilbao 2008) or through the re-use of pre-existing digital works found on the internet (Condon 2008).

Figurative digital sculpture has continued the practice of creating images of stylised perfection. This along with atelier (artisanal) simplifications and styles of teaching in CG as per Petroc and Loomis’s teaching methods, have sustained this perfectionist ideal in the medium. Part of my practice looks at this ideal of perfection, as I believe these conceptual approaches fail to capture the details of life, what I refer to as the naturally imperfect form.

This failing in digital sculpture has led me to use available technology to capture ‘found art’, keeping as many inherent details of the objects. Minor imperfections and general patina, the objects histories are kept. McCullough reinforces this concept of digital artifacts having history with “a unique accumulation of responses to material imperfections” (McCullough, 1996, p165). This history of the original object is used and re-interpreted. Imperfections of the original along with digital detritus, (created in the process of capturing the works) are used as a basis for additional re-interpretation of the sculptural form in this new medium.

By using this process I am attempting to circumvent Walter Benjamin’s argument that mechanical reproduction removes the aura produced by the traces of the hand of the artist. As documented in his essay “The Work of Art in the Age of Mechanical Reproduction” (Benjamin 1935). The digital medium is one of the most reproducible mediums, as anything created digitally is infinitely reproducible, a digital copy is identical to the original (Mitchell 1992). Economist and artist Hans Abbing counters Benjamin’s argument on aura proposing that instead of diminishing the "aura" of art, reproduction helps to extend the aura of the works

13 See Sculptural Practice chapters (Chapter 3.1.2 p 51).
reproduced instead of destroying that aura. He uses a recording of Bach’s oeuvre as an example stating that because of reproduction, it has increased its aura; as more people are now aware of it and have access to it. Abbing also notes that the allographic arts, such as writing music and theatre have always maintained their aura (and these have been reproducible since before the industrial revolution) and that people have faulty expectations on originality (Abbing 2004).

Abbing’s assertions on reproduction support the established artist, but raise questions about the role of reproduction in the works created by the emerging or unknown artists. As an emerging artist I have attempted to extend or maintain this aura of the work while working in the digital by keeping something of the original form, allowing the work to be adapted and assimilated into its new medium.

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14 Allographic, is a term introduced by Nelson Goodman in Languages of Art (1968) to describe works of art such as music or written works of which there can be multiple copies, each of which is equally accepted as an instance of the work. Nelson contrasts this form of art to paintings where there is only one instance of the work, and any copies are either reproductions or forgeries.
1.3 ARTISTIC INFLUENCES

My goal of keeping a relationship with the original artefact and maintaining an ‘aura’ led me to adapt a workflow which allowed me to incorporate the original into a new work, Picasso and Duchamp’s concepts on the reuse of materials has been adopted by many contemporary artists. This reuse of material can be via the digital capturing of the artefact (Bilbao, Collins), or the reuse of physical elements combined into the sculptural works themselves as with the works of Alexander and Brewer.

The reuse and adaptation of the medium, such as the adoptions of the game engine as in Brody Condon’s work was a logical extension to my practice that was in part virtual. My primary artistic influence has been in the forms found within the bones themselves.

1.3.1 BONES, THE NATURALLY IMPERFECT FORM.

My interest in incorporating an original physical (naturally imperfect) sculptural form, into my practice, stems from my fascination with the random imperfections existent in the natural world. The practice evolved as reaction to the digital medium being seen as a clean and perfect medium, an impersonal medium, a medium without history. My practice goes against this pre-conception of the medium, as the digital works do indeed have a history, both through its creation process and through ones interaction with the medium as an artist (McCullough 1997).

In my practice I translate physical ‘found art’ into my digital sculptural explorations. Additionally, I use the digital detritus, generated by the errors of translation from the physical into the digital as part of my artistic process. My interest in incorporating an original (naturally imperfect) form into my practice stems from my fascination with the random imperfections existent in the natural world. These captured and translated imperfections (to me) reveal the true nature of the object and the technology used to capture it. I reflect on this nature through the medium of digital sculpture, exploring this relationship between technology and nature.

There is an abstract beauty in the shapes of bones, an aesthetic of construction, which can be seen at both a macro and microscopic level. I am interested in monumentalizing these forgotten shapes or forms. Process wise I initially see these forms in the physical world; I then capture that form, working from it, much as I would

when working with a physical material, then reinterpreting it in the digital medium. I chose the digital medium to extend upon my sculptural practice, as it is one free of physical constrictions, I can focus on the forms as I see them without restriction.

I use natural forms found in bones and decayed sculptures as a starting point to expand upon into the digital. When I initially started this research practice, I incorporated the theme of ‘memento mori’, a Latin term that translates as ‘remember that you must die’ into my digital practice. The concept is not only a reminder of our mortality, but a means to reference its rich visual historical lineage, connecting my explorations of imperfection found within bones and decaying sculptural art pieces, with the tradition of western sculptural practices.

1.3.2 BONES AS ART: INTERACTIVE

The term interactive is generally understood as the allowing of a two-way flow of information between a computer and a computer-user. This contemporary concept of interactivity is preceded by many traditional works of art where the viewer interacts with the works in order to fully appreciate it. Sculpture is a traditionally interactive art medium as the viewer often has to change their point and move around the sculpture to fully see the piece. Interactive artworks of this type incorporating bones and the theme of memento mori are not a recent phenomenon as Hans Holbein’s painting, ‘The Ambassadors’ (1553) demonstrates. It combine’s technical, aesthetic and scientific processes to create an interactive artwork which is a precursor to any digital works.

16 Tate glossary definition
Colson uses The Ambassadors as a case study of interactivity in art, stating that when viewing the painting you have to change your position, to fully see the skull image on the canvass.

It is this tradition of interactivity with images of bones that I wish to extend upon. This artwork required the audiences to do more than take up one position in front of the piece. (Colson. 2007) In order to correctly view the skull one must change one’s angle of view the side to see the form morph into an accurate rendering of a human skull. The skull is rendered on an anamorphic or accelerated perspective plane and is meant to be a visual puzzle as the viewer must look at the image from an extreme angle to properly see the human skull.

A more recent digital exploration of the anamorphic skull is seen in Robert Lazzarini’s Skulls. Lazzarini uses the two-dimensional distortions of anamorphic perspective and then applies them to three-dimensional objects. His sculptures are an exploration of complex distortions of three-dimensional objects.

With ‘Skull’, the original object was digitized and brought into computer space as a 3D model. The perspective distortions were then applied using a computer workstation. Physical models were then generated by rapid prototyping (RP) machines.
1.3.3 BONES AS ART: TECHNOLOGY INCORPORATING SCANNING AND RAPID PROTOTYPING.

Monumentalisation of bones can be seen in the works of Íñigo Bilbao, whose use of medicinal scans to create a series of rapid prototype sculptures on the theme of memento mori in its modern context. He takes medical tools and data used for diagnostic purposes and uses them to sculpt people who find themselves in a state of helplessness, just because they are laid out on a stretcher during the scanning process. (Bilbao 2008)

Figure 8- CATs – Experimentation with biomedical imaging Íñigo Bilbao (ES) BioLab 2008

Bilbao states that this kind of portrait isn't supposed to be gloomy, to reflect morbidity or death, but just the opposite; it offers a new, in-depth version of the living, in all its complexity. (Bilbao 2008). Bilbao’s non morbid philosophy reflects my own practice, my sculptural works based on bones are not explorations of memento more in its classical gothic sense (as a fascination with death). They are more of an expression of underlying structures behind life.

Additionally Bilbaos' practice examines how a 3D scanner translates a physical object into a virtual environment and how a 3D printer then translates that virtual object back into the physical environment. By combining these two processes, Bilbao offers a return trip between the real and the digital, allowing us to examine the changes that these translations produce in the physical and the virtual objects. (Bilbao 2008).
My fascination with the structural forms found in bones are similar to Bilbao’s biomedical artist explorations, but in my practice I am interested in redefining and reinterpreting this digital data, to actually sculpt with it (virtually), but still keeping some of the imperfections and nuances of the original. I incorporate the errors in translation into the digital medium, which I refer to as digital detritus.

Digital artists working in production avoid these errors in translation (artifacts), and clean them up and remove them from the piece\(^\text{17}\), such as document by Roussel in his reconstruction of the Venus of the Rhone River for the Arles Museum (Roussell 2011). Roussel created a full reconstruction and recreation of an ancient sculpture based on scanned data. The scan was used as a basis to re-create an undamaged virtual version of the Venus of the Rhone River.

\[^\text{17}\text{ The model is cleaned up made perfect, exemplified by Angelina Joli’s virtual avatar character in Zemicki’s Beowulf (Chapter 2.2.3 p.39).}^\]
This technique of using scanned data of bones and RP printing is utilised by Keith Thompson in his glass sculpture series titled ‘Reflections’. These works explore 15 different Monkey Skulls in glass, based on 3D digital data of primate skulls.

‘Monkeys are a common motif combined with mirrors in Eastern European arts and crafts - this serves to remind the viewer of our common, primitive roots. These works are illuminated from within, but they also present the viewer with their own reflection; literally and figuratively,’ (Thompson 2011, para 5).

This particular work resonated within my own explorations of a Vervet monkey skull (Figure 12) which I captured, reconstructed and adapted to become the piece Vervet Triclops (2011).
Vervet Triclops (see figure 12 Appendix A), adapts and plays with forms found in the original Vervet skull, but exemplifies the freedom to adapt the forms possible using a voxel based sculpting application, without the restrictions of geometry and topology that polygonal based applications are restricted by. (See technical chapter 3.3 p.51). This allowed me to create my own gaffes similar to Brewers Feejee Mermaid (Figure 16) adapting and re-using elements from the original sculptural form.

![Vervet Triclops](image-source: http://digitaleyes2008.org/?q=gallery-twister)

The relationship between the original source object and its virtual counterpart interests me as an artist and technician, Dan Collins’s work looks at these relationships between virtual and the tangible. His research bridges three domains: data acquisition, modeling, and form realization (through RP printing).

