Made By Motion:
a Conceptual Framework for Abstracted Animation Derived from Motion-Captured Movements

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Abstract

Outside the realm of feature films, smaller creative collectives and individual animators are currently exploring the creative applications of motion capture technology to develop compelling and unique abstract animated shorts that are receiving acclaim from the wider arts community. However, despite an increasing number of acclaimed examples, there has been little detailed documentation of this practice and the processes involved in this format of animation production. More specifically, there has been little documentation and analysis of the key considerations and issues that might confront practitioners when integrating motion capture movement data into their abstract animation practice. As such, a more developed understanding of approaches to incorporating motion capture technologies into the field of abstract animation is called for. This study emerges at the intersection of three key areas of knowledge: motion capture, abstract animation and computational generative art. Through practice-led research, the outcomes of this study—outlined and theorised within this exegesis—contribute to closing this emergent gap by exploring and documenting possible strategies and approaches for generating elements that compose abstract animated short films from captured dance movements. This study has resulted in a possible framework for this type of practice and outlines five key considerations: *capture of human movement*, *retention of human form and movement*, *influence of the simulation*, *influence of the virtual environment* and *visual connection to practice,* which should be taken into account by practitioners who use motion capture in the production of abstract animated short films.

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Statement of Original Authorship

The work contained in this thesis 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 thesis contains no material previously published or written by another person except where due reference is made.

QUT Verified Signature

Signature:

Date: _______09/06/2015___________

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CHAPTER 1: INTRODUCTION AND BACKGROUND

> Animation has always embraced new technologies and sought out ways in which new tools might facilitate new outcomes. (Wells & Hardstaff, 2008, p. 16)

As suggested in the above quote by Paul Wells and Johnny Hardstaff (2008) from their book *Re-Imagining Animation: The Changing Face of the Moving Image,* the development of animation throughout history has always been intertwined with technology and this has led to a number of advancements within the screen-based arts. For example, the rotoscope technique, which the Fleischer brothers developed as early as 1917, facilitated the extraction of motion from captured performance by allowing animators to trace over film frame-by-frame and, thus, fuelled the desire of animators to capture and make further use of "real life" movements. Furthermore, this desire was also prevalent in experiments undertaken at Disney Studios in 1964, where they developed technology that allowed human motion to be recorded and applied to the audio animatronic puppets at Disneyland's various attractions (Sito, 2013). These precursors to modern motion capture seem crude but they provided the technological base upon which contemporary animation, games and visual effects are now building.

In recent years, motion capture technologies have been used prolifically across a wide range of industries from the entertainment and medical professions to the military. Arguably, motion capture's biggest impact is in the film and games industries. The Hollywood motion picture *Avatar* (Cameron, 2009) and the popular game title *Ryse: Son of Rome* (2013) are two prominent examples of this technology's mainstream application, where detailed performances are captured and retargeted onto a digital character. Outside of the realm of feature film, smaller creative collectives and individual animators are currently exploring the creative applications of motion capture technology, along with the captured human movement data to produce abstract animated short films (hereafter referred to interchangeably as abstract animated shorts). The focus of this practice-led research project was the use of motion-captured human movement data to create the visual elements or artefacts that compose these abstract animated shorts.

Although discussed in more depth in the contextual review, abstract animation can be defined as being non-narrative, non-diegetic and non-character driven animation (Furniss, 1998) that is predominantly concerned with movement, form and aesthetics (Wells 1998). The boundaries of abstract animation sometimes blur with what Wells (1998) defines as *experimental animation*; that is, a site where animators commonly experiment with form, aesthetics and technology to discover how these aspects of animated production can facilitate new methods of practice and new outcomes (Wells & Hardstaff, 2008). In recent years, these experiments with motion capture to develop non-narrative forms have resulted in the generation of compelling and unique abstract animated shorts that are receiving acclaim from the wider arts community. One such example is an animation by Universal Everything, a multidisciplinary studio whose clients have included MTV, Nike, Intel and Hyundai and that was recently awarded a prestigious Golden Nica at the 2014 Prix Ars Electronica awards. The studio has created a number of abstract animated shorts using captured human movements, with a recent example being a project titled *Tai*

Chi (2012). The production of *Tai Chi* made use of the motion-captured movements of a Tai Chi Master to generate a number of animated abstract visual artefacts referred to as "fragmented digital sculptures" (Pyke, n.d., para. 2), as displayed in Figure 1 below.

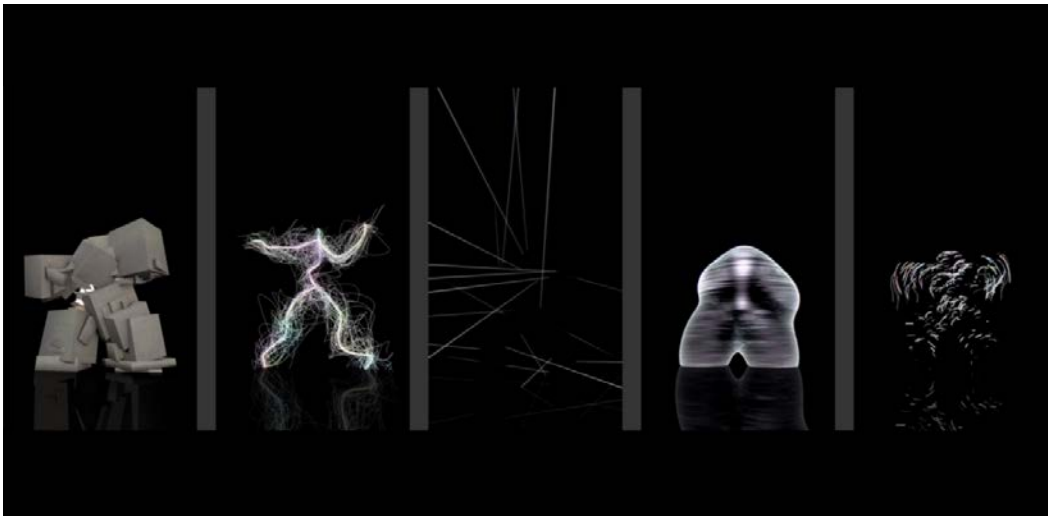

Figure 1. Images of *Tai Chi* (Universal Everything, 2012)

Another recent work is *unnamed soundsculpture,* which received an Honorary Mention at Prix Ars Electronica in 2012. *Unnamed soundsculpture* is an abstract animated short film by Daniel Franke and Cedric Kiefer that was created from captured dance movements recorded using three Xbox Kinects as a form of full-body motion capture. Through the creative process, the captured movement was turned into an animated artefact composed of a 3D point cloud that would display as an abstracted human form and then proceed to fall and scatter on the ground like sand (Visnjic, n.d.), as displayed in Figure 2 below.

Figure 2. Still from *unnamed soundsculpture* (Franke & Kiefer, 2012)

However, despite an increasing number of acclaimed examples of animators turning to motion capture to produce abstract animation, to date there has been little detailed documentation of this practice and the processes involved in this format of animation production. More specifically, there has been little documentation and analysis of the key considerations and issues that might confront practitioners when integrating motion capture movement data into their abstract animation practice. These issues centre on finding a balance between the influence of the captured human movements and the influence of the computational simulations used to generate the visual components of an abstract animation. With the animator having to consider many factors including the setup and use of the motion capture system, what movement data is selected to be used to generate visual artefacts, the settings and processes of the computational simulation system used in creating the visual artefact and 'how' the captured movement is displayed to the viewer which affects the visual artefact being created and how it is perceived. In the case of the two examples outlined above, although some of the production processes (e.g., controlling the movements of a digital character) by retargeting motion-captured movements onto its control rig and generating a particle point cloud or object from, or as the digital skin of the character, are publicly accessible for other animaters working in the field, there is a lack of a defined and systematic conceptual framework that articulates the processes involved and, more importantly, the possible key considerations and issues that emerge for practitioners when working with motion capture in the creation of abstract animation. As such, there is a need for the development of a framework that outlines these key considerations along with possible strategies for the creation of abstract animation using motion capture.

Research Question

The central research questions driving this research are:

How can motion-captured movement data be incorporated into the practice of creating visual elements or artefacts that comprise abstract animated shorts films? More specifically, what are an abstract animator's key areas of consideration in terms of finding a balance between abstraction and the original human form or movement through the computational process? In particular, how does this inform how an abstract animator can react to the data? In addition, can a conceptual framework be developed from the findings of the practice?

To investigate the research questions, three abstract animated short films were produced between mid-2012 and late 2013. Each production made use of motion-captured movement data acquired during two capture sessions conducted at Queensland University of Technology, Brisbane, Australia.

This practice-led research project, therefore, comprises a creative component and a written exegesis. The creative practice is weighted at 65% of the project and consists of the production of three abstract animated short films that constitute an enquiry through practice into strategies for the animated abstract forms derived from motion-captured dance performances. The written exegesis, weighted at 35%, outlines and theorises the practice, and proposes a conceptual framework for the production of animated abstract forms based on motion-captured dance movements. The exegesis also situates the practice within three related fields of animation practice and related bodies of knowledge: motion capture, experimental animation and computational generative art.

The final outcome of this investigation is presented as a single artefact composed of three abstract animated short films embedded within the written exegesis. The written exegetical component and abstract animated short films are interconnected aspects of this study and should be viewed together. It is suggested, therefore, that this document be read in its electronic format with an active internet connection to enable viewing the embedded videos and accessing further hyperlinked sources. If this is not possible, then a copy of each of the creative works has been included on the attached flash drive.

The outcomes of this research contribute to knowledge in the field of abstract animation and will be significant for creative practitioners wanting to engage with the use of motion-captured human movements to produce abstract animation.

Methodology

This practice-led research project emerged from my ongoing involvement in the field of animation since 2007. Over the past eight years, I have worked professionally as a freelance animator, creating an eclectic range of animated, static and real-time works. In an academic context, I also teach 3D, visual effects, animation and motion capture. Over the course of my teaching and practice I have come to view technology and software as a "creative tool" akin to a paintbrush or pencil—just more complex—and like many creative practitioners, a key part of my work is experimenting with new creative tools as a means to discover what new applications and outcomes might be possible. Therefore, when Queensland University of Technology's Film, Screen and Animation discipline acquired its first professional-grade motion capture system in 2012, I saw this as an opportunity to experiment, from my perspective, with a 'new' technology (having never physically used a high-grade motion capture system but already being aware of the processes and applications of the technology).

Practice-led research

This study adopted a practice-led approach based on that presented by Carole Gray (1996), who defines practice-led research as a form of 'naturalistic inquiry' that embeds the researcher firmly within the research process and positions the emergence of problems, questions and challenges as occurring within the creative practice itself. Adopting a practice-led approach to research is further advocated by Paul Wells and Johnny Hardstaff, who describe this approach to research as an opportunity for "practitioners to theorise their approach through practice, and practice through their theoretically determined outlooks" (Wells & Hardstaff, 2008, p. 147). Furthermore, Gray states that practice-led research "…is carried out through practice, using predominantly methodologies and specific methods familiar to us as practitioners in the visual arts" (Gray, 1996, p. 3). This study is positioned within the larger field of animation studies, where practitioners commonly conduct practice-led research through the production of animated short films. This can be evidenced in the introduction to Jayne Pilling's (2001) book *Animation 2D and Beyond*, where she highlights the engagement of short animated film production as a common approach to conducting research by stating that "…shorts are often seen as the 'research and development' branch of the industry; a test-bed for new ideas, approaches, styles and techniques" (Pilling, 2001, p. 7). This research and development is often undertaken as an exploration of how a new technology can facilitate new forms and modes of practice, resulting in new outcomes (Wells & Hardstaff, 2008). An example of research and experimentation through the medium of animated short film is illustrated by the technical innovations of John Lasseter and Alvy Ray Smith in the production of *The Adventures of André and Wally B.* (1984), which Smith (1984) describes as a ground-breaking CGI film.

Epistemologically, this approach to research aligns with Denzin and Lincoln's (2000) definition of qualitative research by taking a constructivist approach in exploring and developing new knowledge of abstract animation practices that involve motion capture technology. This practice-led research project achieves this through first-hand experience and observation of strategies used to produce the animated visual artefacts for three abstract animated short films. To provide a structured approach to the practice-led research methodology, the production of the abstract animated short films emerged from a series of action research cycles. Kurt Lewin (1952) describes action research as a “spiralling cyclical process that included planning, execution and reconnaissance” (Mills, 2011, p. 14) this is also how it is commonly depicted in the widely used action research spiral created by Stephen Kemmis in 1988 (Mills, 2011). However, in his seminal work, *The Reflective Practitioner: How Professionals Think in Action*, Donald Schön states that “when a practitioner becomes a researcher into his own practice, he engages in a continuing process of self-education” (Schön, 1983, p. 299). This explanation of action research, which is widely accepted in fine arts research, is more closely aligned to this research study. Schön also proposes the concept of gaining new knowledge about methods and strategies ingrained in the practice through reflecting on and reflecting in action. His method “attempts to unite research and practice, thought and action into a framework for inquiry which involves practice, and which acknowledges the particular and special knowledge of the practitioner” (Gray & Malins, 2004, p. 39). Incorporating reflective practice into the methodology shifts the role of the researcher from that of a positivist approach, where the researcher is an outside observer, to being an active participant within the research and, thus, affecting what is being investigated. This method acknowledges the interaction between the researcher and research material, with the result being personal construction by the “practitioner-researcher” and the generation of new knowledge in a context-bound intersubjective “real-world” state (Gray & Malins, 2004).

As mentioned above, Schön proposes two fundamentally different approaches to action research: *reflection in* and *reflection on* action. *Reflection in* action requires the researcher to actively reflect on the situation while it is occurring. The researcher then makes changes to the situation based on the “real-time” reflections to improve the outcome. In contrast, *reflection on* action occurs after each action has been completed and is normally completed by the practitioner in a systematic and deliberate review aimed at informing and improving new creative outcomes (Schön, 1995).

The methodology for this research involves both practice-led and action research methodologies and makes use of reflective practice across a series of action research cycles in the form of three abstract animated short films. This method provides a means for the discovery of new knowledge about abstract animation practices that involve motion-captured movements through a research paradigm that is epistemologically constructive and ontologically subjective.

Research Design

Iterative cycles of practice

To facilitate the evolution of the creative component and to ensure that new questions, problems and challenges result from the production of each short film, the research project consisted of three iterative cycles of practice, which follows Kemmis and McTaggart’s (1988) action research model (referred to as the Kemmis–McTaggart Action Research Model). As illustrated in Figure 3, this method involves four phases: developing a plan, actioning the plan, observing the effects of the action and reflecting on these effects (Kemmis & McTaggart, 1988).

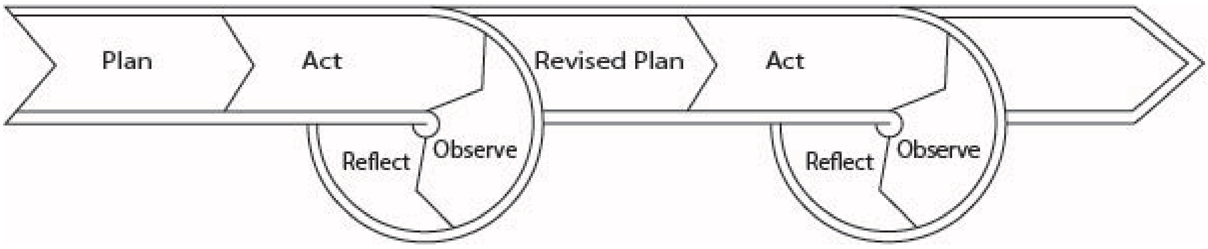

Figure 3. Kemmis−McTaggart action research model (Kemmis & McTaggart, 1988)

Each cycle of practice constituted the production of an abstract animated short film and coincided with the segmented approach normally undertaken during short film production: pre-production, production and post-production (Kerlow, 2009). The design of this research intertwines the general phases of short film production with the phases of the presented model of action research cycles by positing the development of a plan for the cycle within the pre-production phase, the actioning of the plan and the observing of practice within the production phase and the reflection on outcomes and observations made during production within the post-production phase. As illustrated in Figure 4 below, each research cycle revolved around the following conceptual design:

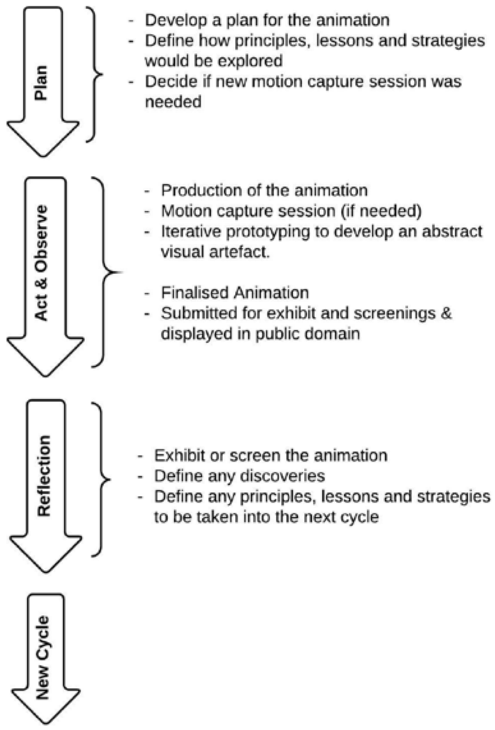

Figure 4. Conceptual design of the research cycles

The pre-production phase defines the approaches or strategies to be implemented during production that will develop new knowledge of methods for creating abstract animated forms, and also defines whether new motion data is needed for the production. The planning undertaken during the pre-production drew on the cumulative knowledge generated by the previous cycles along with insights drawn from the contextualisation of practice undertaken during this study. The plan would fall short of developing a completely clear picture of the final outcome, mostly because until the visual form was generated during production only a general aesthetic direction could be defined. This also allowed for a degree of spontaneity within the production, meaning that the “happy accidents” that occurred during and as a result of the experimenting with new approaches and strategies for creating abstract animation could be followed and explored. The outcome of the planning was a written artist statement that described the proposed abstract animated short film and was used to apply for peer-reviewed exhibitions and screening locations during the post-production phase. This added validity to the abstract animated short films and assisted the reflective process of the research cycles. The pre-production or planning phase of the research cycle meant that each short film responded to clear objectives and a plan of investigation, which cumulatively augmented my knowledge about motion capture based abstract animated shorts and refined the practice over the course of the study.

