Adopting Virtual Production For Animated Filmmaking

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Abstract—Virtual Production is a rapidly growing approach to filmmaking that utilises 3D software, virtual camera systems and motion capture technology to visually interact with a real-time virtual environment. The use of these technologies has continued to increase, however, little has been done to document the various approaches for incorporating this new film making technique into a production.

This practice-led research project outlines the development of virtual production in the entertainment industry and explores possible strategies for adopting aspects of this new film making technique into the production of short animated films. The outcome is an improved understanding of possible strategies that could be utilised to assist producers and directors with the transition into this new film making technique.

Animation; Film; Virtual Production; Virtual Moviemaking; Motion Capture; Performance Capture; Virtual Performance; Virtual Environment; Virtual Camera; Virtual Scene; Live-action; Real-Time.

I. INTRODUCTION

Virtual Production is a new film making technique that utilises real-time 3D computer graphics, virtual camera systems and motion capture technology to visually explore, define and communicate creative ideas. Through the use of virtual production, filmmakers can visually interact with a 3D virtual environment, which allows them to make decisions about the production process and the ability to implement these decisions in real-time, much like a live-action production [1].

James Cameron’s Avatar [2] is considered the “birthplace” of virtual production. To create Avatar, James Cameron’s team developed new technologies and techniques for incorporating motion capture and virtual cameras into the production process with the aim of permitting the director to work with digital beings in a manner more closely aligned to live-action film making [3]. This paper documents our experimentation with similar technologies as those used on Avatar for the production of three short and low budget animated films.

A. Research Problem

Virtual Production is a relatively recent development in film making, which has been utilised across a range of different projects such as film, TV, Games and live performance. Despite the rapid growth of this film making technique and improved accessibility to required technology, little has been done to outline the various approaches for incorporating this new film making technique into a production pipeline. This research contributes to closing this apparent gap by exploring and documenting possible strategies for using motion capture in the production of three short films (within the context of virtual production).

B. Central Research Question

This practice-led research project responded to one central research question:

‘What strategies can facilitate the adoption of virtual production into a production pipeline for short animated films?’

C. Aims

In response to this central research question, this research project set out to identify, explore and test a range of strategies for using virtual production with an emphasis on motion capture for animated filmmaking.

Objectives:

- Create one film that compares and contrasts hand keyed animation with motion captured performance.
- Create one film that explores typical character actions used to learn character animation including push, pull, lift and jump.
Create one character driven narrative film that uses motion capture as the primary means of recording human performance.

II. METHODOLOGY

A. Practice-led Research

This practice-led research project utilised qualitative methods commonly associated with reflective practice to generate research data. That is, this project was carried out through the practice of creating animated works incorporating virtual production as the primary production methodology. This approach aligns with Carole Gray’s definition of practice-led research, which according to Gray, allows questions, problems and challenges to develop through and within the creative practice [5].

B. Reflective-based Analysis

Reflective-based analysis was used as the primary means for analyzing research data [6]. Reflective-based analysis allows the practitioner to develop an understanding of the methods and strategies ingrained in the practice. Therefore, this method of research provided a means to gain new understanding about virtual production that has yet to be defined.

Practice-led research and reflective-based analysis are iterative research methods that follow the Kemmis-McTaggart action research model. This entails planning, actioning, observing and reflecting on each research cycle. Using this method ensures that new questions, problems and challenges will arise with each cycle of practice [7].

C. Research Design

An action research cycle incorporating three cycles of creative practice were used to conduct this research. This research design was based on Kemmis-McTaggart’s Action Plan Research [7] shown in figure 1.

Each research cycle responded to a clear plan of investigation:

- Cycle 1 focused on developing an in depth motion capture plan that included the movements needed to capture for each scene, how many iterations of these movements would be captured and the overall time for each movement.
- Cycle 2 used a performer that had no prior knowledge in motion capture and animation to test the limitations of working under such arrangements.
- Cycle 3 tested the process of retargeting motion capture data onto a custom 3D character, which was not developed to handle motion capture data.

D. Documenting the Research

A short documentary video was used as the primary means of documenting the research process. This process of reflection helped further refine the analysis of each strategy and informed each step in the next iteration of the action research cycle.

III. LITERATURE AND CONTEXTUAL REVIEW

A. Virtual Production

Virtual production is rising in popularity because of the increasing use of computer-generated characters and visual effects in films. Filmmakers want to be able to scout locations or direct a performance of characters regardless of whether they are real or virtual.