Works such as Twister (Figure13), explore how distortion in data acquisition can affect a piece. With his Twister series of self-portrait scans, Dan moved his body while the scan took place, which resulted in distortions of the final scan. He intentionally creates these distortions to explore ‘the gap between the virtual space of the computer and the tangibility of sculptural objects’ (Collins para 2, 2008). Collins interest in this loss in translation data is what I see as a form of digital detritus, a theme which is explored and adapted in my own works.
Another major influence or realisation of my work has been the hybridisation and mixing of various bone elements. I have combined bones from differing species into a single sculptural work. CowSkull Redux0.01 (figure 14, Appendix B), combines a hand sculpted human pelvis and femur with a heavily re-sculpted cow skull, sourced from very rough photogrammetry data.¹⁸

Jane Alexander is a South African artist who incorporates animal parts into her work and extends upon the original source material by refiguring and adjusting it. Her sculptures mix materials such as bone, horn, paint and plaster. One particular piece stands out, ‘The Butcher Boys’ (figure 16). The sculpture has three white life-size naked figures sitting on a bench, they have neither mouths nor genitals, horns grow from their heads, and frayed spines are exposed in their backs. This figurative sculpture incorporates animal elements referencing the baser brutal elements underlying humankind, referencing a culture of indifference in apartheid South Africa during the mid 1980’s.

¹⁸ See Chapter 4 appendix CD.
Additionally, the works created by Sarina Brewe (see, e.g. figure 16), which are a mixing of taxidermy and sculpture, show the possibilities of incorporating multiple parts into one piece. Brewer’s re-use of various found art elements to form single sculptural pieces is based on the taxidermy tradition of the gaffe, creating taxidermy fakes, combining two animals to make a new hybrid creature. Brewer’s early works were shrines to the animals they incorporated, creating final resting places for them. It’s Brewer’s deep respect for animals and the natural world that initially drew me to her work.

‘...she does not view a dead animal as disgusting or offensive... but feels .... that all creatures exhibit beauty in death, as well as in life, and pays homage to them by reincarnating them in her works of art...’(Brewer, 2007 para 3).

Conceptually Brewer’s work appeals to me; through its re-use of various animal parts to create something new, but visually I have more interest in exploring and displaying what I see as the pure sculptural forms found in bones.
1.3.5 VIRTUAL READYMADERS:

Duchamp’s readymade techniques of appropriation and re-use of materials has been embraced by digital internet artists such as Brody Condon. Condon’s work appropriates material on two levels, firstly Condon sources his visual 3D elements, ‘found art’, from the internet and secondly Condon appropriates a display medium for his work using a pre-existent game as a platform for display. This technique of modifying computer games is termed modding.

With Brody this practice of modding is another form of digital found art appropriation, using this technique he create pieces such as Judgment Modification (Condon, 2008; see figure 18), based on Hans Memling’s painting of the Last Judgement 1467-71. Condon appropriates this classical religious artwork, taking the layout and colour, but transposing it into the interactive medium of a modified game. Condon re-purposes existing computer and live games to create sculpture software installations (Condon 2008).
In my practice the readymade objects are not sourced from the internet but I do make use of a pre-existent game engine\textsuperscript{19}. Instead my readymades are the geometry data sets derived from actual objects which are then converted, adapted and rebuilt to be incorporated into virtual (game-like) spaces. My principle motivation for displaying these works in the virtual medium was to allow viewer access to the same navigation and interaction affordances as used in my digital sculpting practice\textsuperscript{20}.

\begin{center}
\textsuperscript{19} Unity Game engine, see Chapter 3.4.1 p.67
\end{center}

\begin{center}
\textsuperscript{20} See technical Chapter 3.4.1 Re-display Interactive games spaces.
\end{center}
CHAPTER 2:

Although my art practice has been inspired by artists such as Bilbao, Collins, Alexander and Brewer my art work has grown from action, observation and reflection. It is through my interactions in the digital sculpting medium as well as through the capturing and processing of physical artifacts that I gain inspiration.

Practice based research methods allow me this artistic immersion to develop new works and expand on my artistic goals.

2.1 METHODOLOGY – PRACTICE BASED RESEARCH

When I initially started this research practice I had a technological problem to solve, proposing to create a series of template meshes to be used and integrated into the ACID (Australian CRC for Interaction Design) photogrammetry application 3DSee. This research was complimentary to my initial research on topology for animation. But as I worked with the mesh data generated from 3DSee I discovered more creative uses for the technology, my focus then shifted from technological research to an artistic practice which is reliant on technology.

As my practice is driven by technology I initially found a correlation with Scrivener’s (2000) norms of technology based research.

Norms of Technology Research Projects

- artefact is produced
- artefact is new or improved
- artefact is the solution to a known problem
- artefact demonstrates a solution to problem
- the problem recognised as such by to others
- artefact (solution) is useful
- knowledge reified in artefact can be described
- this knowledge is widely applicable and widely transferable
- knowledge reified in the artefact is more important than the artifact

Additionally Scrivener defines a creative production research as differing from a pure technology based research path as follows:
Norms of Creative-production Research Projects

- artefacts are produced
- artefacts are original in a cultural context
- artefacts are a response to issues, concerns and interests
- artefacts manifests these issues, concerns and interests
- the issues, concerns and interests reflect cultural preoccupations
- artefacts contribute to human experience
- artefacts are more important than any knowledge embodied in them (Scrivener 2000)

My practice subsequently has more resonance with Haseman’s ‘performative research’, where the practice is the main research activity, and the works from the practice are the research findings (Haseman 2006). My practice uses a technique of photogrammetry along with a combination of digital sculpting tools to translate and interpret what I term ‘the naturally imperfect forms’ of the original into the medium of the digital.
2.2 ARTISTIC PRACTICE

2.2.1 METHOD

I work every day in the digital, working as a digital artisan by day and as digital artist by night. My current professional practice as a Character Artist relies heavily on digital sculpting software (tools) such as Mudbox and Zbrush, to recreate the realism and idealization called for in today’s games. Anhut considers this trend of realism in game art as having a negative impact towards the medium, in his article ‘Realism Vs. Idealization’ Anhut (2010) describes how the games industry is moving from images of abstraction, which were driven by hardware limitations, towards focusing on realism which is now limiting the medium conceptually.

1. Realism is only a standard for the power of the available game technology, not a standard for artistic expression.
2. Realism is not the key to a convincing experience. It is just one ingredient to create believable idealization.
3. Realism therefore is not the king quality, many claim it to be and we need to stop judging games by the degree of perceived realism’ – (Anhut para 13 2010)

Having worked on hand optimising dense realistic head scans of licensed movie stars to capture and display their likeness in a game engine, I have also come to recognise this current phase or obsession of the medium.

This led me to look at other ways to incorporate the physical world and re-interpret that information into my digital practice. The practice merges art with my interest in the study of bones (Osteology) and anatomy through digital sculpting techniques. Through the works I explore the aesthetic forms found within bones, without its associated morbidity.

I have the ability through technology today; to reflect on these collections of found forms, but without a need to damage or physically capture the objects of reflection. These captured and translated imperfections (to me) reveal the true nature of the object, I reflect on this nature of the object through the medium of digital sculpture, exploring a relationship between technology and nature.

I use natural forms found in bones as a starting point to expand upon into the digital, using the works to explore monuments to life rather than a ‘memento mori’, (a monument to death). It was only part way through my practice that I realized that that one of my primary motivations for incorporating and exploring these bone forms was the commonalities of skeletal structures and not necessarily an interest in the macabre. To me bones show our place in the world, they show us, that we as living beings are related to the world and part of a greater whole. Bones show our genetic relation to other living creatures. Bones are the structure of
life and are not images that represent *memento mori* but, *memento vita*, reminders of life, Panafieu notes this concept in *Evolution [IN ACTION]* that

“... despite the extraordinary diversity among vertebrates, from the goldfish to the whale, the pink flamingo to the crocodile’ their common origin is still legible on their skeletons...” (Panafieu, 2007, p 14).

It is part this commonality\textsuperscript{21} of the sculptural form that I explore through capturing these shapes. My work is conflicted with my desire to explore the forms of bones as wholesome shapes and by their associated intrinsic content as macabre objects. I have always seen bones as beautiful sculptures in themselves and I would prefer the pieces to be viewed in what Panofsky refers to as their primary\textsuperscript{22} or natural subject matter (context), rather than the viewer jumping to a conventional or intrinsic meaning (Panofsky, 1972).

There is an abstract beauty in the remains of life, which to me raises ones awareness of our debt to nature and life. This I believe reminds us of our need to keep in touch with the natural world, although there is a certain irony in working in the digital as this much removed from the natural as is currently possible.

\textsuperscript{21} Or a perceived commonality - A skull of an elephant can be mistaken for the skull of a Cyclops – we make up our own associations, when we see things that we don’t understand – see attached sculptural piece Cyclops in appendix CD.

\textsuperscript{22} In his 1939 work Studies in Iconology, Panofsky documented Three Strata of Subject Matter or Meaning which he broke down into primary, secondary and tertiary.

Primary or Natural Subject Matter: The most basic level of understanding, this stratum consists of perception of the work’s pure form, the most basic understanding of a work, devoid of any added cultural knowledge.

Secondary or Conventional subject matter (Iconography): This stratum goes a step further and brings to the equation cultural and iconographic knowledge. Tertiary or Intrinsic Meaning or Content (Iconology): This level takes into account personal, technical, and cultural history into the understanding of a work. It looks at art not as an isolated incident, but as the product of a historical environment. Working in this stratum, the art historian can ask questions like “why did the artist choose to represent *The Last Supper* in this way?”

Essentially, this last stratum is a synthesis; it is the art historian asking “what does it all mean?”
2.2.2 WESTERN IDEALS OF PERFECTION.

Today CG imagery is still dominated by classical aesthetics of harmony and rational order. This aesthetic grew out of the architects, artists and philosophers of the early and high classical periods in Greece who strived for perfection in their work. Sculptor Polyclitus wrote on the proportions of the human form that makes up beauty, in a treatise known as the ‘canon’ or rule (Butler 1979). Polyclitus created a larger than life size sculpture ‘Doryphoros’ or Spear Bearer’ based on the mathematical relationships of proportions of the body. This mathematical aesthetic viewpoint continues to permeate through CG medium today, with idealized versions of the human form seen in film, and computer games.

I believe this orderliness associated with digital work is due to the medium being a technologically restrictive one, encouraging more technically focused individuals to use it. The more intuitive and expressive artists have found the medium of CG too restrictive.

2.2.3 CG PRACTICE

As a digital artisan, I work every day in an exacting medium; every element which is put together is based on a mathematically accurate model, even when modelling facsimiles’ of real world items, the starting point is a perfect cube, sphere or cylinder. This reliance on an ideal [perfect] primitive is partly a technical restriction of the medium, but also an aesthetic legacy of computer science, which is based on the classical aesthetic of the perfect. There is no longer a [aesthetic] reason to be restrained by the perfect.