The objective of the first abstract animated short film, *Experiment One,* was to create an abstract animation that mimics the mainstream trends of abstract animation using motion-captured human movements. The purpose of this iteration was to develop a clear understanding of the motion capture system and processes for performance capture, and to establish a software pipeline to handle motion data.

The second abstract animated short film, *Experiment Two*, attempted to create an abstract animation that diverges from mainstream trends by not using full-body motion-captured data. The purpose of this cycle was to explore the motion data itself and how individual points of data might be used to generate abstract artefacts.

The objective of the third abstract animated short film, *Contours in Motion*, was to create another animation that transforms the captured movements and forces of a dancer into an abstract visual artefact that goes beyond simple abstract data visualisation. The purpose of this cycle was to explore the repurposing of generative art theories into this study.

The production phase captured the movements of a professional dance performer using motion capture technology and created the visual elements for the short film from the resulting movement data. The main focus of this phase was the application of the strategies and approaches for creating animated abstract forms from captured human movements and observing the effects on the practice and the outcomes. This action, undertaken during the production phase, forms the main part of this study; that is, the observations made during the production phase needed to be captured and retained, which occurred in a number of formats. The motion capture sessions were documented using video and audio captured from normally two cameras, with still pictures taken of any key aspects. Written notes were also taken and the movement data files captured by the motion capture system were also defined as a format of documentation. Similarly, during the creation of the abstract visual forms, written notes were taken both of the technical process, creative observations and outcomes of tests and experiments, which were enhanced using screen captures of the in-software processes. All versions of the digital processes (such as working within the 3D software package) were indexed as incremental versions of the digital working files. During the production phase, a number of smaller tests and experiments were also undertaken that completed the cycle of practice. These smaller tests engaged with the finer nuances of the strategies and approaches implemented in the production phase and were used to refine the final abstract animated short film.

The post-production phase was used to reflect on and review the outcomes and actions undertaken during the production phase. Ultimately, this phase helped draw out how implementing the strategies and approaches – that were outlined in the pre-production phase – impacted upon the creation of a short film using motion-captured dance movements. The knowledge generated through the reflective practice undertaken within the post-production phase added to the new knowledge accumulated from the previous cycles of practice, which, along with learning and insights drawn from the contextualisation process of my practice, was then used to influence the starting point and the approach taken in the next cycle of practice. During this phase, the final abstract animated short films produced through the cycle of practice were screened or exhibited. This not only added validity to the creative work but also assisted the review and reflection processes during each research cycle.

Working as an individual animator and the decision to capture dance movement

Unlike the abstract animated short films outlined in the introduction of this document and those detailed in the contextual review, which were all constructed using a team of creative professionals, the short films of interest in this study were all created by myself as the single creative practitioner. Therefore, each aspect of the creative processes was conducted by me, with the exception of the dance performances. This limited the scope of film production to be primarily concerned with the creation of a single abstract animated visual form from the captured dance movements. The decision to focus on dance movements was made for two reasons. At the commencement of this project, I was introduced to Elise May, an award-winning professional dancer, choreographer and multimedia artist, who was looking to collaborate on creative projects for her own research. This presented an opportunity to work with a professional whose main focus is human movement and performance, and to gain access to creative and innovative performances on which to base my animation works. The second reason was to continue the long tradition of interdisciplinary collaboration between dance and animation, as seen in Lee Harrison's animation *The Stick Man* (1967), which used an early version of a motion capture suit, called the "Waldo Suit" (Sito, 2013). The rotoscope technique was first used to "capture" one of the brother's dance movements.

Figure 5. Experiment 1, displayed at The Block, QUT Kelvin Grove (Ignite Postgraduate Conference, 2012)

Exhibition of the study's animated shorts

The outcomes from the first and second cycles of practice, *Experiment One* (2012) and *Experiment Two* (2012), were exhibited at Ignite12! Crossing the Line, a postgraduate conference held at the Queensland University of Technology, Kelvin Grove between 31 October and 2 November 2012. The outcome from the third cycle of practice formed a series of abstract animated shorts titled *Contours in Motion* (2013). The first prototypes in the series screened at the Melbourne Fringe Festival as part of "Digital Creatures" between 18 September and 6 October 2013. A full exhibit of the entire series was later conducted between 22 and 24 November 2013 at Metro Arts in Brisbane, Australia, as part of Supascreen, an exhibition of expanded and experimental screen works. Some of the smaller iterative prototypes were also displayed at the conference Ignite13! Illuminating Futures on 3 October 2013 under the title *Made by motion*, *Series one*.

Study Structure

As discussed at the beginning of this chapter, this study was undertaken through the production of three abstract animated short films. These creative components of the research are intrinsically connected to the written word of this exegetical document; therefore, both are presented here and should be viewed as a single artefact. This following section outlines the remaining structure of this artefact.

Having already defined the research questions and methodological approach in Chapter 1, Chapter 2 continues by establishing a context for my practice-led research through the investigation of three key abstract animated short films that use motion-captured human movements. Further contextualisation is generating by establishing an understanding of the practice undertaken during this research through overviewing the three key conceptual domains that underpin this research project. Next, Chapter 3 covers the results and analysis of the abstract animation practice conducted during this study through three action research cycles that investigate the research questions outlined in Chapter 1. The three abstract animated shorts that comprise the creative artefact resulting from this practice-led research are embedded within Chapter 3 and presented in mp4 video format. These films are also accessible through the hyperlinks and the accompanying digital files. Not to be confused with these abstract animated short films are a number of smaller experiments also presented within this chapter and are either embedded through web links to online videos or contained within the Appendix of this study. Finally, Chapter 4 concludes the study by discussing contributions to the body of knowledge and synthesising the key findings from the cycles of practice outlined in Chapter 3. Chapter 4 also defines the key considerations and issues for practitioners when working with motion-captured movement data to create abstract animated short films. This final chapter also outlines areas that warrant further research.

CHAPTER 2: CONTEXTUAL REVIEW

> Ultimately, outside the hierarchical studio project, or the established production pipeline, which have very clearly designated roles and functions, animation remains a highly specific model of expression, profoundly determined by the practice defined by the animator or artist (Wells & Hardstaff, 2008, p. 148).

This research project engages with animation practice through an approach that reflects an artistic study of form and motion. This largely experimental approach does not adhere to the conventional forms and rigid structures of the standardised animation studio model and, as stated by Wells and Hardstaff (2008) above, relies on the artist or animator to define "what the animation is" through defining what the practice itself is. In this fashion, this chapter establishes a context for my practice-led research by building an understanding of the practice undertaken in this research through first overviewing the three key conceptual domains—motion capture, generative art and experimental animation—that underpin this research project. This chapter concludes with an overview of three key creative works within the field of practice. This further contextualises the research and also forms a starting point for my own practice, which is discussed in Chapter 3.

Motion Capture

Motion capture involves the recording of an object's orientation and position within a physical volume. The resulting movement data is often used to animate virtual characters or objects within a virtual environment created using 3D software packages. This mainstream application of motion capture can be seen in the creation of the character “Gollum” in the *Lord of the Rings* trilogy (2001, 2002, 2003) and, more recently, *The Hobbit* trilogy (2012, 2013, 2014). James Cameron’s film *Avatar* (2009) is also well known for its application of motion capture in the larger field of virtual production.

However, objects that can be captured are not limited to human bodies, but can include any object living or inanimate including finer movements, such as facial expressions (Dyer, Martin & Zulauf, 1995). An example of non-human capture can be seen in the Tooheys Extra Dry *Nocturnal Migration* television advertisement, where Deakin Motion Lab motion-captured a single deer. The captured movement was later used to animate a large number of virtual deer for the advertisement (Deakin Motion Lab, 2011). This type of functionality and versatility is achieved by adapting the hardware and the software of the capture technology for almost any arrangement, thus offering a nearly endless list of possible data sources for creative practitioners.

Motion capture technology

There are several forms of motion capture technology: mechanical, magnetic, optical and inertial. This section overviews the optical and inertial systems, the most widely used in the industry.

Optical motion capture uses an array of high-speed cameras positioned and calibrated to form an area known as the capture volume. Within the volume, cameras track reflective markers positioned on the surface of the object being captured. The size of the capture volume and the number of objects that can be captured at any given time is limited by the resolution and number of cameras within the array (Carter, Van Opdenbosch & Bennett, 2013).

Figure 6. Optical motion capture system temporary setup at QUT

Optical motion capture offers a high degree of versatility in what objects can be captured so that practitioners can quickly and inexpensively position reflective markers in any arrangement needed. The downfall of optical systems is the lack of portability stemming from the fixed capture volume and the time taken to set up the system. In addition, if enough reflective markers are obscured from the cameras' fields of view or cannot be distinguished due to unfavourable lighting conditions, then the data capture can be interrupted, which results in data that requires further "clean up" in the post-production phase.

Inertial-based motion capture systems use a hierarchy of miniature inertial sensors positioned on the surface of the object to be captured, normally as a suit the performer wears. Once calibrated, these sensors transmit changes in position, rotation and acceleration wirelessly back to a receiver, where it is computed and recorded (Carter, Van Opdenbosch & Bennett, 2013).

Figure 7. Inertial motion capture system being used at QUT

This system is highly portable and does not need an array of cameras to perform the capture. However, the capture of non-human forms requires extensive and often expensive reconfiguration of the suit, with additional suits needed to capture more than one performer at a time. The sensors are affected by high impact forces and can be “knocked out”, effectively rendering the suit’s network ineffective until the damage is fixed or the sensor replaced. The non-optical nature of the system also means it is not affected by sensors being obscured and can effectively capture movement through most objects. The setup and capture is quick and can be performed in almost any location. For example, this type of system has been used to motion capture skydivers and downhill skiers.

Capture process

In motion capture, the placement of the sensors or reflectors and cameras (for an optical system) along with the process of calibration, defines (for the software) the form to be captured and enables the recording of positional changes of the form’s segments along with its overall position within a virtual environment. Through preliminary research conducted at QUT, a best practice model was developed for the Xsens MVN Inertial Motion Capture System, as displayed in Figure 8.

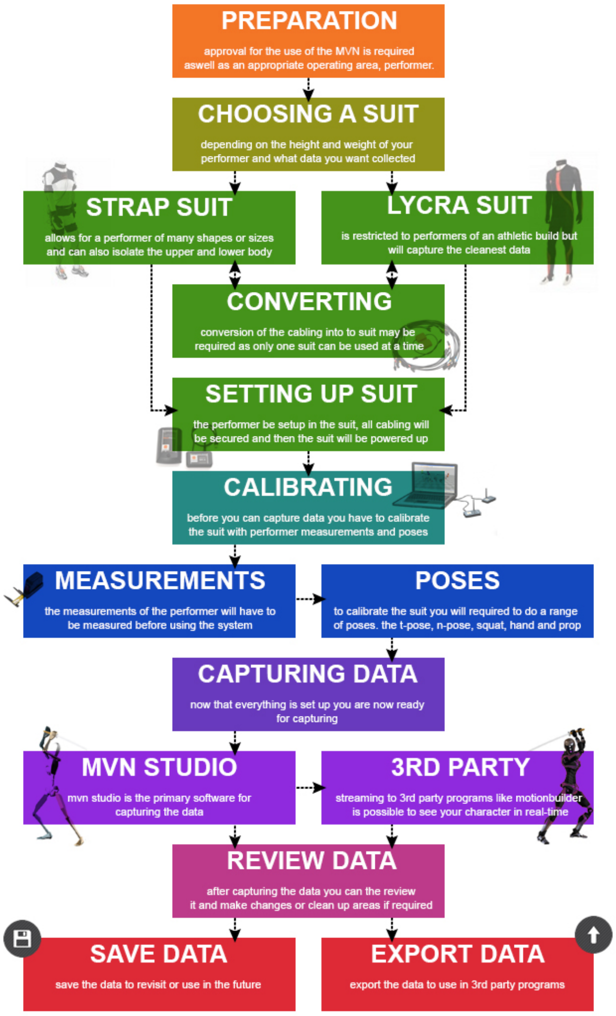

Figure 8. System workflow (Carter, Van Opdenbosch & Bennett, 2013)

This process starts with the preparation phase, where the “what and where” of the capture is determined. This is largely centred on a safe location for the performer as well as the system (as outlined before the sensors can be damaged if enough force is applied). As the MVN Studio system has two variants of the same technology (straps and a full spandex suit), the next phase involves selecting the type of suit. The system takes time to convert from one format to another; however, either approach requires the system to be set up on the performer as noted in the next phase: "setting up the suit". Once the system is set up, the calibration process is undertaken to define for the system the range of movement and dimensions of the capture subject. This process normally requires measuring specific body segments and performing a number of predefined poses. Once calibration is completed, the movement can be recorded by the pre-packaged software MVN Studio. The movement can also be streamed to third-party software, such as Autodesk Motion Builder, where it can be animated onto a character in real-time. While the capture is in progress, or after it has been completed, the movement can be reviewed in its digital form through an avatar present within the software. At this point, the data can be manipulated or "cleaned up" and/or saved and exported for use in other third-party software packages.

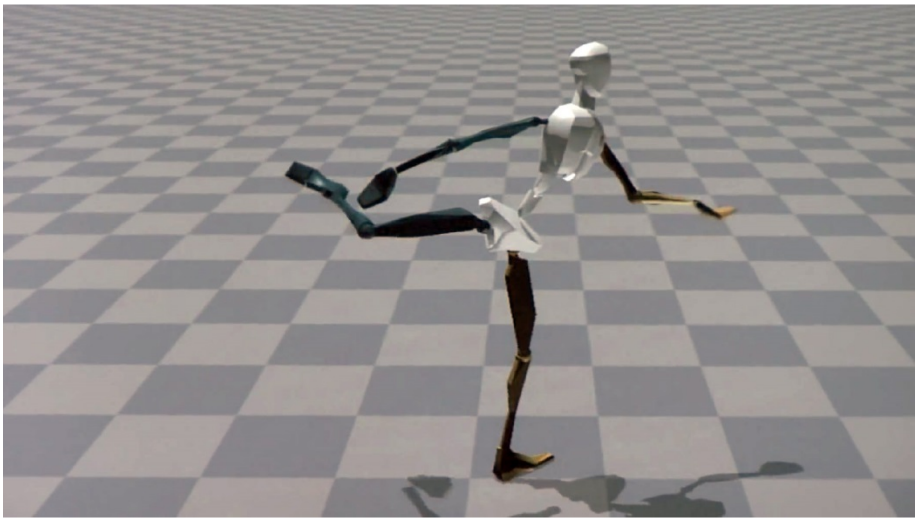

Figure 9. Avatar within the software MVN Studio

Expanding on the motion capture workflow outlined in Figure 8, a general workflow for using motion capture data would also include retargeting the motion capture onto a virtual character, which is normally done within the third-party software package that data are imported into. Once retargeted, an additional clean-up process, where further adjustments are made to the captured data, would take place, usually to conform the movement to the morphology of the virtual character. At this point, extra animations might also be added to the captured motion, such as hands, feet and facial animations, as a number of these systems do not record such details within larger volumes. Non-anthropomorphic features, such as tails and wings, also need to be added. Depending on the details of the production process, these additional animations may occur as part of the production or the character might be exported for use in another software package or by another creative professional working on the production.