Prior to contemporary postproduction technologies, if a director wanted to shoot a special effect or add a creature to a shot they would have to figure out a way to shoot it on camera. This imposed limitations on what could be realistically achieved. Early techniques developed by visual effects artists such as Ray Harryhausen made it possible to combine animated creatures and characters within the same diegetic space as live action actors, however, the director had very little control over the effect as live action performance and animated characters were separate processes.

By the late 1980s high-resolution image scanners and high performance computers made it possible to create more realistic visual effects. Thanks to Computer-Generated Imagery (CGI) it was now possible to create what had long been considered impossible. Despite the advantages of CGI, much like the earlier techniques, live action recording and character animation were still separate parts of the creative process. The director would only be able to
review the pre-rendered shots for approval, thus removing the creative process and control of the outcome of the visual effects [1].

One of the first films with CGI was *Westworld* [8], they used two-dimensional computer images to give the infrared point of view of Yul Brynner's gunslinger. The frequency of CGI effects in films continued to increase over time to eventually become prolific. By 1995, PIXAR animation released the first CGI feature length film, *Toy Story* [9].

The increased use of digital visual effects resulted in a need for more effective planning and visualisation as a part of the creative process. Preparation and planning of the visual effects, creative ideas and identifying credible problems before going into production enabled the director to have greater control in achieving the final result. This process is more commonly known as pre-visualisation (previs). Despite the benefits previs provides to the director, there was still no correlation to the post-production stage, impeding the director from being involved in the direct outcome of the visual effects [1].

Virtual production solves the issue of the director being disconnected from creative process because it is an interactive and iterative process that starts with previs and continues through to post-production. Virtual production differs from traditional CGI because it is driven by the director in real-time, as opposed to being done by animators and artists in post-production. This allows the director to make creative decisions regarding the film on set rather than waiting for an indefinite period for the CG shots [10].

Now with the use of virtual production, CGI and visual effects shots can be experienced more like a live-action shoot, yet still offer creative flexibility because they are based in a virtual world. Due to the flexibility, virtual production is gaining traction with a broader range of film production professionals from directors, art directors, cinematographers and visual effects supervisors.

Today, virtual production technology is being pioneered by directors working on large-scale blockbusters, some of these include *Avatar* [2], *The Adventures of Tintin* [11], *Rise Of the Guardians* [12] and *Wreck-It Ralph* [13]. These directors and their production studios are already designing and building digital capture volumes. Today, the technology is mainly used by large-budget productions. However, given the rapid evolution of computer performance and its capabilities, virtual production will likely become more accessible to a broader range of production budgets.

The most prominent large scale production is *Avatar* [2] because it is considered to be the birthplace of virtual production. Together with a team of technicians, James Cameron pioneered this new film making technique in *Avatar* by bringing together and further developing key technologies that could provide the creative freedom he required when working within a virtual world [3].

One of the key technologies developed for *Avatar* was a custom tablet computer that could see into the virtual world of Pandora. This technology is what makes virtual production possible as it allows the director to see the actors as aliens within the CG set in real-time. This technology makes filming a virtual world interactive, nonlinear and can span the whole production [14].

*Avatar* [2] set the stage for virtual production however movies like *The Adventures of Tintin* [11] further explored the possibilities of this new film making technique. In *The Adventures of Tintin* a complete 360-degree virtual world for each location was developed before any filming took place. This allowed the director, Steven Spielberg, to scout locations for each shot much like you would in a live-action film [15].

Virtual production uses a range of technologies from the film production and gaming industries that were originally independent. The synergy of using these technologies in conjunction with each other resulted in a revolutionary new interactive film making technique. These technologies include motion capture and virtual cameras, without either of these technologies virtual production would not be possible. Whilst virtual production as a
production concept is only new, these technologies have been developing over the last few decades.

B. Motion Capture

Motion capture involves measuring an object’s position and orientation in physical space and then recording said information for the use in a virtual world that is developed through 3D programs on computers. In most circumstances a performer is used to capture data. However, motion capture is not limited to capturing the movement of the performer [16].

C. Types of Motion Capture Systems

There are many different types of motion capture systems. However, the most prominent systems available are mechanical, magnetic, optical and inertial.

1) Mechanical Motion Capture: Or often referred to as exoskeletons are a skeleton like structure that attaches to the performer’s body and as they move the mechanical parts measure the relative motion and transmit the movement in real-time. Mechanical systems are commonly used in the medical industry [17].