Currently CG is proliferated with images of “perfection”. Doing a Google image search on “CG” results in popular culture images of perfect CG females and shiny product illustrations (see figure 19). And even though the process of CG creation is very structured and very rational; the medium can be controlling of the inexperienced user. This is because it is directed to having something that works technically (i.e. doesn’t crash the system).
This restriction of the medium initially defines you as user; mastery of the medium only comes through practice and repetition. But the medium can support far more than just this type of CG. The ideal position as artist or craftsperson is when one becomes unconscious of one’s working medium (McCullough, 1996). One of the aims of my research practice is to achieve a level of mastery of the medium which only comes with time involved with the medium. The research practice works unravel these tacit actions and HCI affordances making them intuitive to me as an artist.
The elements of crispness and perfection seen in most explorations of computer graphics are ones that I find unnatural. Both Ray Winstone and Angelina Jolie’s’ characters in the entirely CG Film Beowulf (Zemeckis 2007), are examples of this intentionally idealised image of perfection in Hollywood CG (see figure 20). Angelina Jolie’s’ CG avatar, is a character that plays on the contrast between her son the “monstrous”, Grendel. Even Grendels’ mutations are carefully planned and constructed. In the digital medium the random needs to be carefully planned and created, where as in reality it exists naturally.

For my purposes, there are very few CG images of what I would consider natural objects. Subsequently I resolved to appropriate available physical material converting them into 3D data (my found art basis). These digitised artifacts contain some of the natural (original objects) flaws, as well as its own flaws in translation into CG. My intention was to avoid the tendency of visual perfection as commonly seen in CG, exploring an alternative to these perfect forms. I have chosen to explore subject matter that is usually associated with the imperfection of death and decay.
As a digital sculptor I can investigate and experiment with various outcomes of a piece based on the 3D data. I can revisit and re-interpret archived pieces. By manipulating photogrammetric data, I am attempting a form of digital sculptural frottage. I use the term sculptural frottage as a frottage differs from a direct copy as it’s aleatoric and random in its nature (West, 1996). It is this addition of randomness to the medium that appeals to me as a creative. Working as a practicing digital artist, more often than not, the technical processes that one uses in production are counterproductive towards one’s creative processes. One has to straddle the extremes of the technical and creative processes to maintain one’s practice.

2.2.4 CONCEPTUAL PROCESS AS PRACTICE

Even working in a virtual medium, with an undo button the end results are not always predictable, which I believe has enhanced my practice. Allowing one to go with these ‘errors’ is something I am very unused to in my artisanal practice. This, along with using errors in translation to the digital, allows me to incorporate digital detritus in my works. Working this way has changed the research (practice) outcomes, avoiding what I see as a predictability of the digital medium. This method of purposefully using unpredictable tools to translate from the physical to the digital, ties in with Schön’s ideas on reflective practice. Essentially one allows oneself as the artist to not know all the final outcome but be surprised by the end. One can then reflect on that surprising result furthering the conceptual framework of the piece.

“The practitioner allows himself... to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behaviour. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation.” (Schön, 1983 p.68)

The appeal of working in a random evolutionary fashion is that one is never entirely certain of the outcome, relating back to the idea of natural imperfection and Schön’s (1983) comments on surprise in reflective practice. The process of using the errors in the translation process into the digital, results in unexpected shapes and interpretations in the final piece, the digital detritus. This double error process allows me to be surprised by the results of my own work, deliberately avoiding a predictable Fordist (linear) process in my digital creative practice. It is this random surprising nature to creative development which satisfies me as an artist.

23 When creating a frottage the artist takes a pencil or charcoal and makes a rubbing on paper over a textured surface. The resultant rubbing can be left as is or used as the base for further refinement.
The advantage of this is the creation process is an iterative one in which I am not entirely sure of the final direction\(^24\) a piece will take.

As a part of my process with some of my digital sculpts, I record the sculpting process, capturing in video the evolution of a piece. The piece suffers decay through the translation process of converting from the photographic images into the digital object (see technical document) as well as by the hands of its maker through use of the software itself\(^25\).

Along with recording my process I save iterative versions of my piece regularly, this is not just a good HCI practice but also an artistic method. I can then go back to pieces at various stages of its development and explore very different outcomes fully using the affordance of the medium.

2.2.5 MOTIVATIONS FOR ARTISTIC PRACTICE

The research direction of using physical ‘found art’ pieces as a starting point taken in this practice is partly a reaction to the VFX/Games industries’ abandonment of using an actual object as the starting point of a digital piece, a reaction to John Cox’s’ statement “Sculpting up from maquettes was intermediate technology probably more in use from 2002 -2007/8, ZBrush and Modo have definitely taken over, you’re doing it once and its already digital, ready for film production.” (John Cox, personal communication, January 28, 2010). I counter that if the object already exists and can be manipulated in the digital then why re-create it from scratch.

A more personal motivation for this stance of working from physical data stems from my introduction to professional practice in computer graphics. As an Artist, I initially developed 3D environments on *Alien vs. Predator* (1996, released 1998, Rebellion Developments) by physically modeling the game environment wall panels of the space ship corridors, which were photographed and scanned. These images were then used as the basis for the games texture maps.

\(^{24}\) Which is very different to my artisanal practice where I am directed every step of the way to make a final product which matches a pre-approved design.

\(^{25}\) I used this recording process to created an animated sculptural piece for projection display, further discussed in chapter 3.4.4 p.79
CG today as a medium has become locked into what could be seen as simplified ‘visuality’ (Rose, 2007). This established digital practice of creating perfection raises the core questions this work investigates:

What are the artisanal, artistic practice, processes and motivations of working in the medium of digital sculpture?

How does one explore the experimental workflow and processes of creation in a digital sculpture practice?

Although my artistic practice is production based; I explore an alternative to typical polygon based CAD centric approaches to digital sculpture. My practice explores techniques used in traditional sculptural work, where the artist builds up or removes material from a chosen base form, allowing the artist to ‘see’ something within the shape of the material and to then re-interpret this as a unique form.

I combine Michelangelo’s philosophy of seeing something within the base form, with the more modern concepts of the ‘ready made’ as defined by Duchamp and ‘assemblage art’.

I looked at contemporary artists such as Jane Alexander and Sarina Brewer for inspiration in my practice; both have continued and incorporated the concept of the ready made in their works, through the use of bones and animal parts (discussed further in the artistic influences chapter). All have incorporated the detritus of modern day life.

My sculptural explorations in the digital medium are driven by what Haseman (2006) describes as an enthusiasm of practice; where one does not necessarily research a specific problem, but investigates something which is exciting to one as a practitioner or something which wasn’t possible, such as an emerging technology (Haseman, 2006). This research is a cyclic process where the practice drives the research, and the research refocuses the practice.

My digital practice as an artisan (commercial practice) has always been self evident in its production focus. Now working as an artist researcher, I have had to explore and document my perceived failures and rationalise what I consider conceptual successes in order to further my practice.

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26 Readymade is the term used by the French artist Marcel Duchamp to describe works of art he made from manufactured objects. - Tate Glossary definition source: [http://www.tate.org.uk/collections/glossary/definition.jsp?entryId=239](http://www.tate.org.uk/collections/glossary/definition.jsp?entryId=239)

27 Art made by assembling disparate elements often created as three dimensional works - Tate Glossary definition source: [http://www.tate.org.uk/collections/glossary/definition.jsp?entryId=34](http://www.tate.org.uk/collections/glossary/definition.jsp?entryId=34)
A rationale behind my enthusiasm of practice, my interest in bones, could be seen as a post colonial nostalgia (Walder 2010). This fascination with the collecting of bones stems from my upbringing in post colonial Africa, where as a child in Zimbabwe I saw examples of skeletons and taxidermy in people’s homes, either exemplified as hunting trophies or as seemingly left over artifacts from early settler history. It's through my current work I reflect on those formative pieces which I see as monuments to nature. I have been re-exploring the sculptural forms of bones, incorporating them into works since the 1990’s, combining them with a fascination with found art elements to create sculptural pieces (see figure 20 next page).
I still have these same drives and desire to collect the bones and trophies, this has evolved into my current digital sculptural practice which is based on assemblages of shells, human and animal bones or adaptations of figurative sculpture. The visual material is variously sourced, including my own personal collection. However, the majority of the objects come from publicly accessible museum exhibitions and sculpture gardens. This
material is initially captured photographically, and then converted into digital sculptures (see Chapter 3.2). This raw material becomes the foundation of the works to be explored and re-interpreted in the digital medium.

Thus, this technologically based practice is driven by tools and equipment used to make, structure and display a digital sculptural form. In addition, my intention for the final exhibition is to allow for access and viewer interaction with both the virtual as with the physical sculptures. This reasoning has led me on to use of AR (Augmented Reality), RP (Rapid prototyping 3D prints) and video animation to display my works in an attempt to remove as many barriers between viewer interaction with a virtual piece as possible, in order to engage the audience with the digital as physical.

The final representations of the forms are varied in their re-display, they can be screen based, interactive, 2D digital prints or displayed as a tactile 3D print. The commonality of these ‘forms’ is that they are derived from objects in the physical world. My practice has evolved to what I see as collaboration between myself as the artist and my materials, what Bolt refers to as ‘material productivity’ (Bolt, 2006, p.5)

### 2.2.6 SEEING AND SOURCING MATERIAL

Most of the forms that I find of interest are bones, stuffed animals and figurative sculpture, all of which are accessible to the public in Museums. It was in museums where most of my pieces were photographed and essentially captured. I initially made several informal trips to the Brisbane Natural History Museum in 2008 - 2009. Before making a formal trip in March of 2009 where data was captured with the help of Dr David McKinnon and used in “BirdSpace” interactive pieces, “CowSkull Redux” 2009.

I managed to capture some material from my own collection of bones, which became pieces such as “GoatSkull”, “CrowSkull Reduxv0.1” and “Crowskull _Scrimshaw”

But I was also able to capture some pieces in situ, my favourite among them is the central element to my interactive space “Whale Cairn” 2010/11 elements of which are based on a beached Southern Wright Whale that I encountered on the beach of Fraser Island in 2009, along with the skull of a Blue Whale sourced from the Pitt Rivers Museum in Oxford in 2010 (see figure 22).

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28 During the development of photogrammetry application 3Dsee, see Chapter 3.1.1 p.49
But my largest data acquisition took place on a trip to Europe in June 2010, where I visited; Natural History Museum (London), British Museum (London), Pit Rivers Museum (Oxford), Louvre (Paris), Doges Palace (Venice), Uffizi (Florence), St Peter basilica (Vatican). It was from these various guerrilla shoots that mesh data (my sculpting material) was captured and stored in my mesh library, as shown in figure 23.
Figure 20- Screen grab of a selection of mesh stock from my data library – showing raw un-worked mesh generated by 3DSsee.
2.3 CRAFT

As a digital artist, one cannot avoid artisanal processes when working in the digital medium. The concept of craft or craftsmanship is key to my creative practice; this has led me to look at McCullough’s notions on digital craftsmanship and mastery (1996). This is because my research practice as a digital sculptor is aimed towards mastery of the medium, and not just a technical mastery in an artisanal sense, but a true mastery where one’s actions become unconscious, where one loses oneself in the medium, i.e. – true interactivity.