Generative Art

An increasing number of practitioners across diverse creative fields such as music, visual art, robotics and animation, among many others, are using computational generative techniques within their creative process to create visual artworks. This diversity in use and application has led to the emergence of various subsets within the larger field of generative art, such as generative computer art and generative animation. These subcategories are normally defined according to methodologies, media or approaches used in the artistic activity (McCormack, 2012). A key paper that develops a detailed definition of generative art and helped frame generative art within the context of my practice and research cycles, is Philip Galanter's *What is Generative Art? Complexity Theory as a Context for Art Theory* (2003). For Galanter (2003, p. 4), generative art can be understood as "art (that) refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy, contributing to or resulting in a completed work of art". Simplifying this even further, McCormack (2014, p. 2) argues that "all generative art focuses on the process by which an artwork is made and this is required to have a degree of autonomy and independence from the artist who defines it". Although they suit the practice of this research project, these widely bandied definitions of generative art do not detail aspects of the generative systems used in the creative process. To further characterise the structure of a generative art system, Dorin et al. (2012), in their journal article "A Framework for Understanding Generative Art", define generative art as having the following elements: *entities*, *processes*, *environmental interaction* and *sensory outcomes*. *Entities* are normally singular objects with definable attributes that are crucial to the generative process. *Entities* can exist in structured or hierarchical relationships with other entities and can be physical, digital, conceptual or simulated (p. 244). *Processes* enact change within a generative system by performing operations on or facilitating the interaction between entities. *Processes* can be physical, computational, under human control or a combination operating collectively. More detailed descriptions of the processes usually depend on the type of generative system being used (p. 245). *Environmental interaction* describes the flow of information between processes, along with the environment this communication takes place in. These interactions can be detailed by the frequency, range and significance of the interactions within the generative system (p. 246). *Sensory outcomes* are the results from a generative system and can be considered as artefacts, visual or audible objects formed by the user. How viewers experience the work is determined not only by the format of display but by how much of the generative system is revealed (p. 247).

As such, it can be argued that generative art focuses on the use of a system that is composed of autonomous entities and processes connected through environmental interactions to produce sensory outcome from seed data. However, generative art theories are predominately concerned with the “act” or the “how” of the creative process and do not accurately describe the outcomes from practice or the motivations for undertaking the production of a creative work. As McCormack (2012, p. 2) argues, “generative art is understood primarily as a methodology, with little, if anything, to say about the art itself or the motivations of its practitioners”.

It is worth highlighting that the practice undertaken during this study could be defined as generative animation (a subsection of generative art) due to the use of dynamic simulations (a computational system) that runs independently once the motion data is introduced. The presented theories about generative art practice are applied or repurposed during this study as a means to understand aspects of the practice and not as an attempt to define the practice as generative art.

Abstract and Experimental Animation

Abstract animation is a highly experimental sub-genre of animation, where an intersection of practice and new technologies often takes place. This mode of enquiry into practice has a long history of facilitating new forms and modes of practice, resulting in new outcomes (Wells & Hardstaff, 2008). The practice of Mary Ellen Bute and John Whitney during the 1950s and 1960s, which explored the use of oscilloscopes as a tool to create animations, is an early example of experimentation with technology within the genre of abstract animation. John Whitney, Sr. would later become the first artist-in-residence at IBM to experiment with IBM computer equipment to creating *Arabesque* (1975), now referred to as “a triumph of vector graphics and oscillation” (Sito, 2013, p. 29). This legacy of exploring animation through technology and developing technology through animation has continued into current times and is evidenced by the technical innovations of John Lasseter and Alvy Ray Smith for the production of *The Adventures of André and Wally B.* (1984), which Smith (1984) describes as a ground-breaking CGI film, and the more recent advancements of virtual production used for the animated visual effects sequences in James Cameron's film *Avatar* (2009).

However, just because an animated work engages with new technology or results in new technical innovations, does not mean it can be classified as an abstract animation. As Maureen Furniss (1998, p. 252) argues:

> In abstract animation there are no characters with which to identify, there is no diegesis to transport the viewer to a different time and place and, when the animation is over, the viewer does not have a complete 'understanding' of its meaning as he or she would with a closed narrative structure.

In spite of their experiments with 3D graphics technology, which resulted in a number of technical innovations, works such as Pixar's *Toy Story* (1995)—acknowledged as the first CGI feature film (Paik, 2007)—cannot be classified as abstract animation due to their clearly character-based narrative structure. Paul Wells (1998, p. 8) expands upon Furniss's argument by situating "non-objective, non-linear or abstract films as experimental animation". As illustrated in Figure 10, Wells divides animation styles into two extremes: orthodox and experimental. A third section, developmental animation, incorporates elements of each.

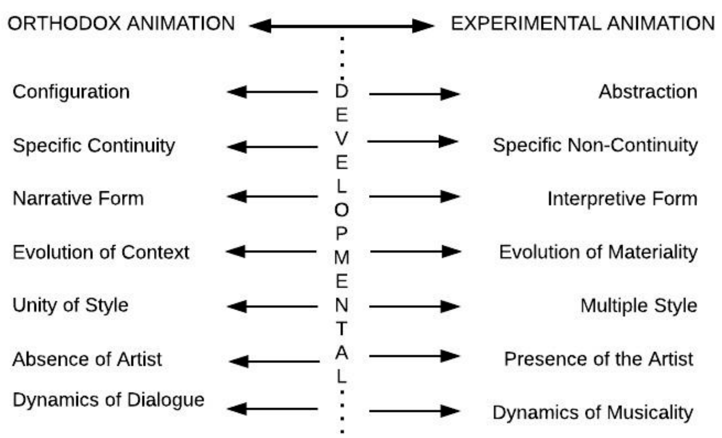

Figure 10. Orthodox animation vs. experimental animation (Wells, 1998, p. 36)

To paraphrase Wells (1998), "orthodox animation" has a clear character-driven narrative structure presented in a uniform style that makes use of dialogue and normally is produced by a number of artists. The mainstream commercial works produced by Disney and Pixar would be considered orthodox animation. Conversely, experimental animation resists the structure of orthodox animation by incorporating multiple styles and abstract forms without a discernible narrative structure, leaving the interpretation of the work up to the viewer (Wells, 1998). Len Lye's films *A Colour Box* (1935) and *Free Radicals* (1979), along with Norman McLaren's film *Synchromy* (1971), which experimented in animated sound, could be considered experimental animation.

The abstract animated short films created during this research project are more along the lines of Wells's definition of experimental animation than orthodox animation. For Wells (1998), experimental animation is composed of the following key elements: *abstraction*, *specific non-continuity*, *interpretive forms*, *evolution of materiality*, *multiple styles*, *presence of the artist* and *dynamics of musicality*. *Abstraction* defines the use of various shapes and forms in place of illustrative images and figures. This shifts the focus of creating rhythm and movement away from a particular character and back to the concern of the animation itself (p. 43). *Specific non-continuity* describes the divergence from retaining continuity within mainstream forms of animation. This brings out the specific vocabulary of the particular animation in question through defining its own form, conditions and uses as a distinctive language within the animation itself (p. 43). *Interpretive forms* highlights the non-narrative aesthetic bias of the animation, which favours using a visual vocabulary common to the visual artists creating the work, meaning that the animated outcome is to be interpreted by the audience in a number of different ways, without the aid of formal narrative strategies and often on their own terms or ones defined by the artist (p. 43). *Multiple styles* defines the use of different modes of animation to allow the creator to incorporate the multiplicity of their personal vision, to challenge standard or mainstream codes and conventions, and to produce new outcomes (p. 45). *Evolution of materiality* describes the shapes, colours and textures used in the animation and how these aspects literally evolve within the piece (p. 45). Wells uses the example of a painted dot evolving into a set of circles; the audience recognises the aesthetics of these forms as they change (Wells, 1998). He goes on to state, "This sense of 'materiality' goes hand-in-hand with the emergent technologies which have liberated more innovative approaches to animations" (Wells, 1998, p. 45). *Presence of the artist* describes the relationship between the artists and the work along with the relationship between the audiences and the artists through the work. Experimental animations are largely personal, subjective, original responses that seek to use animated form in an innovative way and often aspire to create "dream-like" conditions (p. 45). *Dynamics of musicality* covers the relationship between music and experimental animation: "It may be suggested that if music could be visualised it would look like colours and shapes moving through time with differing rhythms, movements and speeds” (Wells, 1998, p. 46). Creating this state has been the goal of the majority of experimental animations created to date and is often referred to as “synaesthesia”: a neurological condition in which stimulation of one sense provokes involuntary responses in a second sense (Cai et al., 2010).

The abstract animated shorts created during this study align with Wells (1998) concept of experimental animation and, in fact, should be referred to as experimental animated short films created to discover new knowledge about abstract animation practices through experimentation with a new creative tool—motion capture. However, for the purpose of clarity within this document, I will continue to use the terminology of abstract animated shorts and abstract animated short films.

Analysis of Current Creative Works

This section outlines three key examples of existing practice that have informed my own practice during this research project, and offers a starting point to the contextualisation of this practice-led study. This overview focuses on the methods and technologies used in performing motion capture, along with the approach taken to creating the abstract visual forms that compose the final outcome. The artworks are *Forms* (2012), a two minute audio-visual installation by Quayola and Memo Akten; *unnamed soundsculpture* (2012), a video artwork by Daniel Franke and Cedric Kiefer; and *Presence* (2013), an abstract visual installation work by Matt Pyke from Universal Everything. These animated visual artworks have influenced my research as conceptual precursors to my creative enquiry as well as points of reference during the development of creative cycles. However, these examples by no means represent the totality of the creative works that have influenced the development of my practice over the course of this research project. Nevertheless, they are the works with which I had constant dialogue.

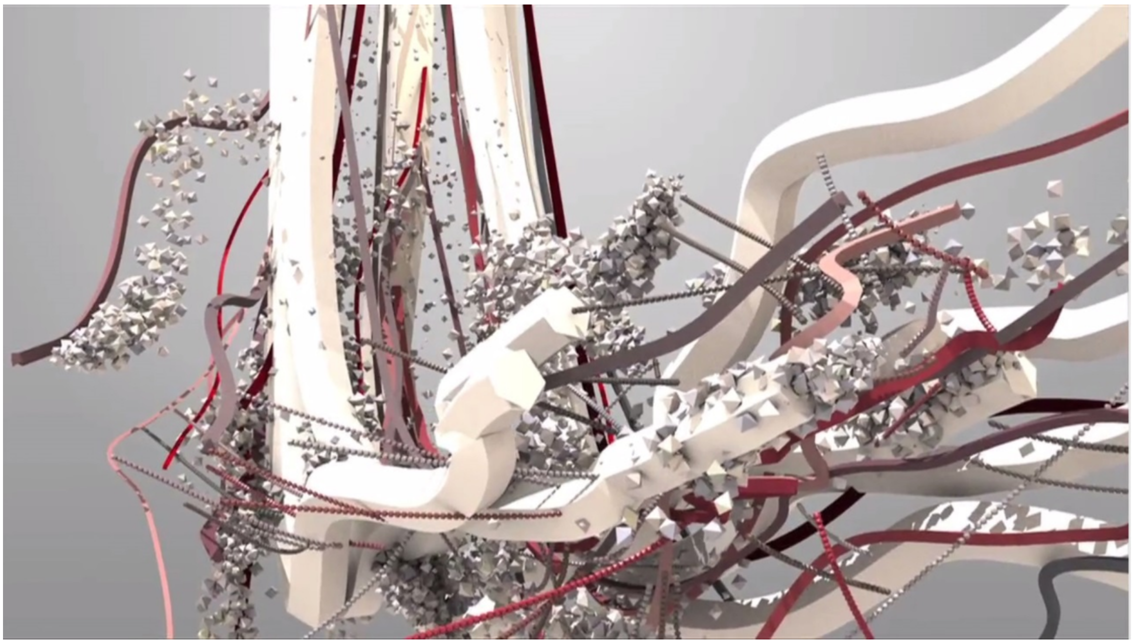

Figure 11. Still from Forms (excerpt) (Akten & Quayola, 2012d)

This two minute audio-visual installation uses footage of athletes competing in the Commonwealth Games as the seed in a generative system. The artwork focuses solely on the mechanics of the human body when performing at the extremes of perfection (*In the Blink of an Eye*, 2012). The artwork was inspired by pioneering works in photographic studies of motion created by Eadweard Muybridge, Harold Edgerton and Etienne-Jules Marey (Akten, 2012). However, "rather than focusing on observable trajectories, it explores techniques of extrapolation to sculpt abstract forms, visualizing unseen relationships – power, balance, grace and conflict – between the body and its surroundings" (Akten, 2012).

Human movement capture

In an interview about the artwork, Memo Akten overviews the creative process involved, starting with a review of footage from the Commonwealth Games. From this review, 10 short clips were selected and given to an animator who tracked the camera movement and, using the videoed body movements as a reference, animated a 3D virtual character (National Media Museum UK, 2012).

This approach to capturing human movement data is called rotoscoping, where an animator "traces" over footage and captures the movement in a new form. This approach to animating a character is widely used by animators across a number of fields and while it can yield results that are visually very close to the movement of the original reference, the 3D movement of the character is still a product of the animator's input over a direct capture of human movement.

Abstract visual forms

The process used to produce the animated artwork involved three dynamic simulations. Each of the systems was attached to the vertices of a 3D mesh, which allowed the movement of the mesh to drive the position of the dynamic simulations. The attributes of each simulation were set to achieve different outcomes: a point cloud, particle trails and springs. These simulation outcomes control the rendered sculptural forms apparent in the exhibited work (National Media Museum UK, 2012). Across all ten selected movements, the same three dynamic systems were attached to the digital character; however, not all of the systems or all parts of the individual systems were selected for use.

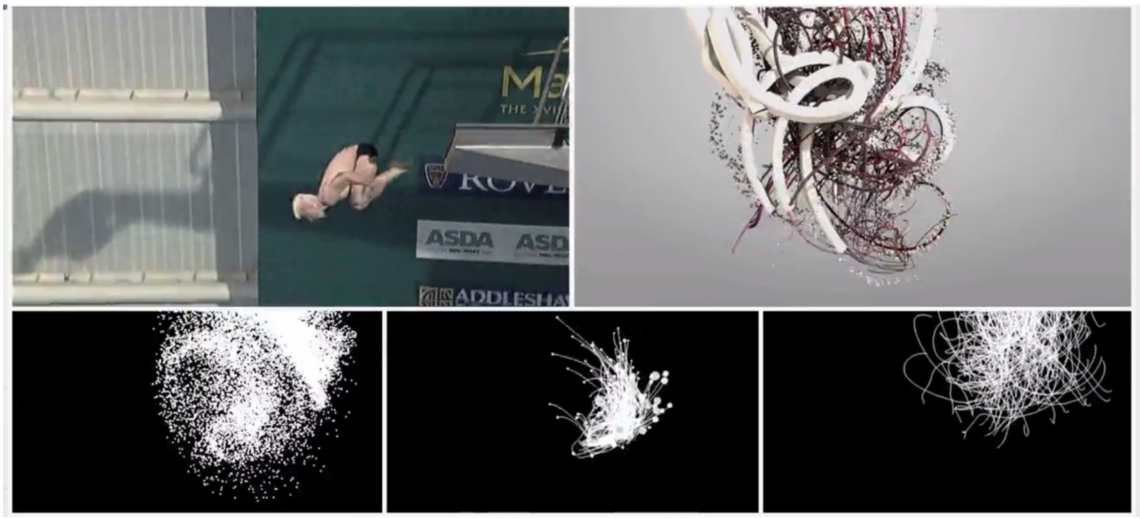

Figure 12. Still from Forms (process) (Akten & Quayola, 2012d)

This process presents the viewer with abstracted visual forms that have no relation to human form and, in fact, visually describe the human movements that have been translated and abstracted through the dynamic systems. To reintroduce and communicate to the viewer that what they are seeing is in fact human movements, people viewing the exhibited works are presented with an extra screen where they can strip away the layers of the process, revealing the original video footage.

The major segments of the production undertaken for *Forms* is visually well documented; however, ambiguity exists around how much of the human movement is selected for use in the abstract forms of the animation as displayed in selecting only parts of the dynamic system connected to the digital character.

Figure 13. Still from *unnamed soundsculpture* (Franke & Kiefer, 2012)

Unnamed soundsculpture (2012) is a video artwork that was created around the idea of a moving sculpture and produced from the movements of a dancer performing to a musical piece. The kinetic sculpture is composed of 22,000 points that individually appear abstract but collectively connect, resulting in an abstract visual form. The form transitions between static poses, morphing into more humanistic shapes during the static poses and back into a collection of abstract dots during the transitions (Moskova, 2012). As Moskova (2012, para 2) explains:

> The body—constant and indefinite at the same time—'bursts' the space already with its mere physicality, creating a first distinction between the self and its environment. Only the body movements create a reference to the otherwise invisible space, much like the dots bounce on the ground to give it a physical dimension.

Human movement capture

The motion capture technology used in capturing the dancer's performance consisted of three synced Xbox Kinects (Moskova, 2012). The Kinect system provides mark-less full-body capture, facilitated by infrared lasers projected in a grid pattern and combined with a monochrome CMOS sensor to calculate the depth of objects in front of the camera (Khoshelham & Elberink, 2012). The captured motion is recorded as an animated depth map composed of a 3D point cloud.

The video titled *unnamed soundsculpture (docu)* (2012), which documents the process of capturing and creating the animated outcome, reveals that the capture process involved calibrating and defining a volume where the movement would be captured. Once the system was set up, the capture was conducted, with the resulting movement data from each Kinect stored as a 3D point cloud. These individual point clouds were then combined into a single point cloud that could be used within a 3D software package to create the visual outcome (Franke, 2012).

From viewing the documenting video and the resulting creative work, it is clear the performance was limited to movements that occurred roughly on a single spot. This result could be by design, giving the digital camera a focal point to move around. However it is more likely that the limited field of vision of the Kinect depth sensor resulted in a capture area between 80 cm and 400 cm directly in front of each of the Kinects (Microsoft, 2012), creating a relatively small area for a performance to take place.