2) Magnetic Motion Capture: Uses a series of sensors that magnetically measure the relationship in space to a nearby transmitter. The sensors are commonly placed at each joint on the performer to capture appropriate movement. This system is susceptible to electrical interference from metal objects and electrical sources within the environment. Magnetic systems are rarely used today as optical and Inertial systems are more effective [17].

3) Optical Motion Capture: Uses a series of reflective markers which are tracked by a number of digital cameras to triangulate the position in relative space. The cameras are calibrated to capture a specific area called the digital volume. The size of the volume is proportionate to the number and quality of cameras used. Optical systems are the most prominent in the entertainment industry because they have the ability to capture facial movements, finger movements and multiple performers. It has no real limitations to the objects it can capture, ranging from bipeds to quadrupeds and even inanimate objects. However, it is currently the most expensive system when compared to the alternative systems available [18].

D. Virtual Cameras

Filmmakers use cameras to record the visual images in the form of movie film to capture the performance of their actors. Virtual cameras are very similar to cameras that are used in film; however, virtual cameras are used within the virtual world to capture the performance of the virtual characters.

A virtual camera can be controlled in the virtual world using a tangible object or familiar device such as a modified camera body. The movements of the camera are then captured using motion capture and
displayed in the virtual world in real-time. This allows performers and filmmakers to shoot digital performances in ways that are intuitively similar to live-action shooting [19].

Figure 7. Game Caster, Intersense and Opti-Track Virtual Cameras.

IV. RESULTS AND ANALYSIS

What follows are the results and analysis of the three action research cycles used in this study.

A. Practice Cycle 1: Comparison

1) Plan: The overall plan for this cycle was to create an animated short film that compares and contrasts standard animation with motion captured performance. Standard animation is a term adopted for this study to describe an animation technique where the animator would develop a character’s movement by hand. Motion capture data removes this process because you have already captured the movements of a character by using a performer and motion-capture technology. However, the captured data is often imperfect and abundant, which pushed computer memory to its limits and often looks messy. There may also be parts of the character missing from the data capture such as hands and feet. Consequently, motion-capture data needs to be reduced, retargeted onto a character and then cleaned up by an animator. For example, the systems utilised throughout this research captured massive quantities of data yet were unable to capture facial or finger movements, so standard animation was required to achieve the final performance that is shown in the animated short films.

The process of this animation was to develop 4 animation loops for standard animation and virtual production. These were limited to 4hrs of production time and included a jump, walk, push and lift. During the development of these loops the following strategies were used to test their impact on the production pipeline.

- Development of an in-depth motion capture plan.
- Working with a performer with no prior knowledge in motion capture or virtual production.

2) Act/Observe: The first strategy was the implementation of an in-depth motion capture plan during the motion capture session that would develop into animation loops. This plan included the movements needed for capture of each loop, how many iterations of these movements would be captured and the overall time needed for each movement. This plan helped optimise the use of the motion capture technology and ensured that the system would only need to be utilised for one session.

The second strategy was using a performer that had no prior knowledge in motion capture and animation. Overall the performer only required a short induction into the system and a period of time to explore their movements and how that translated into the virtual world. This strategy had a slight impact on the motion capture session due to the time required to train the performer and directions required to capture the appropriate movements to develop into animation loops.

The final strategy explored involved working with a non-standardised character that was not developed for motion capture data. The process of applying motion capture data to a virtual character is called retargeting and these virtual characters are not always designed to handle the retargeting process. This strategy proved to be difficult; however, a solution was found by using a custom tool in the form of a MEL Script [20]. This tool allows motion capture data to be applied to any custom 3D character in 3D software used throughout this study.

3) Reflection: Upon reflection it was found that using an in-depth motion capture plan ensured that all the require motion was captured during the first capture session and eliminated any additional costs for setting up a second capture session. Overall this animated short was only a test and proved to be extremely short which actually prevented the audience from appreciating the quality of motion-capture that was showcased. To rectify this issue, in the second research cycle, the short film was designed to be over one minute and focused on a story driven narrative.

4) External Link: https://vimeo.com/70713528
B. Practice Cycle 2: The Next Meal

1) Plan: The overall plan for this cycle of practice was to create an animated short film that explored typical character actions used to learn character animation. These included a walk, push, pull, lift and jump action developed in the context of a character driven narrative.

The process of this animation was to develop a narrative, which included 5 animations that are normally used to develop an understanding of character animation. A simple narrative was developed in order to keep the focus on virtual production.

During the development of this short film an in-depth motion plan strategy was used due to its success in the first research cycle. The following strategies were used to test their impact on the production pipeline.