2.3.1 ABANDONED EXPERIMENTS IN THE CRAFT OF SCULPTURE

During the course of this practice led research I undertook a sculptural exercise to better experience and understand the techniques and processes of sculpting both physically and digitally. I explored this process by creating a portrait sculptural bust; working both physically and digitally to better understand the digital mediums’ affordances (see figure 23). While this comparative experiment or study resulted in unsuccessful art works (aesthetically), it allowed me to confirm and experience the differences, similarities and affordances of the mediums, which as a practicing artist is important to experience first-hand.

29 See appendix document: Appendix C An Exercise in Physical and Digital sculpture, for more information.
Figure 21 - Comparative study of digital and physical sculpture bust – See appendix document C. - Image: the author.
CHAPTER 3:

My desire to avoid Roses’ simplified ‘visuality’ (Rose, 2007), as well as my early unsuccessful explorations of the craft of sculpture, in both the digital and physical spurred me to look at a workflow process that could combine the best of both mediums,

3.1 PROCESSES.

The artistic practice of using found art developed by Duchamp and Picasso subsequently explored digitally by artists such as Bilbao and Collins, have led me to re-examine at the affordances of the CG medium both artistically and technically.

I resolved to use a technique of combining the technologies of photogrammetry with the affordances of voxel based sculpting. This technique has enabled me to develop as an artist and researcher. Additionally I have explored techniques of re-display of my sculptural works to increase audience engagement. These processes have evolved my practice as the works have evolved to suit the mediums of re-display.

3.1.1 DEVELOPING THE TECHNICAL PROCESSES.

The technical side of my sculptural practice developed through my involvement in a research project undertaken for the Australasian CRC for Interaction Design (ACID) on photogrammetry tools. This project was led by Dr. David McKinnon and consisted of a web-based photogrammetry application called 3DSee and a high-end server-based application called ACID Vision.

(http://www.acid.net.au/index4f48.html?option=com_content&task=view&id=131&Itemid=189)

One of my initial research paths consisted of developing animation-ready optimised base meshes. These meshes could then be used as templates onto which photogrammetry data could be transferred. A template driven method of mesh clean up and optimization of data is recommended as the generated mesh data is ‘messy’ in its raw state. A similar template driven concept was developed by Blanz and Vetter, documented in their paper on ‘A Morphable Model For The Synthesis Of 3D Faces’ (Blanz, V., & Vetter, T. 1999).

As the scope of the ACID Vision project changed, my research focus moved towards how one integrates and adapts the raw mesh data available into a digital sculptural practice.
The question grew out of my practice and initially relied on the technology developed by the ACID CRC group. Recently, similar technologies are now publicly released. Affordable and accessible, photogrammetry based scanning applications such as Agisoft’s PhotoScan and web based My3DScanner, (which is very similar to the now defunct 3DSee) are now available.
3.1.2 PHYSICAL OBJECTS INTO MESH.

My process of taking a physical object, photographing it, converting the photographed images into manipulable (sculpt-able) 3d data is summarised as follows;

**See** [I see and identify a form and shape of interest]

**Capture** [photograph the source]

**Convert** [using photogrammetry tools to output to a polygonal base form]

**Clean** [Re-construction of polygonal mesh into a closed surface model polygonal mesh]

**Archive** [to be later re-interpreted]

**Block** [Block out and continued clean up of forms, through voxel sculpting editing phase]

**Re-interpret** [conceptual exploration stage, working both in voxel and polygonal mediums on various explorations of the shape]

**Refine** [Refinement of voxel/polygonal sculpts dependant on final re-display medium]

**Re-display/represent** [The final piece can be screen based/interactive/physical]

This workflow is similar to Busbys ‘3DScanning on a Budget’ (Busby 2011) a manual (home brew) workflow is documented, using ZBrush and AgiSoft’s PhotoScan. This workflow is now considered a standard in visual effects and in games, where the mesh data from the scan is re-projected onto an optimised mesh for further reworking (see figure 25).
In most cases of my professional practice as a CG artist for games and VFX, I have created assets from scratch, modelling using a combination of polygonal primitives and standard edge extrusion techniques. This method of production was mainly due to budgets and the nature of the content of the work – producing fantasy based creatures and characters. Recently there has been rapid development in low-end scanners such as Trimensional on the iPhone (Schindler, 2011) as well as hacks on Xbox Kinect systems such as Fabricate Yourself (Willis, 2011), allowing for even more affordable access to scanned data. ‘Three-dimensional (3D) image acquisition systems are rapidly becoming more affordable’ (Bernardini, Rushmeier 2002). Currently, there is a commercial need for simplified processes for users to incorporate digitised physical objects into their workflows. With this proliferation of low end generated mesh data, issues arise in cleaning and manipulating the generated meshes.

The motivation for simplifying the process and working with the raw data was both artistic and technical. The artistic and conceptual motivations were discussed previously. From a technical perspective, the ideal polygonal mesh should be a closed manifold and free of self intersections (Ju, T. 2009). Mesh data generated

When I have personally been involved with scanned data the meshes were heavily optimised and cleaned up before I received them, but even then required further texture and polygonal optimisation to work in the real time game environment.

See Petrocs workflow Chapter 1.2.
by scanning can have issues such as varying resolutions on surfaces, discontinuity errors, gaps, holes and self-intersections. With polygonal digital sculpting applications such as Mudbox and ZBrush, the ideal sculpting mesh is quad based and of an even geometry resolution (Eaton 2008). This even resolution allows for even manipulation and subdivision of the surface when one needs to add detail to the sculpture.

During the course of researching and developing my personal artistic workflow and processes, I discovered that industrial design practices were using hybrid modelling techniques (Dorta 2005) i.e. starting with a physical model, which was then scanned in 3D and iteratively developed. In Dorta’s case study, this method was used to enable industrial design students during the conceptual phase of development to follow a more tactile work-flow. ‘Using 3D scanning and rapid prototyping techniques, the designer is able to go back and forth between digital and manual mode, thus taking advantage of each one. Starting from physical models, the design is then digitalized in order to be treated with special modeling software. The rapid prototyping physical model becomes a matrix or physical 3D template used to explore design intentions with the hands, allowing the proposal of complex shapes, which is difficult to achieve by 3D modeling software alone.’(Dorta 2006)

To circumvent the process of continually rebuilding and cleaning up the scanned mesh data, I opted for a voxel-centric toolset over a polygonal toolset for the sculpting of the pieces. Working initially with a voxel based sculpting medium has allowed me immediate access to the scanned data with all of its visual aberrations and aesthetic kinks which are desirable to me as an artist, but without the underlying mesh errors.

One thing to note is that when capturing and converting three dimensional objects from reality; in effect ‘modelling from reality’ (Ikeuchi and Sato, 2001); the tools used for capture need to be transportable and the software conversion of the data needs to be converted quickly without need for excessive hand editing. This motivated me to use a guerrilla approach to capturing data and a simpler process to manipulate the 3D data by using voxels.

As most of my source material was based in museums and not physically accessible or handle-able I opted for a non contact\textsuperscript{32} method to capture my base meshes. The most common forms of non-contact methods of capturing and translating physical objects into digitised 3D data in the VFX, games, medical and automotive

\textsuperscript{32} Direct contact methods of data collection were ignored in their entirety for this research practice as most of my source material were based in museums or were too fragile to use direct contact methods.
industries, are divided into two methods, the active and the passive (Remondino and El-Hakim, 2006). In the active method the scanner itself emits radiation, such as a laser scanner. In the case of the passive method; the scanner does not emit any kind of radiation, but instead relies on detecting reflected light from the source material.

Since the active methods rely on lasers and calibration panels they were not explored for this project, primarily because of their lack of portability as in most cases, I was capturing ‘on the fly’, using a digital camera to capture the image, to create the photometric data. This affordability and portability emphasised my use of 3DSee as a primary part of my workflow.

3.1.3 PHOTOGRAMMETRY

Photogrammetry is the process of determining the geometric properties of objects from photographic images. More precisely, the technique used in my working process is stereo photogrammetry. This involves the software estimating the three-dimensional coordinate points of an object through multiple photographic images. Points in a three dimensional space are determined by measurements made in two or more photographic images taken from different positions. Common points are identified on each image, and then a line of sight (ray) can be constructed from the camera location to the point on the object. It is the intersection of these rays (triangulation) that determines the three-dimensional location of the point. These points in space form a ‘point cloud’, which is then reconstructed into a polygonal mesh model.
3.2. SOURCING CAPTURING, CONVERTING AND CLEANING 3D MATERIAL.

The mesh data for my digital sculptures were sourced (as discussed in Ch2.2.6) from various museums as well as my own collection of animal bones and fieldwork.\(^{33}\)

The mesh data used in my practice was generated from photographic images by 3DSee which was a free web-based stereo photogrammetry application developed by ACID research fellow Dr. David McKinnon. It became my principle data acquisition tool, as it was a simple to use digital camera based method, which required no scanning rigs, calibration marks or calibration panels. It did however require a minimum of 5 sequenced images to generate a mesh with texture information. The texture data was embedded into the vertices of the mesh avoiding the complicated task of automatically generating UV textures.

3DSee (McKinnon 2009) existed in two forms; a free web-based version and a high-end commercial application which was under development known as ACID Vision. The web based application was developed for a lower bandwidth, thus the mesh data output was of lower resolution and quality than that of ACID Vision, enabling viewers to preview their mesh data in a java viewer before downloading the data.

Both versions compensate for handheld camera errors such as camera shake and other extreme camera moves which can make data capture and conversion more difficult. I used a digital SLR camera (Nikon D90) to capture data, which proved very intuitive and unobtrusive becoming a simple point click move, procedure. This method allowed me to capture image data in museums with relative ease as well as outdoor environments.\(^{34}\)

One must keep a fixed focal range when shooting, and one should keep as much of the object in focus as possible (a deep depth of field is ideal). If areas of the photograph are out of focus in your sequence, this will create artefacts in your outputted mesh. These artefacts are the result of a lack of useful information in the images. (McKinnon personal communication 2009)

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\(^{33}\) Whale Cairn – based off a Southern Wright Whale photographed on Fraser Island

\(^{34}\) Successful capture was achieved in quite diverse environments, from in situ locations such as Fraser Island (see figure22) and various indoor locations such the British Museum (see figure 28).
Once the subject matter has been selected, the key process in reconstructing the piece in 3D is to maintain a perpendicular and regular spatial distance when photographing the piece as an image sequence. The maximum common area that two photos share between images is the most critical to conversion and should be maintained evenly throughout the photo sequence. The minimum overlap allowed is 80-90% of the intended image. (See Figure 26, middle left)
When photographing your object a minimum of 5 photographs is needed to convert the images into viable mesh data, when using 3DSee (see figure 27).