Abstract visual forms

The abstract visual form is a volumetric cloud fashioned through the constant generation of particles by a dynamic system. At the time of creation the particles are static for about half a second. They then fall away and dissolve on the floor of the virtual environment. The final outcome is displayed to the viewer through a virtual camera aimed at the visual form and its movements are controlled by the soundscape.

The artists started the creative process by experimenting with the settings and processes of the attached dynamics system. This produced a number of visual tests that also included a variation on how the captured movement was abstracted through the visual form. The outcomes ranged from forms that were solid constructs morphing into different shapes to liquids that would continually generate, spilling out and dissolving across the virtual floor. Through this process, the final aesthetic, which visually references the combination of the three individual point clouds produced at the time of capture, was created; however, the video documentation shows that a number of tweaks and adjustments were required before reaching the final abstract visual form.

Figure 14. Still from *unnamed soundsculpture (docu)* (Franke, 2012)

Unlike the production process of *Forms*, where a virtual character enabled the artist to be selective about where the dynamic systems were attached, for *unnamed soundsculpture* the captured movement data exists as a volumetric cloud that relies on full-body capture data (already abstracted by the capture process) to create the abstract visual forms. This process also made use of the 3D nature of the capture data, not restricting the view of the work to a static camera.

Despite the information captured by the video and text items outlining production processes of *unnamed soundsculpture*, it is still unclear how the settings and the components of dynamic (or simulation) systems—such as the virtual world and the object (or entity) being created within—can affect the abstraction of human movement within the animation. Furthermore, not retargeting the captured movement onto a virtual character as an intermediate object between captured movement and the dynamic system raises the of question of whether a digital character is needed and, if so, how can its use in the production affect the resulting abstract animation?

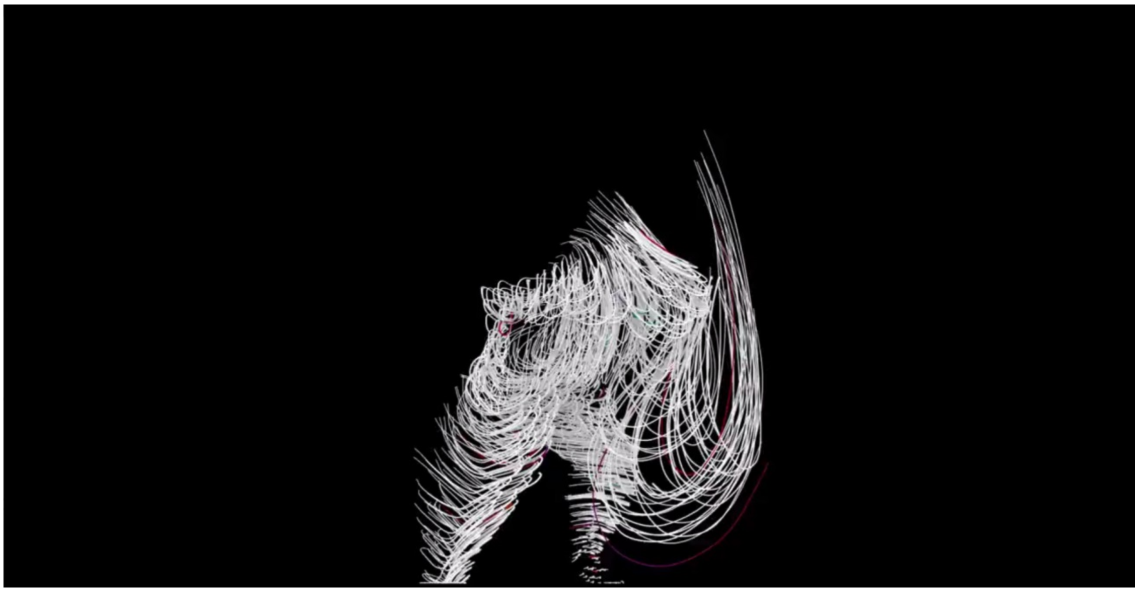

Figure 15. Still from *Presence 04-01* (Universal Everything, 2013d)

Building upon the visual style developed during Universal Everything's earlier works, like *Tai Chi* (2012) and *The Transfiguration* (2011), *Presence* is a clear continuation of Universal Everything's enquiry into choreography, movement and the human form expressed through new technologies and processes. *Presence* was commissioned by Media Space London and created through collaboration between Matt Pyke and choreographer Benjamin Millepied, working with dancers from the LA Dance Project along with Audiomotion to facilitate the motion capture process (Audiomotion Studios, 2014). The artwork is composed of a series of abstract animated shorts that aim to retain and display the human presence through "digitally dressing" motion-captured dance movements in what is described as an array of "digital costumes" (Kaganskiy, 2013). As Kaganskiy (2013, para 2) elaborates:

> Presence turns the screen into a stage, the body into an abstracted sculpture. Experimenting with various materials and forms, the life-sized moving sculptures cycle through a randomised collection of 'costumes' that range from colorful light trails to crystalline

formations, with only the movement revealing the human presence within.

Human movement capture

Unlike the other two creative works covered in this contextual review, the capture of human movements was facilitated by the professional studio Audiomotion, whose capture system is composed of 160 Vicon cameras and a marker-based optical motion capture system that enables the capture of multiple performers within a large volume simultaneously (Audiomotion Studios, 2014). This type of optical system includes cameras calibrated to enable capture within a specific volume, which is dependent on the field of vision of each camera along with the number of cameras in the array. The number of performers able to be captured, along with the accuracy of the data, can also be affected by camera density around the volume. Once set up, the cameras are used to track and triangulate the reflective marks that cover the suit worn by the performer. The markers or “dots” are normally made out of lightweight compressible material and attached to a spandex suit so the performer’s movements are not impaired (Furniss, 1999). This system can be customised to track a large variety and number of objects. However, if enough of the reflective dots are obscured from the cameras’ views, the recorded data might be “dirty” and require further processing either at capture time by the software or through clean-up after the capture is completed (Furniss, 1999).

During the captured sessions, real-time particle trails were attached to the digital avatar and displayed to the performers to help them visualise the shapes that might be created by their movements and allowing for adjustments to be made to the choreographed dance (Visnjic, 2013).

Figure 16. Still from *Behind the Scenes: Universal Everything & LA Dance Project* (Universal Everything, 2013b)

Abstract visual forms

Matt Pyke refers to the abstract visual forms as the “digital costumes” that clothe the human presence and acquired through the motion capture process (Kaganskiy, 2013). These procedurally generated costumes make use of a simplified aesthetic that takes inspiration from tribal patterns and ancient graphics, with aspects of the design controlled by the movement; for example, the acceleration of a limb might affect the colour intensity or how erratic or long a particle trail is. The process of creating the visual forms was primarily concerned with finding a balance of tension between the human presence and visual abstraction (Visnjic, 2013). Pyke (quoted in Kaganskiy, 2013, para. 9) states that “We wanted to see how far you can abstract things and still see the human presence inside? Can you still feel the soul inside there?” When audiences observe the work, the human presence is not readable at first; instead, it evolves and reveals itself gradually, only becoming apparent from the movement driving the forms (Kaganskiy, 2013). To investigate the limits of abstraction while still retaining the human presence, the team, through the rapid prototyping functionality of a procedural software pipeline, was able to evolve the original hand-drawn concepts into hundreds of costume variations.

Figure 17. Hand-drawn concepts juxtaposed with the final digital outcome (Universal Everything, 2013c)

This concept of exploring the boundaries of visual abstraction while retaining the human presence has become a main theme in my creative work with a number of the aspect of the creative process cantered around balancing the human with the computational influences on the generation of abstract visual forms.

The multiple abstract animated shots resulting from the investigation undertaken by Universal Everything do, indeed, visually display a small number of outcomes that can result from creating abstract animation using motion-captured human movement. However, despite this investigation no detailed description has been offered of what options were presented to the artist, and what considerations were undertaken during the production of *Presence*. These aspects of production would have presented, and initiated the prototyping process that is described in the text and video documentation of the production; as such, these aspects of abstract animated short film production are unclear.

Different approaches to capturing human movements are used in all three contextual modes. However, it is unclear how these processes might affect the visual forms been created for use within the abstract animated film and also what opportunities the capture process might present to an animator in relation to abstracting the human movement and delineating the visual elements away from recognisable or orthodox forms normally found in animation.

Tying Together the Threads

Despite the apparent differences in their aesthetic style, technology and approach to capturing human movement, the three creative works presented above all have a common approach (using a motion capture and computational system) to the practice and they all capture and use human movement data to create the components of abstract animated short films.

These creative works also centre upon a common theme: the abstraction of human form and motion.

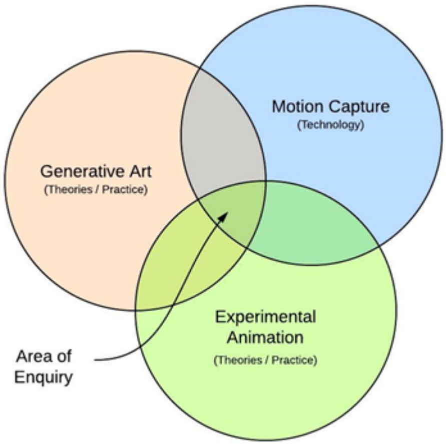

Figure 18. Area of enquiry

My practice uses the three conceptual domains outlined at the beginning of this chapter: *motion capture* and 3D dynamics simulations (a *generative system*) to produce an *animated abstract visual artefact*. It is at the intersection of these three conceptual domains, where theories and practice intertwine with technology, that this practice-based enquiry will discover new knowledge about abstract animation practice. This investigation is detailed in the next chapter.

CHAPTER 3: ANALYSIS & CREATIVE PRACTICE

> Technology inspires the art, and art challenges the technology
> (Lasseter quoted in Catmull, 2008, p. 8).

This well-recognised quote from John Lasseter refers to the ethos within the Pixar animation studio that the interplay of technology and art results in "magic". This echoes Walt Disney's belief that new ideas and outcomes, or "magic", can happen through the combination of technology and art (Catmull, 2008). This chapter covers the results and analysis of abstract animation practice conducted during this study through three action research cycles that investigate the research question outlined in Chapter 1.

Practice Cycle 1: Experiment One

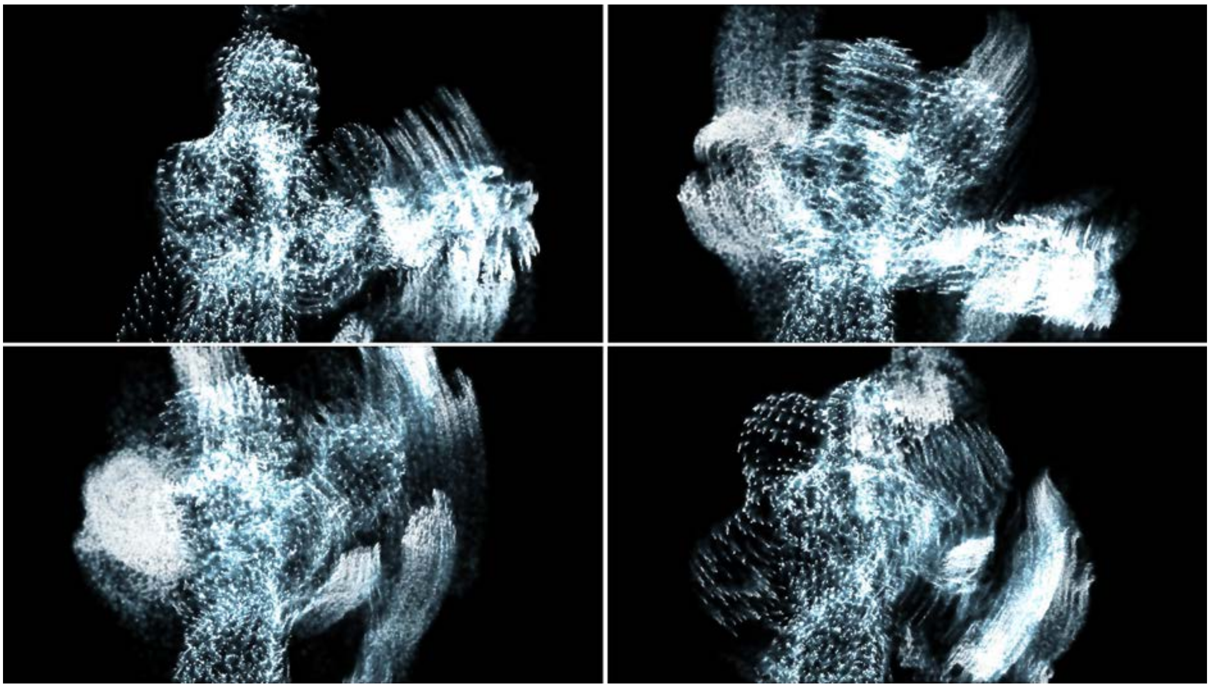

Figure 19. First experimental creative work (Van Opdenbosch, 2012a)

The objective of the first cycle of practice was to create an abstract animation that mimics mainstream trends in contemporary abstract animation based on motion-captured dance movements. As such, this research cycle aimed to develop a clear understanding of the motion capture system and processes needed to perform capture, and to establish a software pipeline to handle motion data. The resulting abstract animation from this cycle of practice can also be viewed at https://vimeo.com/65520382 or in the accompanying digital files.

Plan

Normally in orthodox animation, the use of motion capture is essentially limited to the process of animating characters and other objects, such as the flying ships in *Avatar*. However, in this practice cycle, the affordances of motion capture technology were explored through the creation of a non-orthodox abstract animation that attempts mimic current trends in abstract animation created using motion capture data by applying Wells's (1998) experimental animation principles into the practice. This cycle of practice also used the Xsens MVN motion capture system, which allowed the researcher to define a clear process for capturing movement in future creative cycles. The movements to be captured were non-choreographed and largely spontaneous, with a focus on testing the range of movements the system could capture without error. This first cycle of practice made use of the following strategies: *first*, it attempted to develop a clear understanding of the motion capture system and processes needed to perform capture; *second*, it sought to capture a range of non-narrative spontaneous movements; and *third*, it led to an understanding of how to process and use the motion capture data through a software pipeline.

Act and observe

This practice cycle started with the first experience using the Xsens MVN motion capture system at QUT. The main aim of this first capture session was to gain an understanding of the system and the capture process. Thus, the first strategy—developing a framework for performing capture—was implemented. This process started by using the best practice model outlined in the contextual review. The first phase, *preparation*, involved selecting a dance studio at QUT for the capture to take place; this would ensure the safety of the performer while using the system and would also mean the performer was not limited by aspects of the location, such as the flooring, and could attempt a range of movements. This phase also required the format of the suit to be selected. Normally for this type of capture, the lycra version of the suit would be used to make sure no exposed cords would impact the performer's movement. However, as this session was also used to gain an understanding of the system's layout and connections, the strapped or "biomech" layout was used. As the default setup of the system used the lycra version, the suit had to be converted to the strapped version before the capture session. At this time, I reviewed the instruction manual that came with the system and practised physically connecting the system into its predefined arrangement to familiarise myself with the system and process. During the capture session, the suit was set up and calibrated for use in the second strategy. This was to capture a range of non-narrative based movements, which was achieved by allowing the performer to spontaneously derive the dance phases and predominately focused on exploring the range of movements capable while wearing the system and not focused on communicating a story.

Figure 20. Time-lapse of suit setup (May & Van Opdenbosch, 2012b) and testing range of movements (May & Van Opdenbosch, 2012a)

With the first capture session complete, the practice cycle moved on to implementing the third strategy, which aimed at establishing a preliminary software pipeline for handling the motion data. This started with a review of the capture data within the capture software, MVN Studio. I found that the avatar's movements were extremely accurate and followed the performer's movements in real-time, with little to no error. This allowed for the data to be used in a "raw" state, without the need for clean-up, a process normally undertaken during a general application of motion capture data. The data were then exported to the 3D software package to create an abstract artefact. Following a standard application of motion capture data, I applied the captured movement to a virtual character using a process referred to as "retargeting". This resulted in a general human form being animated by the motion capture data. At this point in a normal pipeline for motion capture data, another phase of clean-up and additional animation (such as face and hands movement) would be added. However, as the goal of this practice is to abstract the human form and movement, no extra animation of the virtual character was undertaken. In its place, a particle system was attached to the character's polygon mesh and the visibility of the mesh was turned off, which effectively left the partial points generated by the system as the only visual descriptors of the captured motion. At this point in the practice cycle the abstract animation was "rendered out" or exported, then taken into a post-production phase. Additional effects were added that would increase the abstraction of the work through disturbing the clear display of human form still present in the rendered particles. The final version of the visual form is represented in Figure 21.