- Working with a performer with prior knowledge in motion capture or virtual production.
- Working with separated motion capture tracks for each scene or shot.
- Increasing the audiences engagement to showcase what is possible with virtual production.

2) Act/Observe: The first strategy was working with a performer with prior knowledge in motion capture or virtual production unlike our first animation when we worked with a performer with no prior knowledge.

The second strategy was exploring the impact of separating the motion capture data into individual tracks for each scene or shot and seeing how that would affect the clean-up process. These scenes or shots included the intro, walk, push, jump, lift, pull and ending.

The final strategy was trying to increase the audience’s engagement through a range of different techniques. These techniques included development of dynamic camera movements within postproduction, commissioning a sound designer to develop sound and music for the animation and developing and creating a virtual environment to further engage the narrative of the animation.

3) Reflection: There were obvious benefits to working with an experience motion capture performer, the capture session remained tightly focussed on the animation and removed any need for induction to the system. Overall the outcome of this animated film was a strong representation of what is possible with virtual production. The whole production was completed within one week.

Following a process of splitting the motion capture into separate files reduced the load on the computing system. This removed many of the complications within the production pipeline that were experienced in the first cycle of practice.

C. Practice Cycle 3: Crystalised

1) Plan: The overall plan for this cycle was to create an animated short film that featured one character in an abstract story driven narrative using motion capture as the primary means of recording human performance.

The process involved collaboration with the performer in developing an abstract story driven narrative. This production was started with very little preproduction planning. Only a vague idea on the story and central idea around humankind’s curiosity and our pursuit for knowledge were taken into the creative process. Working collaboratively with a performer, we developed a narrative around a crystal and captured the scene after the story was finalized.

The following strategies were employed to test their impact on the production pipeline.

- Using a standardised virtual character that was developed for motion capture data.
- Working with large motion-capture tracks.

4) External Link: https://vimeo.com/71195615
• Working with a Virtual Camera.

2) Act/Observe: The first strategy was working with a standardised character that was developed for motion capture data. Working with a non-standardised virtual character was explored in the first animated short and proved to be difficult but achievable. This strategy tested the benefits of working with a standardised character that was developed to handle retargeting. The character chosen utilised a feature in the software that is referred to as Human IK.

The second strategy was exploring the impact of not separating the motion capture data into individual tracks and keeping it as one track for the whole animation.

The final strategy was working with a virtual camera to be fully immersed in the virtual production process. This process was completed in a separate motion capture session. Unfortunately, there were complications in this session with the rotation of the virtual camera. To rectify this complication the final outcome of the camera was a combination of the data captured and standard animation within the 3D program.

3) Reflection: By not separating the motion capture data major problems surfaced throughout the development of the short film. This indicates that motion capture data should be separated into each movement or scene. The main problem caused by working with large files was the impact it had on the computer performance, with such a large file the computer was constantly struggling to process the data in real-time which impacted the production efficiency.

Using this character combined with the Human IK feature was more effective and more intuitive than working with a non-standardised character due to the features available to help the clean-up process.

Overall the outcome of the short film was very successful and proved that separating motion capture tracks will help a production.

![Figure 10. Crystalised Creative Work](https://vimeo.com/74420084)

4) External Link: [https://vimeo.com/74420084](https://vimeo.com/74420084)

D. Documentary

Throughout the development of this research a short documentary series was filmed to visually support the theory and increase the understanding of how virtual production can be adopted into a production pipeline.

External Link: [http://goo.gl/rGW3jr](http://goo.gl/rGW3jr)

V. CONCLUSION

This research set out to explore virtual production and strategies that could be used to assist filmmakers to adopt this new film making technique into a production pipeline. This was achieved through the development of 3 animated short films that utilised virtual production and explored possible strategies that could be used to help with its adoption.

The most significant strategy that was discovered was developing an understanding of the advantages and disadvantages of the motion capture systems available. This strategy would establish a strong foundation for virtual production and understanding what is possible. However a range of strategies were tested and some yielded positive results and some negative.

Positive Strategies:  
- Development of in-depth motion capture plans.
- Working with a trained professional performer.
- Working with standardize characters designed for motion capture data.
- Working with a virtual camera.

Negative Strategies:  
- Working with an untrained professional performer.
- Working with large motion capture files.
- Working with non-standardized characters that were not designed for motion capture data.

Virtual production offers greater creative options and fosters a new collaborative and interactive environment to explore the filmmaking process.
This impact is not only felt by the director but also across all departments and all levels of production. However we are still only scratching the surface on what is possible with virtual production.

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REFERENCES