![Sequence of images converted into a 3D mesh with texture data imbedded into the vertices. -image: the author.](image)

The ideal objects to convert into 3D using an image based modelling technique, are objects with a lot of texture detail. The following successful example (figure 28) is of an almost a complete 360 degree capture of a South American statue shot in low light in the British Museum consisting of only 23 photographs.
Surface texture\(^{35}\) on the object is important as it is used by the software to differentiate between one point of your image to another point, in order to create levels ascertained with its 3D mesh and bump map. Uniform ambient light is the ideal light source for a sequence of photos, however it is not absolutely necessary as one can see in figure 28, where there was bright primary light source in the room where the statue was photographed. The use of photogrammetry captures the inherent natural errors of the original, rather than relying on an interpretive initial observation of the subject matter. My artistic re-interpretation takes place later on, through my interactions with the piece sculpturally and not initially.

The actual process of image translation and 3D reconstruction is completed via the 3DSee web server. The user logs in their account and uploads the images to the server. When the server has completed its calculations an email is sent to the user letting them know that the resulting .ply mesh is ready for download in a PLY\(^ {36}\) format.

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\(^{35}\) The irony is that with my primary subject of capture being bones, which have little texture variation – though there is sufficient information to capture the base forms needed for my explorations.

\(^{36}\) The .ply format is known as the Polygon File Format or the Stanford Triangle Format was originally developed to store data from 3D scanners used on the Digital Michelangelo Project at Stanford graphics lab under the direction of Marc Levoy http://graphics.stanford.edu/data/3Dscanrep/. 
Once the stereo photogrammetric data *.ply mesh is downloaded it is then imported into MeshLab\(^{37}\) (Cignoni, P. 2011) which is an open source application for the processing and editing of polygonal meshes.

In MeshLab any holes in the mesh are filled, this allow for easier re-topology and editing in the voxel application. This now contiguous mesh is then saved in the .dae format which will store any texture information captured as vertex colour data information. This vertex colour information can then be converted into a texture used on a geometry with UVs\(^{38}\).

\(^{37}\) MeshLab is used in various academic and research contexts, like microbiology, Cultural heritage, surface reconstruction and desktop manufacturing.

\(^{38}\) UV texturing allows polygons of a 3D object to be painted with colour from an image. The image is called a UV texture map. The UV mapping process involves assigning textures to surface of the polygon. The “U” and “V” denote the axes of the 2D texture as “X”, “Y” and “Z” are already used to denote the axes of the 3D object in model space.
3.3 NEW METHODS: COMBINING POLYGON AND VOXEL SCULPTING.

Most commercial digital sculpting tools use a polygonal based geometry, in which an object is represented by an interconnected surface mesh of polygons that can be pushed and pulled around much like hammering out shapes on a thin copper surface. I have worked in this manner using Zbrush, Maya and Mudbox which were all used in the initial stages of this practice. I integrated voxel-based sculpting application 3DCoat into my workflow during the later stages of my practice. In this application the volume of the object is the basic element (and not the surface geometry), using this process material can be added and removed, much like sculpting in clay.

My motivations for integrating yet another tool into my sculpting workflow were to better utilise meshes generated by 3DSee. This is as some of the data initially captured contained erroneous\(^{39}\) polygonal mesh data. I wanted to keep (visually at least) and use as much of the original photogrammetry mesh data as possible even if this mesh data was erroneous and non representational of the original surface of the object.

Working with a purely polygonal work flow proved impractical from both an artistic and technical perspective. I initially used a similar method to Busby (2011) to re-project the high resolution mesh data from the scan onto an optimised base mesh. This process would clean out the erroneous mesh data, allowing the re-projected surface to be sculpted. This mesh was then sculpted resulting in the pieces created in Zbrush : StGilesRedux v1.1 (2009) and CrowSkull Redux v1.1 (2009) used this method. This process was necessary as the digital sculpting application ZBrush requires that the polygonal base mesh to be sculpted be of an even resolution, contiguous and ideally in non-triangulated quads to allow for smooth subdivision of the base mesh (Eaton 2008).

\(^{39}\) Mesh noise Lamina faces
My adopted workflow combines the best qualities of both sculpting applications Zbrush (polygonal) and 3DCoat (voxel) to gain a more immediate access to the mesh data ⁴⁰ (see figure 28). I consider this technique in my artistic practice as the capturing of ‘the naturally imperfect form’. I use a hybrid software method of importing the raw 3DSee mesh data into 3DCoat where it is converted into the voxel format.

There 3DCoat’s voxel sculpting tools allow one to easily work with scan data, repair them and convert the meshes into sculptable meshes. (Spencer 2011) By using Spencer’s approach the voxel data can then later be easily translated into a polygonal geometry though 3DCoat’s automated retopology tools, to then be imported into Zbrush and further worked (if needed). If a mesh is required for 3D printing, it can then be exported as a stl file.

⁴⁰ Erroneous and difficult to work with mesh data by polygonal sculpting application standards.
The process involves importing an enclosed OBJ file into 3DCoat (3DC), which allows for the free form manipulation (once converted into a voxel) of triangulated, non-contiguous and varied resolutions of mesh. This voxel sculpting technique removed the labour intensive clean up of the data when working with pure polygonal geometry\textsuperscript{41}. In the direct mesh to voxel method, there is less restriction in the manipulation of the original data, allowing for the combining of meshes\textsuperscript{42} of varying polygonal resolution.

\textsuperscript{41} See Busy’s industry standard technique chapter 3.1.1

\textsuperscript{42} Alternatively I could use the free application Mesh Mixer which allows for the combination of varying resolution meshes into a single mesh but this does not allow for the detailed additional sculpting that is required in my artistic workflow.
Sculpting with voxels allows me to sculpt on the object without any topological constraints and create complex details and surfaces. I can easily change the piece fundamentally, without the issues associated with rebuilding or subdividing the topology of polygonal geometries. This is as the sculpting process is not based on surface deformation but on building and filling volumes (Spencer 2011) see figure 31, below.

Figure 29-Shpagin, A. (2011). Effectively voxels are dots in space which are either on or off (0 and 1), a marching cubes algorithm allows one to modify the actual volume of an object rather than just the surface.-image: Retrieved 21 June, 2011, from http://3d-coat.com/voxel-sculpting/

Additionally an important feature was added to the 3.5 release of 3DCoat, an auto-re-topology ‘AUTOPO’ function (Shpagin 2011) this addition is a huge timesaver and allows for easier translation of data from the voxel application to polygonal based applications. Without the inclusion of this voxel sculpting application into my workflow I would never have been able to work with some of the photogrammetry data generated from 3DSee.
3.3.1 POLYGONAL (TRADITIONAL) AND VOXEL (VOLUMETRIC) SCULPTING COMPARISON:

An advantage of voxel based sculpting is that voxels allow complete freedom over form. The topology of a model can be altered continually during the sculpting process as material is added and subtracted; this frees the sculptor from considering the geometries topological layout when working.

A limitation of polygonal sculpting is the fixed topology of the mesh (see figure 32); the arrangement of the underlying polygons at lower resolutions can limit the ways in which detail can be added or manipulated at higher resolutions.

Digital sculptors working in polygonal applications use a technique of working at multiple subdivision levels (resolution levels), where the artist moves up and down resolutions blocking in large forms at lower resolutions (Petroc 2008). Currently voxels (at time of writing) are limited to two options from the voxel modeling mode – ‘surface mode’, which turns a voxel model into a temporary polygonal surface mesh, and ‘downgrade volume’ which is one subdivision down from the surface mode (Sorjonen 2011).

43 This is known as poly-flow (or polygon flow) in the computer games industry.
Whereas polygonal based modeling supports sculpting at multiple resolutions (although how many levels of resolution is hardware dependent). Areas of the model that are finely detailed can have very small polygons while other areas can have larger polygons. In many mesh-based programs, the mesh can be edited at different levels of detail, and the changes at one level will propagate up to higher and down to lower levels of model detail. I opted for a workflow which combined both of their strengths to support my practice.
3.3.2 Blocking [Reconstructing] and Refining the Sculpt

The edited geometry from MeshLab is imported into 3DCoat (3DC) via the .obj format into the voxel sculpting ‘room’. When importing the mesh into the 3DC scene there is an option to make the geometry enclosed and if you want to, to subdivide it. Subdividing of the raw mesh can cause it to lose detail and on some of my pieces I have left the triangulation artefacts from the polygonal geometry in the voxel piece for aesthetic reasons.

Sections of the mesh are sculpted, mirrored and reincorporated into a contiguous whole (see figure 33, middle), similar to my original photographic image but without surface colouring.

It is at this stage that the piece can fully explored as a voxel sculpture. This is primarily a creative task, that can take anywhere for from days to weeks to fully realise (See attached video breakdowns in the appendix DVD of sculptural explorations).

Once the majority of the creative work has been completed, the process returns to a more technical one as the piece is readied for final display (figure 33 right).
3.4 DISPLAY

The final medium of display dictates the finishing off workflow, as the same piece can be re-displayed in various ways, dependent on display medium. The finishing process varies between interactive (game space, AR and mobile AR), physical (2D and 3D prints) or screen based (video animation).

3.4.1 RE-DISPLAY INTERACTIVE: GAME SPACE

To set up the sculptures for re-display in an interactive medium one needs to optimise the high resolution digital sculptures to enable them to be viewed within the constraints of the real time viewers or game engines. To do this, one in effect has to re-make the original sculpture at a lower geometry resolution. I use a method known as re-topologising, where the surface topology of the mesh is rebuilt, generating a new optimised mesh based on the pre-existing (high resolution) mesh. This lower resolution version of the piece then has UV’s assigned, it is then ready for the processes known as normal mapping.

Normal mapping involves capturing the high resolution mesh geometry details ‘storing the colors and normals in texture and normal maps’ (Cohen et al., 1998, p1). In effect a normal map fakes high resolution geometry detail onto a low resolution mesh. Each pixel of a normal map is used to transfer the normal that’s on the high-res mesh onto the surface of the low-res mesh. The red, green, and blue channels of the texture are used to control the direction of each pixel’s normal. The pixels in the normal map basically control what direction each of the pixels on the low-poly model will be facing, controlling how much lighting each pixel will receive, and thus creating the illusion of more surface detail or better curvature. The process of transferring normals from the high-res model to the in-game model is often called baking. These colours and normal details are then assigned to the optimised mesh as a material described as a ‘shader’.