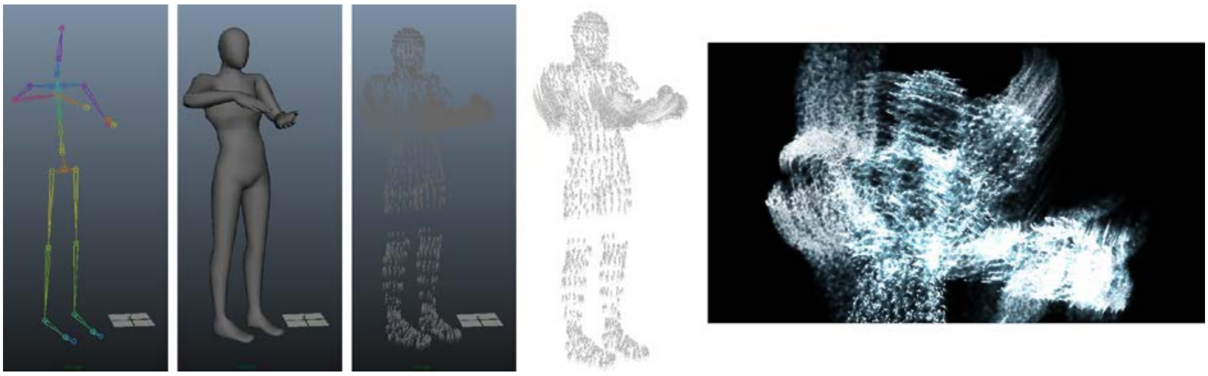

Figure 21. Different phases of practice, from left to right: motion data on a 3D rig, basic virtual character, particle system and rendered and final outcomes

Reflection

Visually, the abstract animated short film is a commentary on the almost cliché use of particle systems attached to general human forms that are animated by motion capture, which has become commonplace on video streaming sites such as Vimeo and YouTube. Visually, the animation also took reference from *unnamed soundsculpture* by attempting to hold a human form for a time, then having the points disperse back into chaos. However, the work does not depict the 3D nature of the data like *unnamed soundsculpture*. This is due to the post-production process used, along with the "hard" polygon mesh of the virtual character being hidden. There is, in fact, a 90 degree turn of the digital camera about halfway through the animation. However, this change in perspective cannot be seen due to the 2D nature of the outcome.

This practice cycle adhered to Wells's (1998) experimental animation theory of *specific non-continuity* by diverging away from standard uses of motion capture that normally retain continuity with the mainstream forms of animation. The practice continued to make use of Wells's principles of experimental animation by using *interpretive forms* that visually redefine "the body" through hiding the generic human form of the virtual character and replacing it with a particle point cloud generated from the virtual character's polygon mesh. The practice made use of *abstraction* by replacing the illustrative image of a human with a collection of data points produced from the motion capture process. This layer of abstraction applied to the captured movement was retained during the practice through forgoing any adjustment or addition to the captured movement; instead, the animation made use of the "raw" data. An *evolution of materiality*, as defined by Wells (1998), was introduced into the animation through the extra post-production effects. These effects allowed for shapes and forms created by the particle system to visually evolve during the course of the animation. These direct applications of the principles of experimental animation into practice guided and aided the generation of new approaches to the use of motion capture within animation practice and allowed the aesthetics of the animation to evolve through the experimental practice. This resulted in a framework for handling the motion capture data, as displayed in Figure 22.

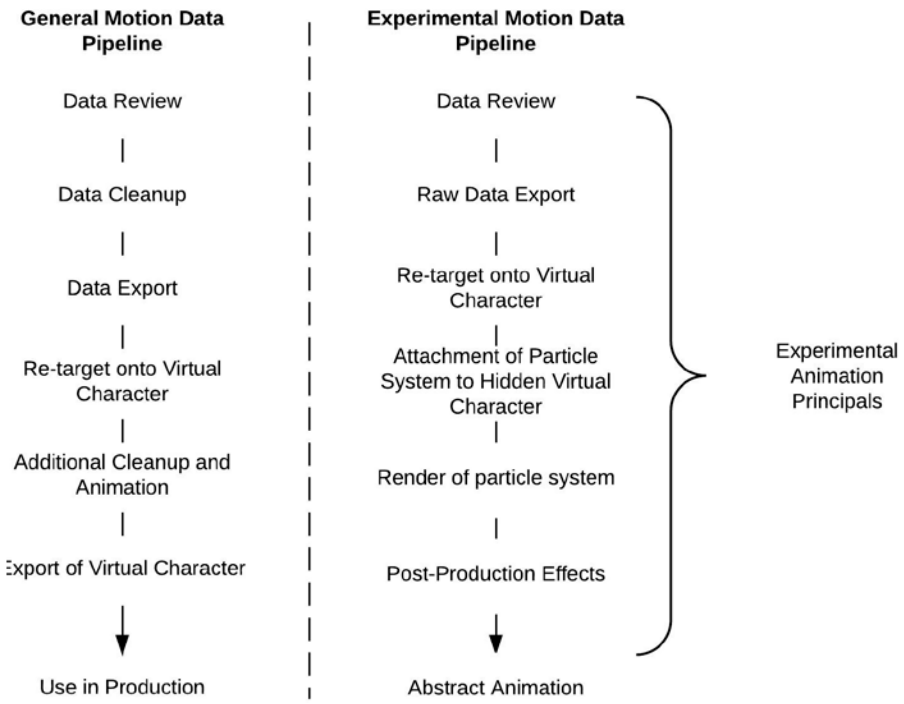

Figure 22. Experimental vs. general motion data pipeline

The motion capture component of this capture cycle allowed me to devise a framework for using the capture system composed of the following phases: *hardware setup*, *calibration* and *capture*. In practice, the hardware setup involved positioning the inertial sensors and transmitters onto the body of the performer and attaching the receivers to the computer running the capture software. The calibration was composed of a number of predefined poses and movements: T-pose, N-pose, squat and hand touch calibration. The system uses the poses/movements along with measurements of the performer's body to calculate the range of movements. Unlike an optical system, the performer has to be present for the system to be set up and calibrated. By defining and familiarising myself with the process and physical components of the motion capture system before the capture session, I was able to optimise use of the capture technology, allowing for shorter capture sessions in future productions. Capturing a range of non-narrative spontaneous movements not only aided the abstraction process, but also allowed the performer to gain an understanding of the range of movements and capabilities of the capture system that could aid in choreographing movements for future capture sessions.

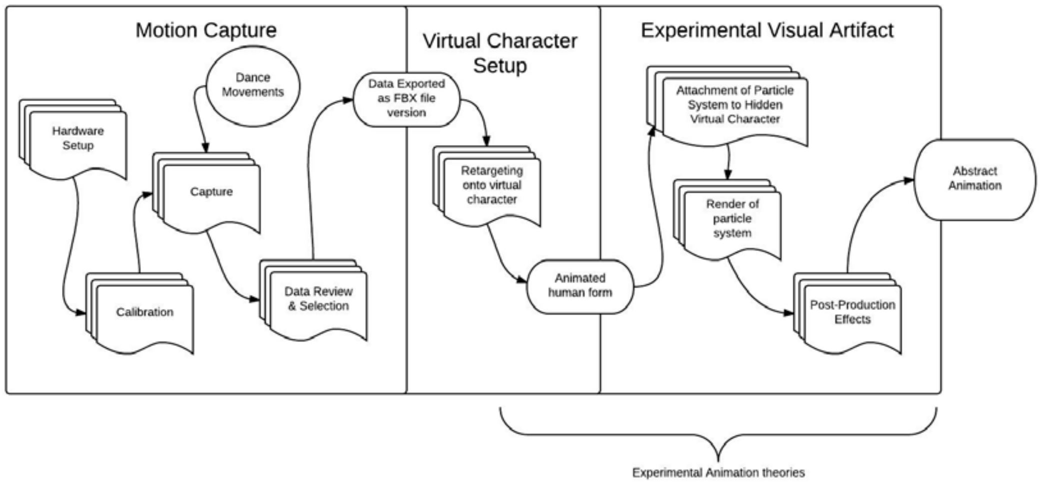

Figure 23. Base framework

In summary, the purpose of this research cycle was to create an abstract animation using motion capture, to develop a clear understanding of the motion capture system and the processes needed to perform capture, and to establish a software pipeline for handling the motion data captured. The outcomes from this practice cycle provided a framework for the following practice cycle and have contributed to the cumulative studies of this research project and the body of knowledge in general, as detailed in Chapter 4.

Practice Cycle 2: Experiment Two

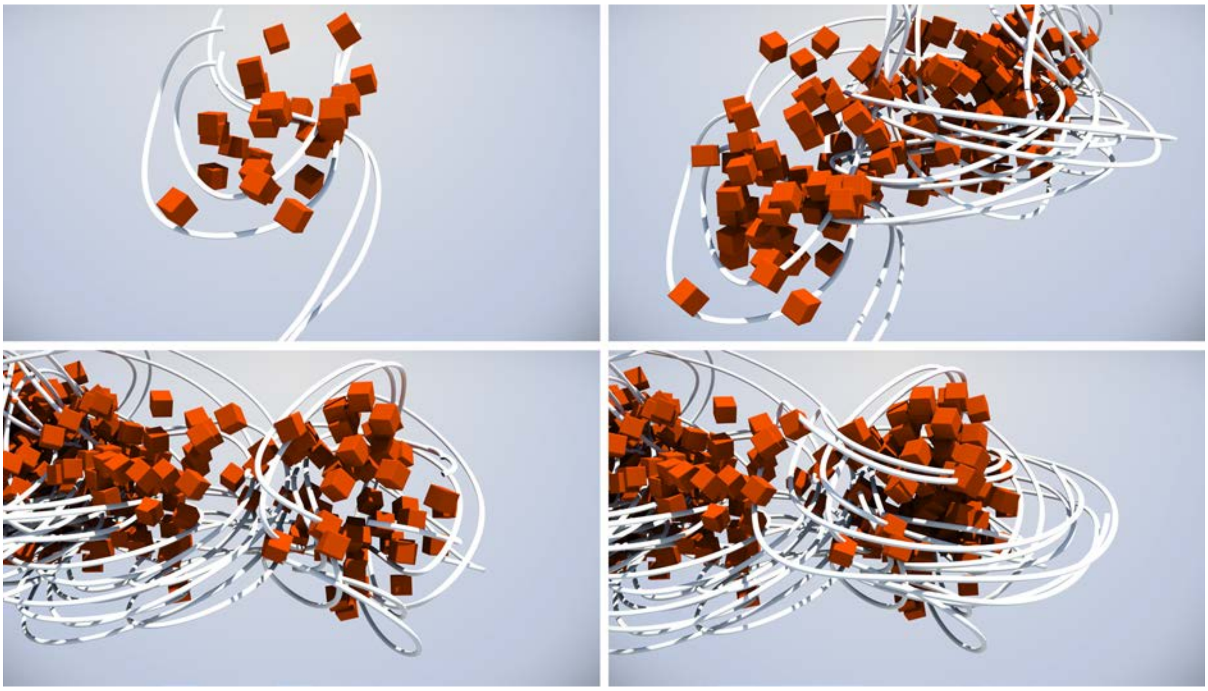

Figure 24. Second experimental creative work (Van Opdenbosch, 2012b)

The objective of the second cycle was to create an abstract animated short film that diverges from recent trends in abstract animation, using particle point clouds as a visual describer of full-body capture by not using all of the captured motion data. The purpose of this cycle was to explore the motion data itself and how individual points of data might be used in the creation of abstract artefacts. The resulting abstract animation from this cycle of practice can also be viewed at https://vimeo.com/59875110 or in the accompanying digital files.

Plan

In developing a plan for this practice cycle, I was influenced by the creative work *Forms*, which was examined in Chapter 2. The production process of *Forms* involved rotoscoping videos of human movement onto a 3D virtual character. This character was then used to drive a number of dynamic systems that produced the visual artefacts found in the exhibited works. The process used in *Forms* is similar to the one described by the base framework resulting from the first practice cycle in that both works use captured human movement to produce abstract visual forms, facilitated by a virtual character and dynamic simulations. However, in place of using the whole polygon mesh of the virtual character as the emitter for the dynamics system, as was the case in the first cycle of practice, the creative process of *Forms* only used selected parts of the virtual character. Thus, *Forms* does not use the whole captured body to create the visual artefacts, only select body segments. The 3D virtual character in *Forms* was a necessity, as the human movement used in the project was captured from video footage through a digital rotoscope process. In comparison, the motion capture technology used during this study exports the captured motion as a collection of 3D points positioned within virtual space.

In this practice cycle, the abstract animated short film was created using the base framework resulting from the first practice cycle, with the key difference being the focus on creating an animation that does not use a particle point cloud and avoids using the full-body capture. To achieve this outcome, the following strategies were implemented within the practice cycle. The first strategy involved removing the virtual character as an intermediate device between the captured performance and visual elements created within the 3D software package. The second strategy was to avoid a particle point cloud to create the resulting visual descriptors within the animation. To juxtapose the movement of this animation with animation from the first research cycle, which used motion-captured movements that occurred at relatively the same point in the virtual space, this practice cycle made use of a performance that would progress through the virtual space. I took this movement from the capture session conducted in the first cycle of practice, as a wide range of movements and performances were captured at that time.

Act and observe

As this practice cycle made use of the data from the first capture session, the first section of the framework was bypassed and the practice was started at the *data review* phase. After a review of the motion capture takes from the original capture session, a take was found where the performer's movements consisted of a single dance phase progressing along a linear path. To enact the first strategy, aimed at removing the virtual character from the creative process, I bypassed the *character creation* phase of the current framework. This meant the raw motion capture data was exported from the capture software in a file format readable by the 3D graphics software, in this case the FBX file format. Once the data was imported into the 3D graphics software, I was presented with a number of null objects or data points connected into a hierarchy that outlined the points on the human body used by the motion capture system. Each null object stored the movement data for the related body section and when played back would perform the captured dance sequence.

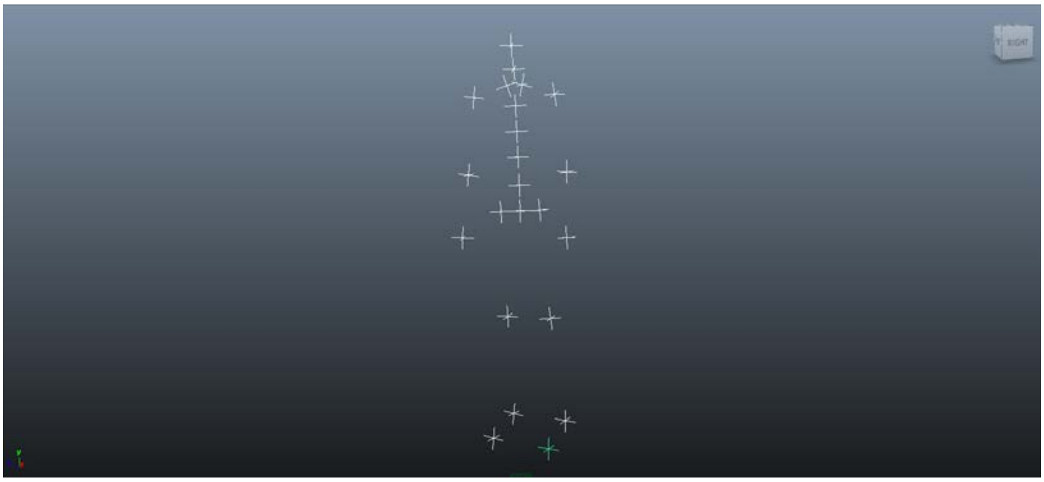

Figure 25. Null objects or data points within the 3D software

This unimpaired view of the data presented the option to use all or only a selection of the captured performance and, as the movement of the upper body was more dynamic, the points that coincided with that segment of the body were selected to create the visual artefacts. At this point in the practice, the second strategy was implemented. The second strategy aimed to avoid visually using particle point clouds within the resulting animation. To achieve this, I first attached independent dynamics systems to each of the selected data points and then set the dynamics system located at the chest to emitted polygon cubes while the dynamics systems driven by the data points corresponding with the arms outputted continuous polygon cylinders, forming motion trails. Further adjustments to the settings of the dynamics system were changed to affect the spread and number of objects emitted. The objects were also set to remain in the virtual space and settle into a static position, forming into a "motion sculpture" by the end of the abstract animation. Once the dynamics system setup was completed, the animation was rendered out; however, this time no post-production processes affecting the visual artefacts were added.

Reflection

The abstract animated short film is devoid of any visual human representation; in its place is a collection of simple shapes suspended in a void. The use of abstract shapes in place of mainstream narrative or illustrative depictions of the body that conform to standardised orthodox animation (Wells, 1998), positions the captured movement, along with the choreographic intent of the dance, as the subject of the visual artefact presented within the animation. The generation of the shapes visually maps the captured human motion into a static sculptural artefact that presents such an abstract translation of human form and movement that as Wells (1998) notes, the viewer is left without a complete understanding of the artwork and it is only with further context that the true intent of the animation can be realised. Visually the animation was influenced by Davide Quayola and Memo Akten's *Forms*, explored in Chapter 2, which also aided in designing the plan for this cycle of practice by providing the creative direction to produce an abstract animation that does not use a particle point cloud as a visual describer and avoids using the full-body capture of the dance performance. This allowed for the practice cycle to explore the motion data itself and how individual points of data might be used in the creation of abstract artefacts. The resulting abstract animation was exhibited at the QUT Creative Industries Precinct, Kelvin Grove between 31 October and 2 November 2012 as part of the Ignite12! Research Conference, alongside the outcome from the first creative cycle; this assisted in the reflection process by offering comparisons between the works to be observed. In the first cycle of practice the captured motion was viewed as a whole or as a body in motion, as evidenced by the visually apparent human form in the resulting creative work. By applying the first strategy, it was discovered that the removal of the virtual character not only streamlined the creative workflow but also allowed for the captured motion data to be viewed as a collection of data points instead of a single body moving in virtual space. This segmented view of the motion data allows practitioners to selectively use or not use parts of captured movement to generate visual artefacts. Through the application of the second strategy, the work was able to progress completely into abstraction and into an experimental animation format by removing the visual representation of the human form in the animation. This outcome is also supported by the first strategy's approach of not using the full-body data. Further reflecting on both practice cycles allowed me realise that each of the creative cycles had used a system built from a 3D simulation that is attached to captured motion data either directly or through another object, such as retargeting the data onto a virtual character. This system is used to produce the visual artefacts that compose the abstract animated short films created during the cycles.

Figure 26. Second experimental creative work as a motion sculpture

The outcomes from this cycle of practice resulted in the addition of a new process occurring after the *data review* and *export* components of the framework. During this new component, called *data point selection*, the practitioner selects individual, or clusters of, data points to be used in the creation of the artefact. In most cases, this process is undertaken once the selected movement is imported into the 3D graphics software, as this offers an unimpaired view of the movement and aids the decision of what data points to use. In this case, data points were selected according to the dynamic nature of the movement that would result in a visually interesting experimental form. Ultimately, the selection is based on what the practitioner wishes to convey through the work and what the purpose of the animation. The number of points and their location can also affect the depiction of human form within the resulting abstract animation. The updated framework is depicted in Figure 27.

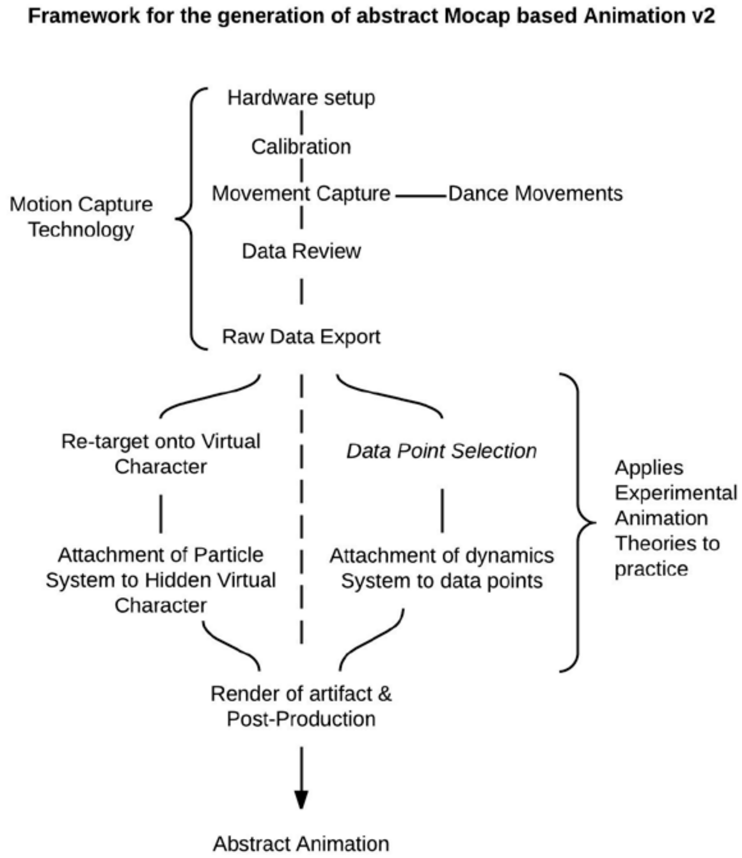

Figure 27. Version 2 of the framework

Practice Cycle 3: *Contours in Motion*

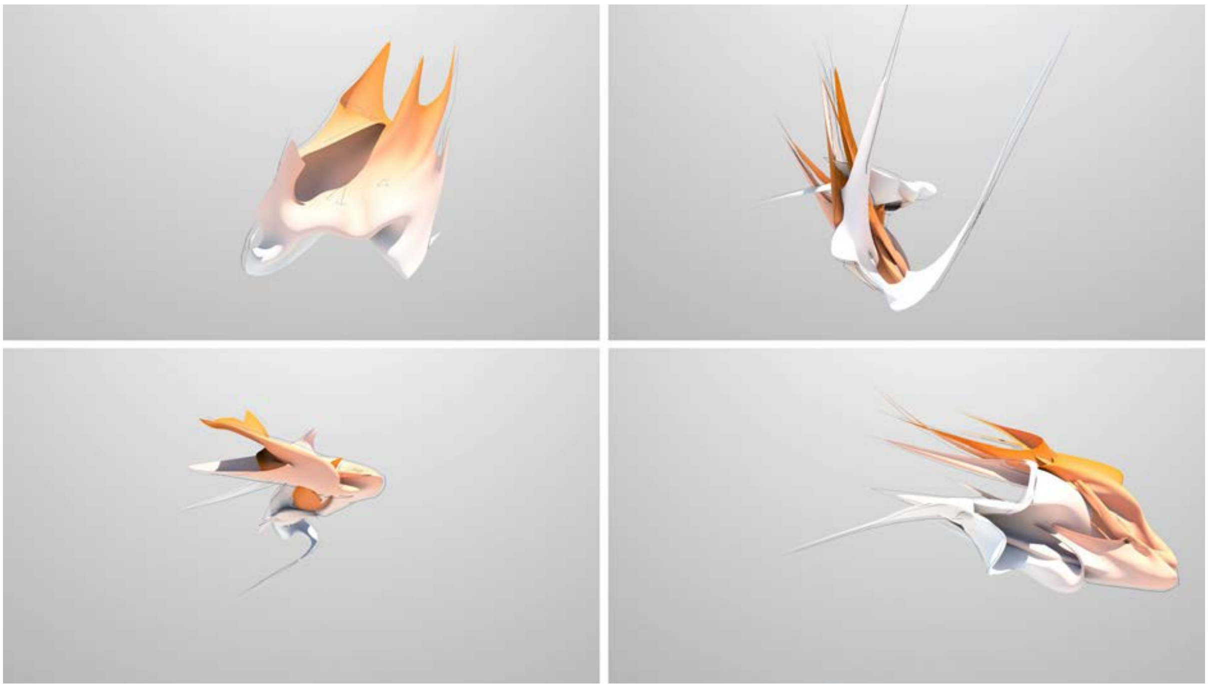

Figure 28. Contours in Motion (Van Opdenbosch, 2013b)

The objective of the third cycle of practice was to create another abstract animated short film with the aim of transforming the captured movements and forces of a dancer into an abstract visual artefact that goes beyond simple abstract data visualisation. The purpose of this cycle of research was to explore the application of generative art principles to the practice of this study. The resulting abstract animation from this cycle of practice can also be viewed at https://vimeo.com/78791613 or in the accompanying digital files.

Plan

After further reflection upon the practice undertaken during the past creative cycles, I observed that all of the creative works discussed above make use of a dynamics simulation that is part of computer software, highlighting a dependence on computational systems for creating visual artefacts. I also observed this in a professional work I was engaged with at the same time, which was to develop an animated backdrop for the dance performance *Paired Black* (2013), which was performed at the Judith Wright Centre in Brisbane as part of *Dance* (*Indie Dance*, 2013). This animated backdrop made use of motion-captured dance movements to dissolve a predefined pattern at a choreographed time in the performance. In creating the animation, the majority of my time was spent setting up a dynamics system that would use the captured dance movements to disperse a pattern composed of static particles.

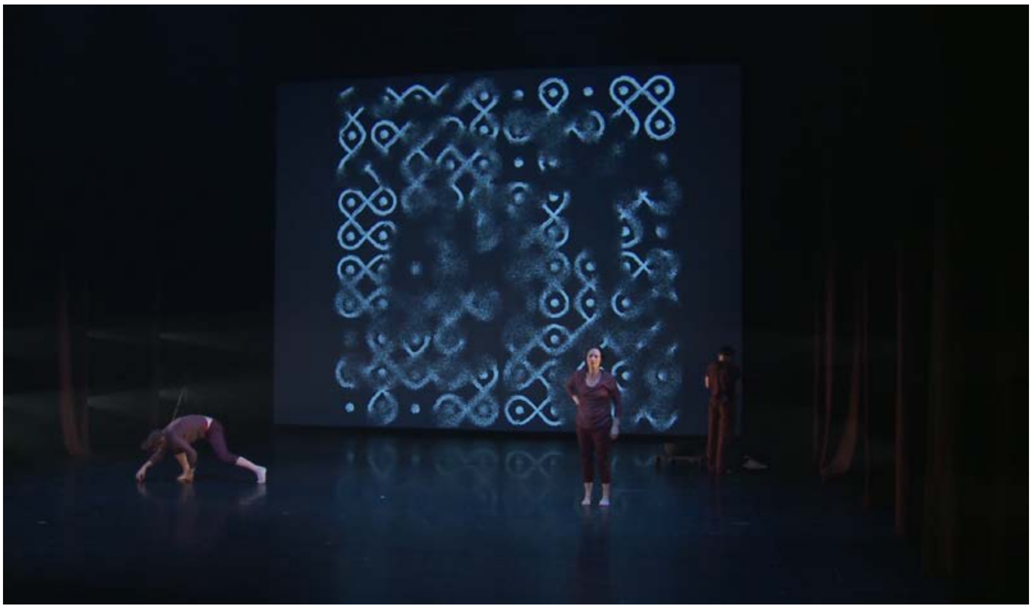

Figure 29. Animated Korma Patterns (Van Opdenbosch, 2013a) integrated in a live dance performance (image by David Pyle)

The process for *Animated Korma Patterns* (2013) involved defining the settings of the dynamics system; once the motion capture data was introduced, it ran autonomously to produce the artefact used in the abstract animation. Further research into this practice format revealed the same processes are present in the field of generative art, as outlined in Chapter 2. This presented a major turning point in the research and informed the plan of this cycle of research, aiming this cycle of practice-led enquiry at the creation of an abstract animation through an application of generative arts theories into the current framework for practice. Additionally, the plan for this cycle explored a virtual cloth simulation in place of a particle system within the 3D software package, with the aim of retaining the 3D nature of the basic polygon shapes used in the second cycle. This required a period of rapid prototyping before starting production on a finalised abstract animation. To support this prototyping process, a new capture session was conducted to capture smaller takes and new movements on which to build the prototypes. To enact the plan for this cycle of research the following strategies were implemented. The first strategy was the integration of generative art theories into the creative workflow and the second strategy was the application of a new computational simulation system as the aesthetic and visual device within the abstract animation.

Act and observe

Following the current framework, the motion capture process progressed in the same way as in previous capture sessions. The movements captured were short spontaneous non-narrative dance phases. Continuing through the current framework, the captured movements were reviewed. Based on the high fidelity of the capture, the data could be used in its unchanged raw state and, thus, the selected movement was exported for use in the 3D software package. Following the exporting of the captured data, I started prototyping the new visual artefact using the imported raw motion data and the virtual cloth simulation within the 3D software package. First, I attached a small virtual cloth to the data points of the left forearm and hand using the default setting for the cloth system. Observing the results, I could see the cloth not only moved in a pleasing way with the arm but also translated the captured movement into the dynamic shape itself.

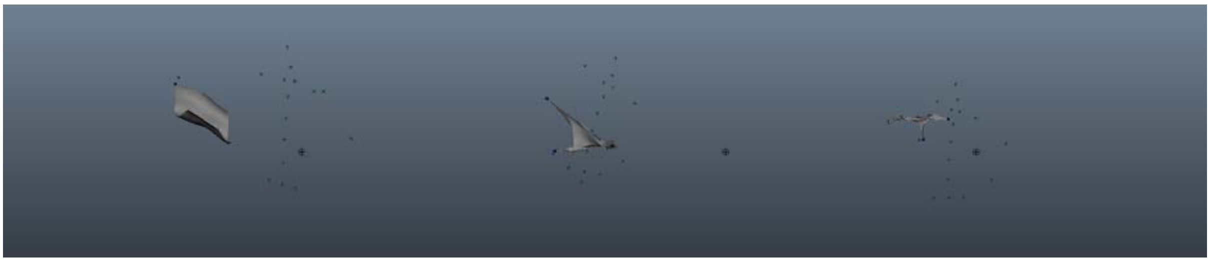

Figure 30. Screen shots of the first test using the cloth simulation

However, the translation of movement into a new form was not visually clear as the shape ended up as a tangled ball of virtual cloth. Therefore, I attached the other side of the virtual cloth to the opposite arm using the same data points and adjusted the settings of the cloth simulation to allow the object to expand, contract and intersect itself. I also adjusted the visual aesthetics of the outcome with a gradient colour along with an outline that would give an extra visual layer to the shape. Once the system was started the movement stored in the selected data points was transferred into the virtual cloth object, enabling it to evolve into an animated abstract artefact.

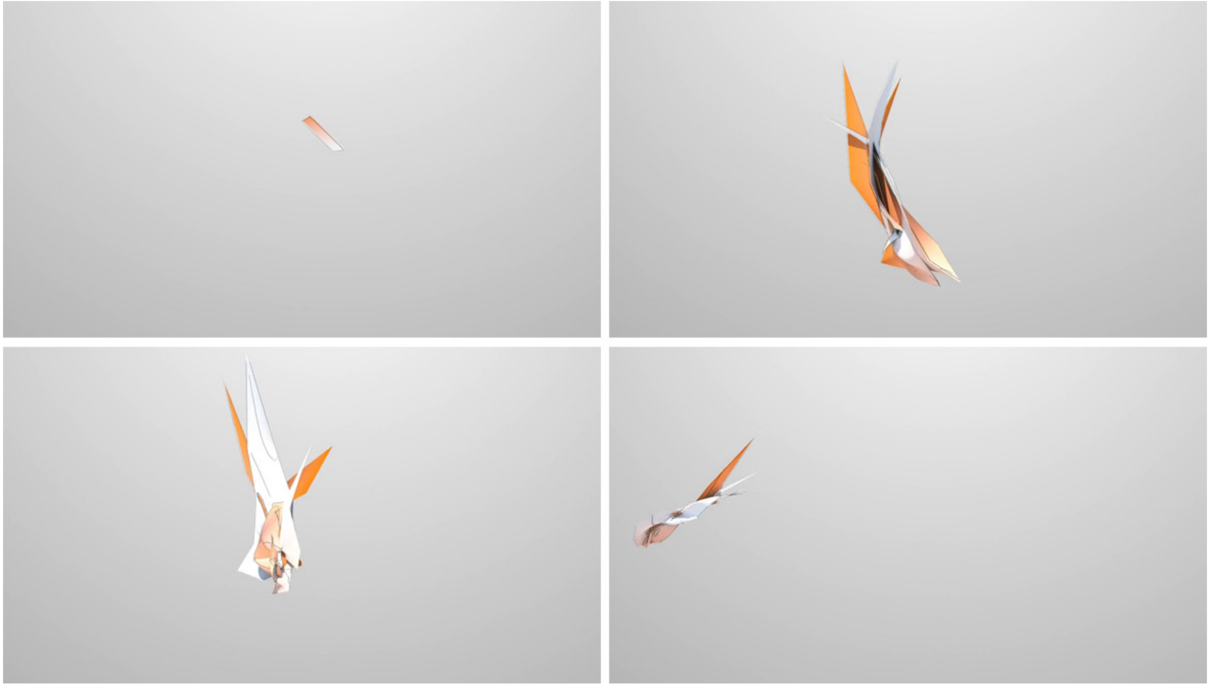

Figure 31. First prototype

The first prototype animation can also be viewed at https://vimeo.com/69594321 or in Appendix 1.

With the successful outcome from the first prototype, I moved on to applying the process to a second prototype. However, this time I attached a larger virtual cloth object to the selected data points. I further adjusted the settings of the cloth system to refine the expansion and contraction properties of the object. The object was also set up to visually appear smoother and less angular.

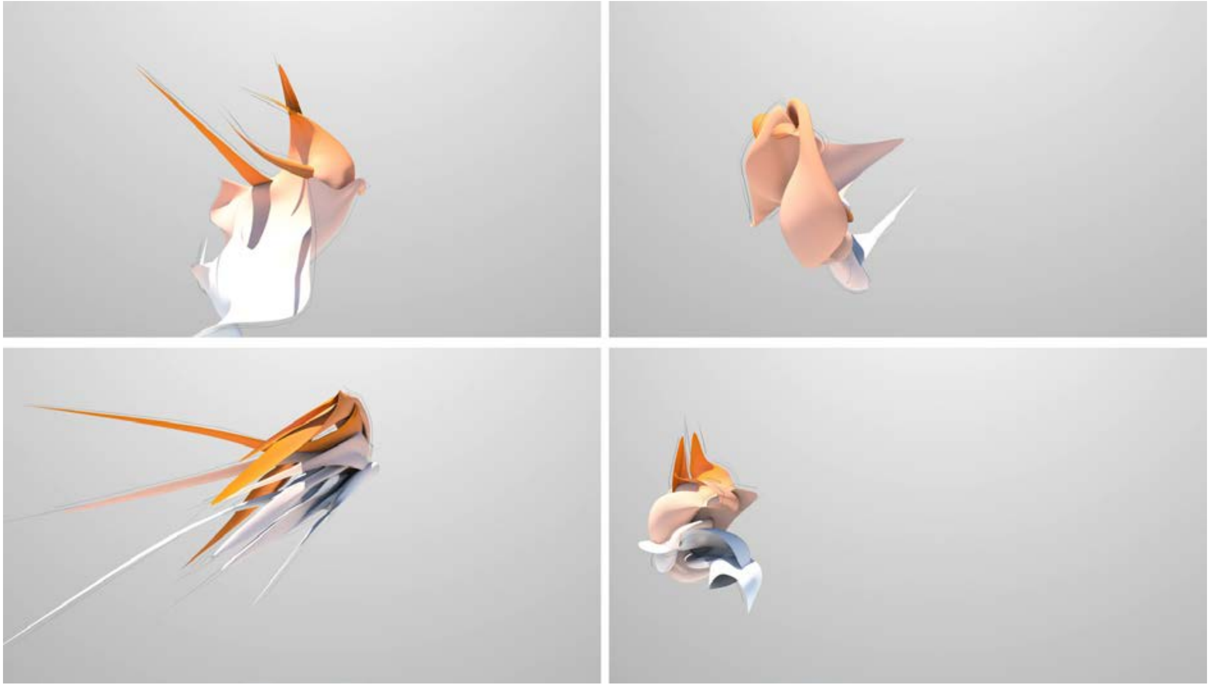

Figure 32. Second prototype

The second prototype animation can also be viewed at https://vimeo.com/90749649 or in Appendix 2.