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44 UV mapping stands for the technique used to “wrap” a 2D image texture onto a 3D mesh. “U” and “V” are the name of the axes of a plane, as “X”, “Y” and “Z” are used for the coordinates in the 3D space.
The interactive display spaces were developed using Unity engine (http://unity3d.com/). This involved importing the optimised versions of meshes into a Unity project. Real time shaders, made up of normal and diffuse maps were assigned to the optimised assets, environmental effects such as fogging, real-time lighting and auditory effects were then added to the scene.
Auditory enhancements were set up for the space. A first person camera was set up in the Unity game editor to allow for viewer interaction and exploration of the space. This camera used a standard PC first person shooter (FPS) style control system for navigation of the space. A surface terrain was generated with collision to allow the FPS camera to ‘walk’ around and view the pieces (and not fall through the world).
The Bird Space project scene was set up to completely enclose the viewer. Sections of mesh data based on White Winged Chough from the Brisbane Natural History Museum were inverted, mirrored and stitched together to form the cave enclosing the viewer (see Figure 36). When exploring the game space (or virtual sculpture garden) the effect is subtle; one can just make out the shape of the Chough which is embedded in the enclosing wall space of the gallery (see Figure 37).
Once all the effects and final positions of the pieces are in place, the gallery space is compiled, an executable is created. This executable file, once tested, can then be easily distributed (published) through direct download from the game space section of my web space here:


45 See appendix CD for game space executables.
3.4.2 RE- DISPLAY INTERACTIVE: AR (SUPPLEMENTAL DISPLAY)

In the later stages of my practice led research I began experimenting with Augmented Reality (AR) as a means to simplify and enable viewer interaction with my works, as an extension to the interactive display mediums I was working on. This decision to use AR in the final exhibition was primarily to allow viewers similar affordances to what I had experienced in the creation of the works, and was not a focal point to my research.

AR combines the real and virtual, is interactive in real time and is registered in 3D and supplements’ reality (Azuma 1997). AR can include a live direct or an indirect view of a physical, real-world environment augmented by computer-generated sensory input, such as sound or graphics.

This experimentation with the AR medium of display grew out of an invitation to show some of my sculptural works on the mobile phone AR platform for the first mobile AR group exhibition in Australia; (Un)Seen Sculptures (2011) [http://www.unseensculptures.com/]

The works displayed were shown in Sydney and in Melbourne. The mobile phone AR pieces are site specific as each piece is placed in a geographic location; hidden from the naked eye but visible to anyone with an iPhone, Android or Nokia smartphone\(^46\) and an app called the Layar Reality Browser, [www.layar.com/](http://www.layar.com/) which can be downloaded for free from iTunes, the Android Market or the Ovi Store.

Once one has downloaded the Layar Reality app, one can simply open it up, search for ‘(Un)Seen Sculptures’, select the layer set up for the show, then hold up their phones at the designated locations, and one will see the 3D artworks (see figure 38).

\(^{46}\) Ironically I don’t own an Android or an iPhone which make development of these pieces difficult both conceptually and technically as I don’t know what my viewer will see and have to rely on my experience in game development and artistic intuition.
The mobile AR pieces initially developed (created) for the (Un)Seen Sculpture mobile AR exhibition formed the basis for the AR works displayed in my final exhibition. These run on a PC with a camera in what is called a Kiosk mode. The Kiosk AR pieces were updated to include animation of sculptural elements; I made changes to the scale of the pieces. I adjusted their surface properties, re-texturing them to creating more complex shaders which included normal maps. These versions were subsequently renamed with an iterative naming convention to become new pieces in their own right.
The PC based AR pieces use a registration card to allow audience interaction with the piece, the viewer selects a card and then approaches the monitor as though approaching a mirror. The AR software integrates with a camera mounted over the monitor and recognises the registration card in the user’s hand and (see figure 39) projects the work into the camera view. This allows the viewer to interact with the piece and in the final exhibition to place multiple pieces together in compositions of their own making (see figure 40).
3.4.3 RE-DISPLAY: RAPID PROTOTYPE PRINT

The scrimshaw bird skull sculpture was developed from very corrupt photogrammetry data, being based on one of the early successful captured data sets from 3DSee. This base mesh was heavily reworked and effectively sculpted from scratch (see figure 41). Subsequent pieces (mesh sets) have required less reworking as the base geometries were much cleaner.

Figure 39 - Photogrammetry data mesh (background) and cleaned up base bird skull (foreground) image: author.

Once voxel sculpt was finished, in order to save on printing material and to allow light to pass through the sculptures, the interior of the model was hollowed out.
The final piece was then exported out as polygonal data, re-imported into ZBrush for geometry optimisation as the on-line based printer service Shapeways has limits on the piece’s physical size, mesh resolution and file size.
In ZBrush I set the physical scale for the piece, adjusting as I see fit for re-display and budget. The piece is then exported as a .stl file, stereo lithography file format\textsuperscript{47}.

The final .stl file is checked for errors in Netfabb Studio Basic, which I use for error checking and sometimes final scale adjustments of the piece if needed. Netfabb Studio Basic will automatically correct mesh issues such as open holes and repair non-manifold errors in the geometry (Peels, 2009). Once all errors are corrected the final .stl is saved. This .stl file is then uploaded to the 3D printing service Shapeways via their web portal.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{final_rp_print.jpg}
\caption{Final RP print-image: the author.}
\end{figure}

The final RP\textsuperscript{48} print takes about 10 days to be processed depending on the material chosen. As the Shapeways 3D print service is physically based in the Netherlands, the final RP print can take up to 5 days to be shipped to Australia (see figure 43).

\begin{flushright}
\textsuperscript{47} The .stl or stereolithography format is an ASCII or binary file used in manufacturing. It is a list of the triangular surfaces that describe a computer generated solid model, it is the standard input for most rapid prototyping machines source http://www.sc.ehu.es/ccwgamoa/docencia/Material/FileFormats/STL-FileFormat.htm.
\end{flushright}
The final exhibition of the works at the QLD State Library facility The Edge, forced me to look at my works collectively and not just as individual experimental pieces. I discovered there was greater disparity of scale in the final RP pieces than I originally intended, but through lighting and displaying the collection of works inside glass display cases unified the work. This formalising of the exhibited works created a museum-like collection of curiosities. As the final pieces were hollow to save on materials I decided to emphasise this property of sculptures by inserting lights into the base plinths to show off the semi translucency of the thinner surfaces (see figure 44). I intend on further exploring these material properties in future RP works.

48 As I am not directly involved in the physical printing process I have not documented this process. More information on the process used by Shapeways can be found here: http://www.youtube.com/watch?v=aBNGnfoGGfQ
Figure 43—For the final exhibition some of the larger RP pieces were lit from within using Light Emitting Diodes (LEDs), which were used to accentuate the semi-translucency of the RP material. These LEDs were then built into the plinths that the pieces sat on.
3.4.4 RE-DISPLAY SCREEN BASED: VIDEO/WEB/ANIMATION

The process to re-display the sculptural pieces in a video form is the least complex of my practice; this is as the medium of CG has been primarily directed towards screen display. I used standard rendering techniques where sculptures were lit and rendered in 3DCoat, Zbrush and Maya. Video turn-arounds were usually created to best display the works. This involves animating a camera slowly moving around the object a full 360 degrees, which is then set up to render as a continuous loop, allowing the viewer to see the full object.

![Image: QUT Big Screen 2009 - Image: the author.](image)

During the practice I also utilised another affordance of sculpting digitally. Part of my practice was to document my sculpting process through screen capture. This technique of playing back time-lapse images of the progression of works is a standard process for teaching and relaying techniques in the CG industry. This affordance along with the mutability of the digital medium allows me to capture the evolution of a piece. This

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49 I have used this method for creating teaching materials for students when teaching at QANTM.
led me to play with the concept of capturing time, using time–lapses of the works progress not as an instructional technique but as a medium of expression. This process of sculptural animation I have subsequently dubbed ‘sculptimation’.

I used this process to record my work as pieces in motion and not just as a static object. These pieces are explorations in the motion of sculpting which can be seen in figure 47 and in the appendix CD. Sphere Forms v1.1, was a video project selected as part of the Optica 12 group for 2011. This work was chosen to be part of 12 emerging artists’ works, selected to be projected onto the windows of Judith Wrights, Brunswick Street in 2011 (see figure 48).

My piece was a play on the conceptual simplifications prevalent in CG\textsuperscript{50}. It was an animated exploration of three spheres (geometric primitives) forming into more complex skull shapes, and then devolving back into their base geometry primitive. There is a mathematical perfection to the sphere, a standard geometry primitive which I played on, degrading the shape sculpting into animated studies of a human skull which have their own beauty. This was set up as an animated cycle of six different skull studies captured and created in ZBrush \footnote{See Chapter 1.2.3 Making digital sculpture.}. (See Chapter 4 appendix CD for Sphere Forms videos).
Figure 46- Judith Wright February 2011 Optica 12 – Sphere Forms v1.1 view from Brunswick street, Fortitude Valley, QLD - image: the author.
CHAPTER 4:

4.1 ART VS. PROCESS

The art of this practice grew out of both my compulsion to collect and explore the sculptural forms of bones and the technical boundaries of the photogrammetry process. The works grew out of what could be seen, from a scientific and technical standpoint, as a failure in the use of the technology of capturing and converting physical objects into the digital. Erroneous mesh data generated in conversion would usually be edited, or the data completely discarded. Within my practice this erroneous data became key to the conceptual framework of my artistic practice.

From a purely digital sculpting point of view; it would have been easier to recreate the forms found in bones in the sculpting software. Instead I have chosen to work from specific mesh data, where the process of choosing, capturing and converting of pieces, became a key part of my artistic practice.

The goal for the works was not only to create a representation of the original, but to act as an interpreter of the captured data in its new medium. With works such as Undine (2010) and Cyclops (2010), I have accentuated the differences in surface quality between the pure digital sculpted areas versus the sections generated by photogrammetry. I kept the spikes, bumps and triangulation facets generated by the conversion process. The ‘pure digital’ sculpted torso areas are smooth unworn and perfect. This surface juxtaposition emphasized the pieces’ translation into the digital. If I had merely displayed the skull of a dolphin or the skull of an elephant, they could be been seen as reproduction miniatures. My goal, however, was to discuss their original inherent beauty, how their meaning has changed through translation into the digital and how the artist’s hand has influenced the piece. I reflect on classical Greek concepts of perfection on the bodies versus the original form. This is again accentuated by the imperfections in translation which also have their own abstract beauty.

4.1.1 CONTINUING PRACTICE.

I initially started this performative research process (Haseman, 2006), exploring ways to capture and translate found objects into digital sculptures, with technology used as the great enabler. The technical processes of my practice are intertwined with conceptual/artistic understanding of my medium and chosen subject matter.

The technical process of capturing and converting these sculptural forms was my initial contribution to knowledge. Although these 3D capturing tools and techniques have been available for the last two decades at the high end level (through the use of laser scanners and such), only recently have lower cost photogrammetry based applications emerged. These allow for a more freehand approach which allows a less technical user to
access and convert data. The method I use to move from photogrammetry data to voxel sculpting allows a more direct access to sculpting with the data.

Through my access, investigations and understanding of the medium, my practice became more concerned with the concept of translation from the physical to the virtual and back to the physical medium. The works explore the restrictions and affordances of the digital sculpting medium(s) in their construction and resultant re-displays. Single pieces were explored and re-explored in multiple mediums of output as physical prints, augmented reality and as video works. For the final exhibition, physical pieces were placed within display cases on mounts and lit from within, this again changed their context, whereas their purely digital counterparts are contained and framed by the monitor or video projector.

I see the access to these mediums of display opening up even further, with affordable home use rapid prototyping printers such as open source type 3D desktop printer RepRap \(^5\) becoming commonplace, allowing for continued experimentation and play with the medium(s). Also improvements in translation between the physical and the digital would eventually allow objects to be physically modelled, converted into a digital model, reworked and then rebuilt physically bringing about Dortas’ (2005) hybrid modeling techniques. This may allow for an endless cycle of exploration; both physically and digitally without any loss of fidelity. The caveat to these eventual improvements in translation for me as an artist; is as long as I can break the fidelity of the translation where I see fit.

My understanding of the medium along with its conceptual and practical affordances has been augmented by the resultant re-display of the work. I no longer consider my practice as focusing purely on static digital sculpture; more recent works include sound, animation and interaction. As new levels of mastery of the medium were achieved (McCullough 1996), this led to more detailed explorations and reflections of the medium itself.

The reflections on my research are the works themselves, which have in turn fed the evolving practice emerging from this research.

\(^5\) RepRap is a free desktop 3D printer capable of printing plastic objects, source - http://reprap.org/wiki/Main_Page
4.2 THE PERFECT VS. IMPERFECT SCULPTURAL FORM.

The works play on and explore concepts of perfection, of what is the perfect sculptural form. It explores the natural or original forms\textsuperscript{52} that the works stem from and the beauty within those forms. The works also combine and explore the atelier based concepts of classical Greek perfection based on the human form\textsuperscript{53},

The word perfect in its formal, literal, and strict sense means to be without flaw. The works explore this term ‘perfect’ in a more informal sense as one which is complete and whole, lacking nothing essential. The resultant works of my practice are not facsimiles or degraded copies of the original, they are interpretations of the original forms with their own proportions, placement and detailing. They are not any more ‘perfect’ or less ‘perfect’ than their source; they are new forms themselves as guided by the artist’s hand as defined by their medium. The term naturally imperfect used in this dissertation\textsuperscript{54} came about from the surface imperfections used by the 3D conversion process to capture and convert the object into a digital version. I have deliberately accentuated these imperfections in the sculptures themselves and play with the concepts of the conversion and degradation of the form in the digital. From a technical and process point of view the surface imperfections and blemishes of the original are necessary in the capturing process. The photogrammetry software uses these surface blemishes as registration points in 3D space to generate the surface geometry in the virtual space. A clean unblemished surface is extremely difficult to convert into a geometry surface. The choice of bone forms as subjects showed up these issues as bones generally don’t have much textual information and are therefore more difficult to convert. This resulted in the erroneous data which I then used in the works.

One of the questions raised by my explorations of subjects in the digital medium asks whether or not natural found forms are perfect in and of themselves? Could I have exhibited the source forms themselves without going to all the effort of capturing and translating them into the digital? I believe this is the case, as I would not have explored the relationships between the capturing of the forms and my involvement in its re-translation. Viewers’ prejudices of the subject matter would have made the case of displaying the beauty of bones difficult.

\textsuperscript{53} (Chapter}
My role of artist is one to interpret, describe, translate this beauty and express it through my actions as a sculptor.

A conscious effort was made during the production of the final pieces for exhibition to translate the subject away from a macabre association. I felt this dissociation or objectification was necessary in order to express the beauty found in these forms. I consciously printed the sculptures in a clean white material and inserted lights into the pieces themselves which gave them, a lightness. The material is opaque, semi-translucency is only achieved where the wall thickness of material is very thin. I used internal lights to show off delicacy of the internal structure of the pieces as well as method of transposing associations.

The act of translating these forms into a new medium as well as consciously objectifying them has given them new meaning. I don’t believe that I could have achieved a truer representation of the sculptural forms by observing the forms by eye (which was never my intention anyway) and then digitally sculpting a piece. The use of a captured data method enables me as an artist to observe the forms in a more abstracted way, giving me additional ways to re-evaluate and re-interpret the forms; that through direct observation would have resulted in a totally different exploration of the piece.

What has grown out of this practice led research, which is explored through the work is an understanding that there is no perfection without imperfection. As de Quincey states; even imperfection itself may have its ideal or perfect state. (de Quincey, Thomas, n.d.)
4.3 CONCLUSION

My practice led research has explored notions of perfection and imperfection through physical and digital artefacts. The resultant works counter the prevailing ideals of perfection that have influenced (or dogged depending on one point of view), 3D digital art.

My adoption of existing digital techniques into an artistic workflow which incorporates the original imperfections into the final piece, avoids these preconceptions of perfection. I have refined this technique to capture what I term the naturally imperfect form of the original, while incorporating similar concepts to the early glitch art\textsuperscript{55} practice of Collins. My primary artistic influences are the forms found within my subject matter themselves, the bones and other natural forms. This along with the final mediums of output have grown and reframed my artistic practice.

I have through the works and techniques discussed, attempted to avoid the more sterile practises used in 3D industry. While digital sculpture’s roots are based on the mathematically precise CAD based automotive industry, processes currently are artist friendly, software and techniques have allowed further artistic affordances as well as access to sculptural material based off the physical. The practice explores how my hand as the artist re-interprets these sculptural forms in the digital; how through utilising digital techniques I can translate the natural imperfections of the original into the digital, at the same time allowing for distortions and additional imperfections caused by translation to be incorporated into the piece.

The final sculptural pieces are not only changed by their translation into the digital but also changed by their end mediums of display. In the end they are perfect in their imperfections.

\textsuperscript{55}Glitch art is the aestheticization of digital or analog errors, such as artifacts and other "bugs", by either corrupting digital code/data or by physically manipulating electronic devices.


Cox, J. (2010). Personal Interview. Molendinar, Gold Coast, QLD.


Duchamp, M. (Artist). (1917). Fountain


# Appendix A: List of Works

A full list of sculptural works developed during the course the practice led research.

**Rapid Prototype Pieces: (Physical 3D Prints)**

<table>
<thead>
<tr>
<th>Work</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unseen Man – The Brothers</td>
<td>2011</td>
</tr>
<tr>
<td>CrowSkull_Skrimshaw</td>
<td>2009</td>
</tr>
<tr>
<td>Hiddenface</td>
<td>2009</td>
</tr>
<tr>
<td>Vertebrae Mandala</td>
<td>2011</td>
</tr>
<tr>
<td>Triclops Vervet</td>
<td>2011</td>
</tr>
<tr>
<td>BaboonSkull</td>
<td>2011</td>
</tr>
<tr>
<td>Undine</td>
<td>2011</td>
</tr>
<tr>
<td>SunGod</td>
<td>2011</td>
</tr>
<tr>
<td>Whale Skull</td>
<td>2010</td>
</tr>
<tr>
<td>Janus</td>
<td>2011</td>
</tr>
<tr>
<td>Cyclops</td>
<td>2011</td>
</tr>
</tbody>
</table>

**Augmented Reality Pieces:**

<table>
<thead>
<tr>
<th>Work</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>ScrimshawCrowSkull</td>
<td>2011</td>
</tr>
<tr>
<td>WhaleSkull</td>
<td>2011</td>
</tr>
<tr>
<td>Vertabrae</td>
<td>2011</td>
</tr>
<tr>
<td>BaboonCluster</td>
<td>2011</td>
</tr>
<tr>
<td>Vervet Skull</td>
<td>2011</td>
</tr>
<tr>
<td>Goat Skull</td>
<td>2011</td>
</tr>
</tbody>
</table>

**Interactive Spaces/Pieces (PC Only):**

<table>
<thead>
<tr>
<th>Work</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>WhaleCairn sp a c.exe</td>
<td>2010</td>
</tr>
<tr>
<td>BirdGallery sp a c.exe</td>
<td>2010</td>
</tr>
<tr>
<td>BirdJade sp a c.exe</td>
<td>2011</td>
</tr>
</tbody>
</table>
All Unity engine executables are downloadable from: http://www.sculpt-forms.com/s-p-a-c-e-s.html

**VIDEO PROJECTION INSTALLATION**

Sphere Forms 01 (2010, 2 minutes, quick time movie)

Works in action (2009, looping video 2 minutes)

Various works (2011, video stills of rendered works, looping video 2 minutes)

**PRINTED WORKS (2D PRINTS)**

Sculptforms 01.1 exhibition booklet
Figure 47- Vervet Triclops (2011) -image: the author.
Figure 48 – Cow Skull Redux 0.01 (2009) [digital sculpture, video projection] - image: the author.
INTRODUCTION

In this appendix section I discuss a studio exercise undertaken in the early stages of my research, I document my initial explorations of virtual and physical sculptural processes. Through this exercise I consider the following: can I through my current working practices produce the same or similar results in both the physical and the digital? Can I produce a technically accurate piece? Can I produce a piece with artistic merit?

The studio exercise was a way of learning about the differences and similarities of the mediums. I will be using the findings of the exercises outlined in this essay to work out a process of eventually integrating the two mediums in my final projects. One of my objectives in my final research, is to cross the divide between virtual and actual mediums multiple times to build a better creative process. I will be using the terms actual as definition of physical sculptural work and virtual as referring to any work or exercise done using CG (Computer Graphics). I make use of the terminology with reference to Keith Browns artist’s statement: “My work embraces a wide range of digital activities, both virtual and actual. The main concern is with “Real Virtuality” or "Cyberealism" rather than “Virtual Reality”, reversing the order between the cyber and the real.”- Professor Keith Brown, Artists Statement, June 04 (http://www.artdes.mmu.ac.uk/profile/kbrown/projectdetails/1)

My eventual aims of my research work approach differs from Keith Brown in that I wish to eliminate the separation of Actual and Virtual and bring about a relationship between the mediums working back and forth between them.