After making the adjustments to the cloth simulation, I turned to the virtual environment in which the new abstract artefact existed. The virtual environment of a 3D software package offers the artist complete control of simulated real-world physics, presenting a nearly endless array of options and attributes that affect objects in the virtual world. To explore this aspect of the practice I created another prototype using a different set of captured data from the motion capture session. This third prototype was composed of two versions of the system. The first was a “control” animation, with no extra physics added, and the second had the cloth affected by simulated gravity and had a ground plane with which the cloth could interact.

Figure 33. Two versions of the third prototype, taken at 19 seconds

The two versions of the third prototype animation can also be viewed at https://vimeo.com/113668432 (control) and https://vimeo.com/113668782 (Virtual Environment) or in Appendices 3 and 4.

Observing the comparisons within the third prototype made it clear that the captured movement was being diluted by the addition of influences exerted on the virtual cloth by the simulated real-world physics. However, the use of a ground plane that the cloth interacts with allows for a shadow of the artefact to be displayed. This forms a visual cue for the viewer that positions the form within the void of the 3D environment and gives the object a “living quality” when in motion.

Following this prototyping, I began production of the finalised creative work with a new motion capture session. However, in contrast to past capture sessions, the movement captured for this animation was set to a musical score and choreographed to take into account knowledge of how the visual artefact might react to different types of movements. A number of takes were captured and reviewed, with the one that presented the highest accuracy in the capture selected to be applied to the generative system. Building on the observations made in the prototyping section of this creative practice, I decided to retain the captured human dance movement as the sole input affecting the movement and form of the generated artefact by running the system within the void of the virtual 3D space without using any simulated world physics like gravity or a ground for the artefact to interact with. I also created a second version of the animation that visually displayed the captured data points as part of the animation (see https://vimeo.com/102896298 or Appendix 12). This animated artwork was presented to the viewer as a means to offer context for the work they were viewing.

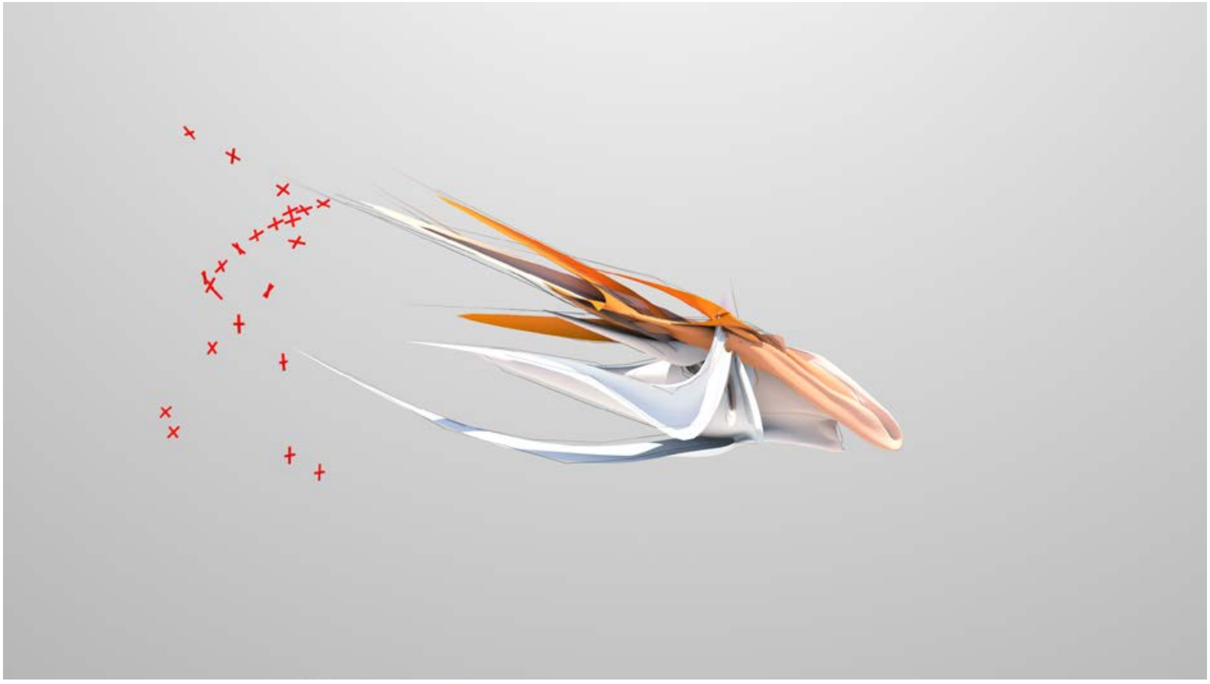

Figure 34. Contours in Motion (2013) with data points

Reflection

The third research cycle integrated theories of generative art practice (outlined in Chapter 2) into the current framework. This generated a visual artefact that is the result of the captured dance performance over a visual description of the performer's position in space and time, as has been the outcomes from the first two cycles. The hierarchy of the motion capture data points and the virtual cloth form the *entities* of the generative art system, as they both are crucial to the generative process and have definable attributes: the cloth is a 3D simulation that has a nearly endless array of attributes that affect how the cloth will react and interact with input, and the attributes of the data points are defined by the dance movements through the motion capture process. The virtual tethering (or parenting) of the parts of the cloth object to the data points is a *process* of the generative system that facilitates the computational interaction between the two *entities* (the cloth and the data points). The internal *processes* of the cloth simulation (how the cloth stretches or reacts to movement and so on) might be viewed as being part of the generative system as they impact how the simulation changes the movement data into a visual form. However, as the artist or designer of the generative system used in this practice, I do not construct the *processes* of the cloth simulation, I only set values of the simulation's attributes. Thus, the cloth simulation, in this case, is defined as a computational *entity* of the generative system whose *process* within the generative system is to convert the movement data into visual form. When the system is started, the movement data flow from the data points into the cloth simulation, resulting in a new visual abstract artefact that is a combination of both. This flow of data occurs within the virtual landscape of the 3D software. This description of how the data move through the system, along with the environment in which it has taken place, forms the *environmental interaction* of the generative system. The resulting animated abstract visual artefact that is normally experienced in a digital format forms the *sensory outcome* of the generative system. This same theory also involves how much of the generative system is revealed to the viewer; in the case of the exhibit of this creative work, visually the animation displays no aspects of the generative system that formed it. However, it was supplemented with a secondary video that contextualised the animation.

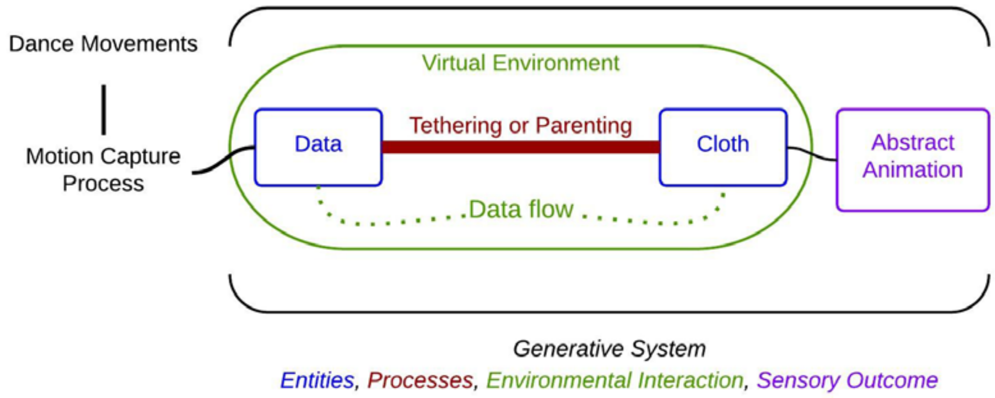

Figure 35. Design of the generative system used in the creative works

The processes of integrating generative art theories into the current framework during this practice cycle involved setting up and adjusting the cloth simulation. This process was guided by the experimental animation principles of *abstraction* and *specific non-continuity*, with adjustments made to the attributes of the virtual cloth affecting the *evolution of materiality* in the generated visual artefact. If we consider the "art" in generative art to be the creation of the system itself, then we could position the *presence of the artist* as being interrelated to the *sensory outcome*. In other words, if the resulting abstract animation communicates information about the generative system used to create it then the resulting animation would also display the *presence of the artist*. This can be seen in the second version of the major outcome of this cycle, where the data points were included in the final animation to offer context by forming a dialogue between viewer and artist and revealing a key part of the generative system to the viewer. In the third prototype, the virtual landscape of the 3D software was affected to include the simulation of real-world physics. These aspects of the simulated world can also affect the generated visual artefact or, put another way, the *environmental interaction* of the generative system could also affect the *evolution of materiality* of the resulting visual artefact.

This cycle of practice incorporated aspects of Dorin et al.'s (2012) framework for generative art into the practice of creating abstract animated short films from captured dance movements. The results from this cycle have added additional phases related to the creation of the generative system to the framework for practice. During these phases, a practitioner would define the *entities* and *processes* of the system; using theories of experimental animation, adjustments would be made to the attributes and *environmental interactions* of the system to affect the *sensory outcome*.

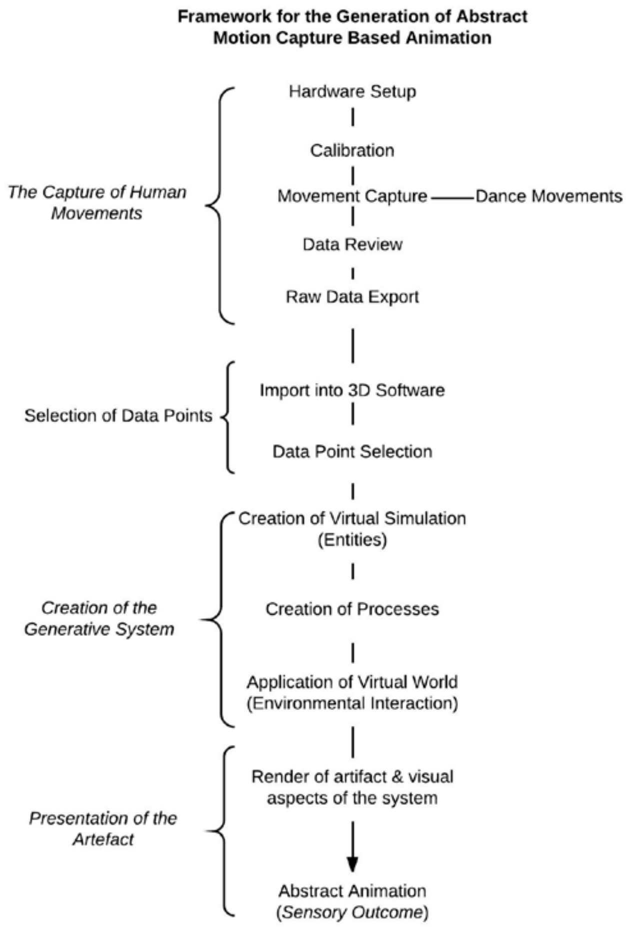

Figure 36. Version three of the framework

The creative outcome from this cycle of practice formed the “capstone project” for this research and completes the analysis section of this document. The outcomes of this analysis process are discussed in the next chapter and amalgamated into a conceptual framework for the practice of generative abstract animation derived from motion-captured dance movements.

CHAPTER 4: FINDINGS AND CONCLUSION

As outlined in the introduction, the project addressed the following research question:

How can motion-captured movement data be incorporated into the practice of creating the visual elements or artefacts that comprise abstract animated short films? More specifically, what are an abstract animator's key areas of consideration in terms of finding a balance between abstraction and the original human form or movement through the computational process? In particular, how does this inform how an abstract animator can react to the data? In addition, can a conceptual framework be developed from the findings of this practice?

This chapter discusses and synthesises the key findings from the cycles of practice outlined in Chapter 3 and, in so doing, identifies a number of key considerations and issues for practitioners when working with motion capture to create abstract animation through a generative system.

The abstract animated short films created as the practice component of this study, along with the contextual creative works outlined in Chapter 2, centre upon a common theme of the abstraction of human form and motion. Creating abstract animated short films often results in the practitioner searching for a balance between the influence of the captured human movements and the influence of the computational simulation used by the generative system to create the artefact present in the resulting animation. Another way to view this process is to think of a balance between pure randomisation (random numbers generated in or by the natural world) and computational randomisation (random numbers generated from the timing of the central processor within a computer). In practice, the search for balance is often a juggling act for the animator, who is presented with a number of options and aspects that can interfere with the captured human movement within the generative system.

Figure 37 identifies the following framework for creating abstract animation from motion-captured dance movements through a generative system.

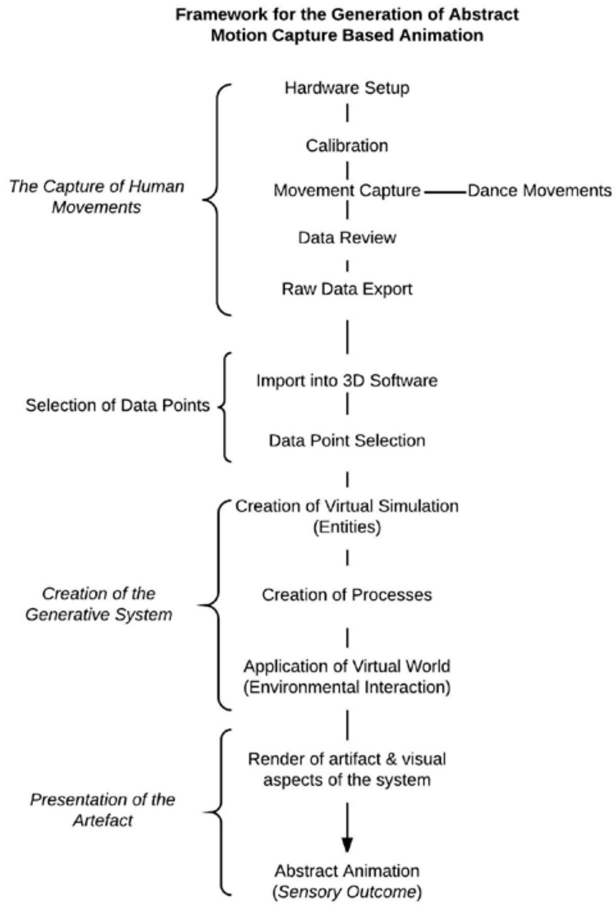

Figure 37. Framework for practice

The components of the framework are (1) *the capture of human movements*; (2) *selection of data points*; (3) *creation of the generative system*; and (4) *presentation of the artefact*. What follows is a discussion of the primary issues that arise in relation to finding a balance between the influence of the captured human movements and the impact of the computational simulation on the generation of an artefact for use in an abstract animation.

The Capture of Human Movements

The first issue any practitioner will face is the setup and use of the motion capture technology. During this component of the framework, the hardware of the motion capture technology is first set up, followed by the calibration process. Next, the capture of the performance is conducted, resulting in a number of "takes" that are reviewed both during capture and after. Once the data are reviewed, a take is selected to export for use within a 3D graphics application. When the motion capture system is first set up, the type of motion capture technology used in the practice, along with how it is set up and calibrated, is a key issue that can affect the balance of human movement and computational influences through the application of *abstraction* and *specific non-continuity* on the captured human movements.

We can consider *abstraction* as first introduced at this point in the framework as a result of just using of motion capture technology. This is because the motion capture process replaces the human form with that of the non-illustrative figures of the data points, which store and translate the real-world movements of the performer as a stream of numeric rotational variables. This translation or abstraction of real-world motion into digital form occurs through the hardware, software and the calibration of the capture system. Therefore, in theory, any changes made to the setup of the capture system outside of the normal operating procedures as outlined in the corresponding manual, or even variations in the data resulting from the use of different motion capture technologies, could affect the degree of *abstraction* and *specific non-continuity* occurring at the time of capture. The degree to which these elements affect the captured movement is displayed through the perceived quality of the capture and informs the practitioner's selection of which motion capture take to export for use in the generative system. The quality of motion capture data is largely determined by the number of artefacts introduced or created as a result of the setup and calibration of the capture system. With the measure of quality or how "dirty" the data are based on the animator's observations of the quantity of the artefacts perceived in the movements of the digital avatar. Once the capture has been selected, the practitioner can choose to retain and make use of these movement artefacts as a form of *abstraction* resulting from the motion capture process by forgoing any additional data clean-up process, which normally involves making changes to, or "correcting" the captured movements so they conform with mainstream orthodox versions of the movements, and export the selected motion capture take in its raw state. While I am not recommending the exclusive use of "dirty" data. I would argue that this phase of the framework offers an opportunity to retain any spontaneous events or "happy accidents" that might occur during the capture process, and could also offer area of approach for the practitioner to affect the human movement.