I planned to use the Virtual and Actual mediums as a state of process in my workflow, not as two separate mediums. Use of tools and processes such as rapid Prototyping and 3D scanning in my future works as a part of my eventual outcomes of my final Masters dissertation.

My interest in working with the virtual and actual, stems from my professional practice of working in the virtual medium and a desire to return to working with the actual. For the last 11 years I have been working as a digital modeler collaborating with other artists and programmers in games production. I wanted to investigate the processes in the ‘virtual’ and ‘actual’, as well as document a comparison between the two mediums, ignoring polygonal software restrictions, professional interferences etc. and explore a self directed independent approach to creating 3 dimensional works. The studio exercises exampled in this essay are all a part of the process of finding a working artistic practice. In the essay I go through my current working process in the two mediums, going through my findings and eventual future applications in my conclusion.

DESCRIPTION OF SCULPTURAL EXERCISE.
The studio tasks were broken into the task of making a technically accurate bust of David Kassan. Kassan made a suitable subject for the bust as he has made painted self portraits from a variety of angles along with photographic which was taken as reference for a virtual bust.

<table>
<thead>
<tr>
<th>Actual materials:</th>
<th>Virtual materials:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lazy Susan</td>
<td>High end PC (1 gig of RAM)</td>
</tr>
<tr>
<td>Base armature, wire and paper</td>
<td>Wacom Tablet (Pressure sensitive stylus device).</td>
</tr>
<tr>
<td>Water containers</td>
<td>Software</td>
</tr>
<tr>
<td>Plastic bags (to keep the clay wet)</td>
<td>Maya 8.5</td>
</tr>
<tr>
<td>Pliers and sculpting tools</td>
<td>Mudbox 1.6</td>
</tr>
<tr>
<td>Water spray bottle and sponges</td>
<td></td>
</tr>
</tbody>
</table>

**Virtual – workflow process:** The virtual modeling workflow I adopted was a two stage process. Initially I started off with a pre-built 'base mesh', which I had used before in other Mudbox sculpts. The advantage of reusing a pre-built base mesh, aside from saving time, was that one can re-use the base mesh on a range of different character sculpts. (See Figure 1)

I then began refining the geometry in Maya, adding additional rows of polygons, blocking out the shape of the head, neck and shoulders. Once the blocking out was completed in Maya, it was then exported into Mudbox for final sculpting. The sculpting procedure in Mudbox was more organic than Maya. At the initial importing stage the mesh was set at a low level of resolution of level 0. However the final resolution my computer was comfortable with, was a level 4 subdivision, which was about 600 000 quadrangles. With any higher geometry resolution than 600 000 quadrangles my machine was unable to function properly.

My working process within Mudbox was to step through the different resolution levels. Levels of subdivision in Mudbox offer a way to increase the amount of detail a mesh can carry by increasing the number of vertices used to describe its surface. Blocking out my masses at the lower levels and refining details at the higher levels of resolution. The set palette of tools in the Mudbox user interface facilitates the pushing in, pulling out and flattening of areas of the mesh. My working process in the virtual is to also block out the major muscle groups of the face which although not visible in the reference, helped define the volumes of the face. (See Figure 4) These muscle groups are then softened out at the higher resolution levels. The final bust was then exported back into Maya for rendering using a realist lighting model to simulate what it would look like if it were to exist in the Actual. (See Figure 8) In retrospect my base mesh resolution was a little too high; if I continue to use this process I will start from a lower resolution base geometry, as that allows for more freedom and looseness in the adjusting of my masses at the lower resolution levels.

**Actual- workflow process:** Initially a crude armature of wire and paper trash was made; slabs of clay were then laid over the armature. (See Figure 4) Initially more clay was laid than needed for the final bust. I then moved onto working and removing pieces of clay was not needed. The paper based clay was a pleasure to
work with as it was smooth fine grained clay recommended for inexperienced sculptors. Part of the process was to step away from the bust, squint my eyes to see the basic form and shape. I additionally closing my eyes and feeling the volumes of the bust in order to get the correct proportions. This was partly because of bad lighting in the studio in the evenings but also because the act of sculpting was tactile as well as a visual medium.

I was working tentatively in the later as I was new to the medium of modeling in clay. It was at this point that I realized that I was not putting down the volumes of clay in the correct places. (See Figure5). In order to see which sections were incorrect and needed to be reworked and adjusted I then added the initial digital drawing studies as an overlay over the web log photographs. This process is one of the first steps of building a cycle relationship with the virtual in this case a two dimensional image and the actual. The final process was to add details and then allowing the clay to dry. I found that at the later stages, the clay had begun to harden too much, making re-adjusting of larges masses difficult. I may not have kept the clay moist enough. With clay dried the supporting armature was then removed from the bust. (See Figure 6)

During the process of creating the busts I have been keeping a Blog of my process and general daily notes- which I will keep up during my studies. This can be viewed here:

http://sculptforms.blogspot.com/

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COMPARATIVE ANALYSIS OF THE MEDIUMS

**Material differences:** The key difference between sculpting in actual and the virtual space is firstly the *physicality* of the process. Physical sculpting is defined by the tactility of the process, a feature entirely absent from virtual modeling. The process of creating this sculpture was not just about ‘seeing’ its development; it was about feeling the piece change and develop beneath the fingertips.

This tactile aspect of sculptural form is an important aspect of sculpture to me as both a maker and a viewer. When I view a sculptural work I often feel the need to touch it order to best ‘see’ it. When I have had the pleasure of touching a work such as Rodin’s *The Thinker*, I found the encounter with the work to be much more memorable and affecting. Touch was more direct medium of expression for me. I cannot do this in the current Mudbox software – it is immensely satisfying to feel one’s work.

Based on my studio investigations so far, I have observed the following distinctions between the physicality of virtual and actual sculpting:

- The lack of gravity in the virtual, there is no need for armature support on the Mudbox model.
- Working in the actual is physically harder work, again an obvious statement but not one I have had to deal with in my professional history.
- In the actual the material changes its state over time. Keeping the clay wet for reworking was an important part of the working process in the Actual.
• In the virtual one has scalable tools, but in the actual I had only set sizes for my tools, if I didn’t have a tool I had to make do with what I had at the nearest approximate size.

An advantage of the virtual was my familiarity with the medium, whereas I have a great deal to learn about the actual sculpting processes and mediums.

Process differences: The most immediate analogy that comes to mind when I started to work on the two busts on alternate evenings, was the concept of scale in the actual versus resolution in the virtual. Scale in the actual parallels resolution in the virtual. The larger I made the bust the easier it was for me to add detail, also the finer the clay the more detail I was able to work into the bust.

In the digital medium this concept equates to a higher resolution mesh, which then relies on my computer hardware.

I started with both versions of the bust simultaneously, but the virtual bust began to lag behind during the studio exercises. I found working on the actual (clay) bust initially more appealing as it was a tactile medium and it was a new medium that I had not worked with before.

Disadvantage of working in the actual and virtual.
• No undo button or “Control z”, when I made a mistake I would have to re-make that section of the sculpture.
• There is no symmetry or mirroring of actions on modeling tools in the Actual.
• The lack of freedom of view positions in the actual. In the virtual space one can rotate the camera view and see and work from any angle.
• My manual dexterity and co-ordination affects the final work in the actual. In the virtual there is already the buffer of the interface and the fact you are using a two dimensional medium to express a three dimensional object.
• In the Virtual the buffer of the interface stops one from making creative unexpected ‘mistakes’ which can then re-direct the work in an unexpected new direction, which will then stimulate additional creative ideas.

This preliminary investigation and analysis has caused me to reflect on the terms given to the creative process in virtual and actual contexts. Within the games studio environment, the virtual creative process is commonly referred to as ‘modeling’, while the manipulation of actual material is generally known as ‘sculpting’. In light of my study of the differences that relate to these different methods of production, I am forced to consider whether these distinctions can be used to critically differentiate the two modes of making. The analysis of this may form a useful terminology for considering the differences and similarities of the mediums as my study proceeds. The two processes can be defined as follows:
<table>
<thead>
<tr>
<th>Modeling (virtual)</th>
<th>Sculpting (actual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical</td>
<td>Physical</td>
</tr>
<tr>
<td>Objective and detached</td>
<td>Subjective</td>
</tr>
<tr>
<td>Rational, logical</td>
<td>Intuitive</td>
</tr>
<tr>
<td>Abstract</td>
<td>Tactile</td>
</tr>
<tr>
<td>Artificial</td>
<td>Authenticity</td>
</tr>
<tr>
<td>Product based</td>
<td>Value (has value)</td>
</tr>
<tr>
<td>Mass reproducible</td>
<td>Is non – reproducible, except with change.</td>
</tr>
<tr>
<td>Flawless, without error</td>
<td>Intentionally flawed, abstracted</td>
</tr>
</tbody>
</table>
CONCLUSION

My initial intention was to reach the same visual result with the actual and virtual. By the end of my current working practice, the resulting pieces were very different. When I lay the same digital drawing over both pieces, it was then that I realized how different they had become. (See Figure 2 and Figure 5)

The virtual piece was a technically more accurate representation of Kassan, while the actual bust had become stylized and cartoonish. (See Figure 6) As I worked through the exercises I had become locked on the ideal of a technical representation of Kassan. Although there were moments in the production of the actual and virtual in the initial laying of form when the bust was more abstracted and artistic in nature, it was in the subsequent reworking and finishing off of the bust that I had lost that element of creativity and artistry. The end results were similar only in the fact that I had produced two busts - they looked quite different because of texture, materials, and facial proportions and lighting. (See figure 7).

My main intention of my long term research is to produce a hybrid process using both actual and virtual, through crossing and re-crossing between the two mediums. The processes in this studio exercise have given rise to many distinctions between the two busts which all tend to emerge from the different physical conditions that are relevant to each medium.

Further exploring these similarities and differences will form the basis of my future research into the possibility of synthesis between the two forms: virtual and actual.
This is the end result of the same base mesh as used in the studio exercise.

Appendix C Figure 49 – Roman style bust – digital sculpture done in Mudbox, Image courtesy of the author.
Appendix Figure 50 - Working view of Mudbox interface with reference image and draw over on screen grab.

Appendix C Figure 51 – work in progress of cg (virtual) sculpture.
Appendix C Figure 52 - Work in progress with physical (actual) bust sculpture.

Appendix C Figure 53 – Later work in progress with drawn over proportional corrections.
Appendix C Figure 54 – Final physical model.

Appendix C Figure 55 – Digital and physical models.
Appendix C Figure 56- Final digital model.