Selection of Data Points

This component of the framework forgoes re-targeting the movement onto a virtual character and continues to make use of the motion data in its raw state. This presents the motion capture take as a collection of individual data points, each constituting its own segment of captured human movement. This concept and view of the captured movement enables the practitioner to selectively use or discount individual aspects of the performance within the generative system to produce the artefact. The process of selecting which data points to use is a subjective decision and is determined by the personal intent of the artist and how the movements are perceived when presented in a segmented format. In the case of the creative works resulting from this study, the selection of data points for the output of the second cycle of practice was based on how dynamic the movement was for each individual segment of the body when presented as a collection of non-descriptive singular data points. However, the selection of data points within the final creative cycle was based on the degree of *specific non-continuity* and *abstraction* I wanted to present in the resulting artefact. Another issue that affects these aspects of the animation is the amount of influence the captured human movement has in the generation of the artefact. The number of data points selected for use within the generative system governs how much of the human movement is used by the system. Thus, if a large number of data points are selected, the resulting animation will retain more continuity with mainstream or orthodox forms of animation through an increased display of human qualities within the artefact, as seen in the outcome from the first cycle of practice. The number of data points used can also affect the *evolution of materiality* of the artefact by producing larger or more intense changes in the shape of the artefact as it evolves over time, influenced by the human movement translated through the generative system. As a consequence, the number of data points selected is a critical issue for a practitioner at this stage in the framework, as it controls the amount of captured human movement used by the generative system and informs the second key consideration for abstract animators: the retention of human form and movement.

Creation of the Generative System

In this component of the framework, the animator creates the computational system that will generate the visual artefact from the movement data stored within the selected data points. This phase positions the collection of data points as one *entity* of the generative system and requires the practitioner to create a new *entity* composed of a virtual simulation, which through its internal processes and attributes, directly impacts upon the outcome of the artefact. The practitioner also needs to create the *processes* that form the connections between the *data point entity* and the *simulation entity*. These connections allow the movement data to be transferred from the data points and into the simulation that then generates the artefact. In the first instance, the practitioner is presented with a nearly endless number of attributes, settings and, sometimes, virtual objects that comprise the *simulation entity*, which can be adjusted to affect how the entity responds and uses the movement stored in the data points. The precise nature of the attributes and objects (if any) that form the components of the system vary depending on the type of virtual simulation system used (cloth, dynamics, fluid, particle and so on). In the third cycle of practice, the *simulation entity* makes use of a virtual cloth simulation, defining attributes like stretch resistance, bounce, expansion, dampening and even if the cloth could tear (just to list a few possibilities). In adjusting the simulations influence within the generative system, the principles of *abstraction* and *specific non-continuity* are used as guides, with the adjustments made to the attributes, settings and objects of the virtual cloth affecting the *evolution of materiality* in the generated visual artefact. This highlights the influence of the *simulation entity* as another key issue for abstract animators. This issue revolves around the amount of influence the simulation system has in the generation of the artefact. The greater the influence of the virtual simulation the more diluted the captured human becomes. This, like the issues faced in the previous component of the framework, directly shapes the display of humanistic qualities within the artefact.

The simulated virtual world that the generative system runs in, or the *environmental interaction* of the generative system, can also introduce aspects of real-world physics that affect the *simulation entity* either directly or indirectly. As evidenced in the third prototype of the final cycle of practice, outlined in Chapter 3, the virtual landscape of the 3D software was changed to exert gravitational forces onto the virtual cloth object of the *simulation entity*. These aspects of the simulated world directly affect the *simulation entity*, further diluting the influence of the captured human movement on the generated visual artefact and impacting the *evolution of materiality* within the resulting abstract animation. An example of an indirect effect of the virtual world is the inclusion of other objects that the cloth simulation can interact with. In the final cycle of practice, the third prototype had a ground plane added to the environment with which the cloth could interact. This, coupled with the shadow projected onto the ground plane, not only influences the *evolution of materiality* but also affects the perception of the generated artefact by visually describing its position and interaction with the virtual environment of the 3D software package. This is a common aspect of 3D production used by 3D artists to aid in the anthropomorphisation of an object into a character through the perceived interactions of the object with the environment. Thus, these aspects of the generative system might affect the presentation of *abstraction* within the animation.

The influence of the virtual environment in the generation of the artefact is another key issue for abstract animators to consider in terms of balancing abstraction and the realistic representation of the original movement. This aspect of the generative system also affects the *interpretive forms* within the animation by providing a means for the practitioner to define the terms through which the audience interprets the work.

Presentation of the Artefact

During this component of the framework, the artefact is presented as a *sensory outcome* that takes on the format of an abstract animation designed for exhibition. The main aspect of this component of the framework is how the *presence of the artist* is presented within the *sensory outcome*. This has to do with “where” the animation will be displayed and “who” will be the audience of the exhibited abstract work, and forms the final issue for the practitioner. If we consider the “art” in generative art to be the creation of the system itself, then we could position the *presence of the artists* as being interrelated to the display of the additional *interpretive forms* within the *sensory outcome*. In other words, if the resulting abstract animation communicates information about the generative system used to create it then the resulting animation would also display the *presence of the artist(s)*. This can be seen in the second version of the major outcome of the third cycle of practice, where the entirety of the *data point entity* was visually included in the final animation and exhibited alongside the completely abstract version. This revealed a key part of the generative system to the viewer as a guide to interpreting the animation. Moreover, a dialogue between viewer and artist was formed. If and when this might be required is once more a subjective decision and depends on whether or not the animator wants to guide the viewer in understanding and obtaining meaning from the work, or whether he or she wants the viewer to form their own conclusions. A possible factor that could influence this aspect of the framework is the degree of human form that is already visible in the resulting artefact, as this might already display enough visual information for the viewer to understand that the resulting animation is made with captured human movements.

Conclusion

This study set out to investigate strategies and a systematic approach for animators when using motion capture technology to produce experimental abstract animation through a generative system. This study was undertaken through the creation of three abstract animated short films, each of which represented a discrete segment of the action research cycle based on the Kemmis−McTaggart action research model. Each new cycle within this model built upon the accumulative knowledge of the pervious cycles that was generated through reflective practice taking place both during and after the creative practice. As illustrated in the graphic below, this research was conducted at the intersection of three conceptual domains: motion capture, generative art and experimental animation.

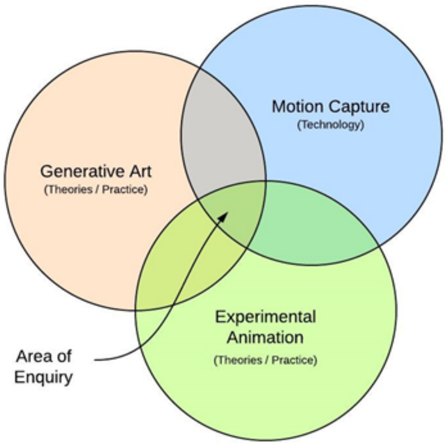

Figure 38. Area of enquiry

To incorporate the three bodies of knowledge into the project's cycles of practice and to define the practice as Motion Data-based Experimental Generative Animation, I took on the paradigm of an abstract animator who is presented with a new piece of technology. This positioned motion capture, or more precisely the outcome of motion capture (the digitalised human movements or *motion data*), as a new creative tool to be used in the production of abstract animated short films, as displayed in Figure 39.

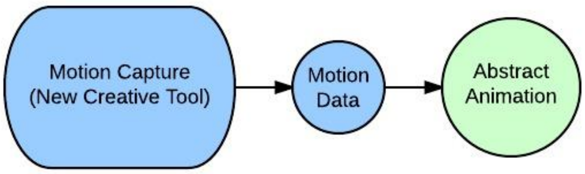

Figure 39. Structure of Practice A

To explore this technology for the purpose of creating abstract animation, theories about experimental animation were drawn upon and incorporated into the practice (see Figure 40). More specifically, the aim of the practice was to produce abstract visual artefacts that adhere to the principles of abstract animation. These visual artefacts are based on aspects of Wells's 1998 definition of experimental animation and resist the structure of mainstream orthodox animations created using motion capture.

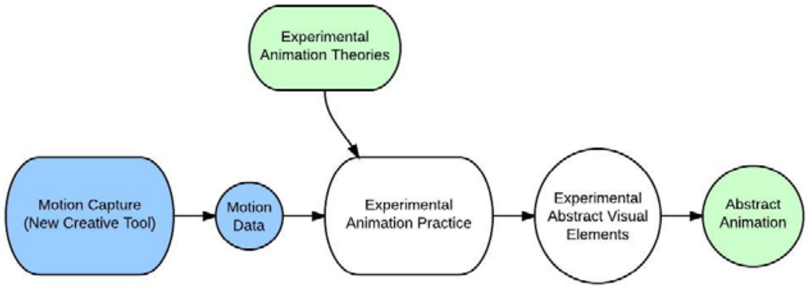

Figure 40. Structure of Practice B

Experimental animation was then mixed with processes common to generative art as displayed in Figure 41. This process resulted in the abstract visual artefacts produced through the use of a computational system. This system was composed of autonomous *entities* and *processes* connected through *environmental interactions* to produce *sensory outcome* from the motion data or seed data.

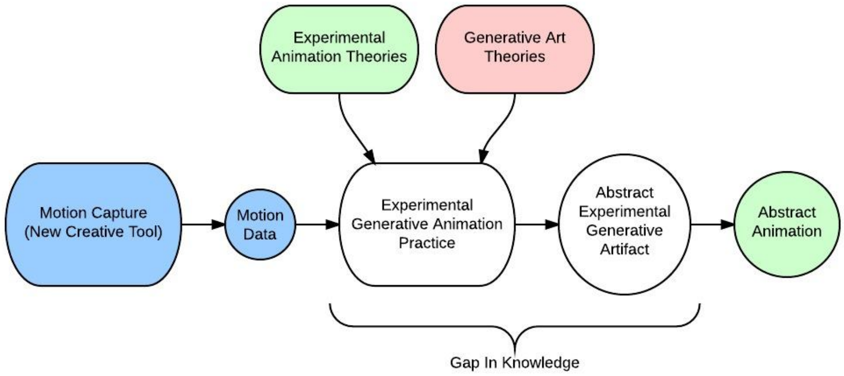

Figure 41. Structure of Practice C

As such, in reconceptualising the three domains of knowledge into practice, the study responded to a gap in knowledge in relation to a lack of defined processes and approaches for creating abstract visual artefacts from motion-captured human dance movements for use in the production of abstract animated short films.

The investigation undertaken in this study took the form of three main cycles of practice. The first cycle of practice aimed to create an animation that mimics the mainstream trends of abstract animation that uses motion-captured human movements. This cycle developed a clear understanding of the motion capture system and processes needed to perform capture, along with establishing a software pipeline. In the second creative cycle, the practice started to diverge from recent trends in abstract animation that uses particle point clouds as a visual describer of the full-body capture, instead exploring the motion data itself and how individual points of data might be used to create abstract artefacts. This cycle resulted in a completely abstracted outcome that was visually devoid of human form and also brought to light the concept of viewing the capture movements as a collection of segmented data points that could be individually used in the creative process. The third cycle of practice was the turning point in the study and involved the incorporation of generative art theories and processes into the practice to transform the captured movements into an abstract visual artefact that goes beyond simple abstract data visualisation. This cycle resulted in the final capstone abstract animated short film of the study and completed the framework for practice by positioning processes related to generative art at the heart of the practice. This in turn impacted the application of experimental animation principals within the practice and brought to light the main aspect of this type of practice: finding a balance between the human and computational influences within the work.

This research identifies five key considerations for abstract animators attempting to balance the influence of the captured human form and movement with the influence of the computational simulation within a generative system when engaging with motion capture technology for the purpose of creating abstract animated short films. *First*, the *Capture of Human Movement*, the type of motion capture technology used along with how it is set up and calibrated, can drastically impact the movement data along with what movements can be captured. Furthermore, if these captured movements are then adjusted after the capture session is completed, or if the movements are exported as raw motion capture data, this can also impact upon the outcomes. *Second*, in terms of the *Retention of Human Form and Movement*, main aspect impacting this consideration is the amount of captured human movement used by the generative system. This is governed by the number of data points the practitioner selects for use within the generative system, with the selection process facilitated by the importing of raw motion capture data into the 3D software package. *Third*, in terms of the *Influence of the Simulation*, the greater the influence of the virtual simulation the more diluted the captured human becomes in the generated artefact. This, like the second key consideration, directly affects the display of humanistic qualities within the artefacts that compose the animation. This is facilitated by changes made by the practitioner to the attributes of the simulation system with the precise nature of the attributes defined by the type of simulation system used within the generative system. *Fourth*, the *Influence of The Virtual Environment* deals with the aspects of the simulated virtual world that the generative system exists in. These aspects can dilute the captured human movements either directly, through forces such as gravity and air density, or indirectly through the simulation entity interacting with other objects within the virtual environment such as the ground or even other entities. The virtual environment can also affect the perception of the artefact by presenting the artefact as a virtual character through its interactions with the simulated world. *Fifth*, the *Visual Connection to Practice* takes into account what is communicated to the viewer about the generative system within the abstract animation as a guide to interpreting the animation. This consideration can offer context to the audience and form a dialogue between viewer and animator. The aspects of the generative system selected to be revealed to the viewer can further humanise the resulting animation; however, aspects of this consideration can also be the result of decisions made in relation to the other five considerations as well as the purpose or meaning the animator wishes to convey through their work.

While this study provides a number of key insights into the processes and concepts that are situated at the core of creating abstract animated short films through a generative system from motion-captured human dance movements, there are numerous areas that require further research. One such area is mapping the locations and methods for abstracting captured human movements during the production processes of abstract animation. In Chapter 2, three creative works are overviewed, each with a different technology or method of capturing human movements. This leads to the question of how does this different technology and its methods affect the abstraction of movement and form presented within the resulting abstract animation. In addition, what does the motion capture process itself offer in terms of methods and locations of abstracting movement and form? For example, could the hardware and software of the motion capture system be manipulated to interfere with the perception of “the body”? This could effectively allow for an abstraction of the form and movement at the time of capture to generate different visual outcomes. Moreover, this study only scratched the surface of the possible effects and outcomes of not only the different types of virtual simulation systems, but also the effects of different combinations of the settings and attributes within the simulation system and how these might impact the generated artefact. The practice segment of the study also only made use of one performer, one collection of data points and one virtual simulation at any given time. As a consequence, another area of future research is the effect of using multiple performers and multiple entities on the artefact and the aforementioned key issues for the practitioner.

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Examinable Abstract Animated Short films

1. **Experiment One.**

   URL: https://vimeo.com/65520382

   Digital File: *CW1 Experiment One.mp4*

2. **Experiment Two**

   URL: https://vimeo.com/59875110

   Digital File: *CW2 Experiment Two.mp4*

3. **Contours in Motion**

   URL: https://vimeo.com/78791613

   Digital File: *CW3a Contours in Motion.mp4*

Appendix

1. **Contours in Motion: First Prototype**

   URL: https://vimeo.com/69594321

   Digital File: *AP1 Contours in Motion - First Prototype.mp4*

2. **Contours in Motion: Second Prototype**

   URL: https://vimeo.com/90749649

   Digital File: *AP2 Contours in Motion - Second Prototype.mp4*

3. **Contours in Motion: Third Prototype (Control)**

   URL: https://vimeo.com/113668432

   Digital File: *AP3 Contours in Motion - Third Prototype - Control.mp4*

4. **Contours in Motion: Third Prototype (Virtual Environment)**

   URL: https://vimeo.com/113668782

   Digital File: *AP4 Contours in Motion - Third Prototype - Virtual Environment.mp4*

5. **Creative Work: Animated Kolam Patterns**

   URL: https://vimeo.com/70457762

   Digital File: *AP5 Animated Kolam Patterns.mp4*

6. **Motion Capture Session: First use of suit**

   Digital File: AP6 *MoCapS1 First use of suit.mp4*

7. **Motion Capture Session: Capture for third animation**

   Digital File: AP7 *MoCapS3 Contours in Motion - Capture take 3.mp4*

8. **Motion Capture Session: MVN Studio Avatar**

Digital File: AP8 *MoCapS3 Contours in Motion - view in MVN studio.mp4*

9. **Motion Capture Session: Experiment One No Post-Production**

   Digital File: *AP9 Experiment One - no post production.mp4*

10. **Creative Work: Contours in Motion In Software**

    Digital File: *AP10 Software View.mp4*

11. **Creative Experiment Two in Motion In Software**

    Digital File: *AP11 Software View.mp4*

12. **Contours in Motion With Data Points**

    URL: https://vimeo.com/102896298

    Digital File: *AP12 Contours in Motion with Data Points.mp4*