# Interactive Art, Immersive Technology and Live Performance

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# Certificate of original authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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# Abstract

This research explores the impact of combining interactive art and immersive technology with live performance. An interactive system was designed to combine the movement of human performers with physical simulations in order to generate complex visualizations that respond to the performers in real-time. This system was used prominently in a series of live performances including dance, music and physical theatre. The performances and system evolved symbiotically throughout this practice-based research. The capabilities of the interactive system was inspired by the demands of each live performance and, in turn, each performance was inspired by the evolving capabilities of the system. A number of immersive technologies including 360 degree stereoscopic visuals, surround sound and physical modeling were added to the system and explored within the context of live interactive performance.

Self-reflections of the researcher's role as interactive artist and technologist is provided. These reflections suggest that the underlying system should be built as flexible and as scalable as possible to cater for different sized venues and budgets. A basic framework is provided for building such a system, utilizing open source software, pre-existing hardware and the flexibility of modern network architectures.

Two major works are examined in detail, a physical theatre show and an immersive installation, both paying homage to the classic Australian children's novel, *Dot and the Kangaroo.* Interviews with the performers, artists and key contributors of these productions were conducted. These interviews were analyzed using grounded theory techniques to gain insights into the use of interactive and immersive technologies within the productions and how it impacted their professional craft.

The interactive technology was found to bring an element of 'aliveness' to the visuals, but were most successful when tightly integrated with the physical choreography to portray a specific part of the narrative. The interactive components were perceived to assume many different roles within these productions including that of character, digital set, theatrical mask and lighting state as the artists attempt to identify with the technology through their own personal knowledge base and expertise. The 360 degree visuals of the interactive installation immersed the participants in a digital depiction of the Australian bush, and invited a sense of exploration and play. The large scale installation allowed multiple children to experience the work simultaneously, while live actors promoted a richness of movement and facilitated social interactions amongst the participants.

The artistic productions, technological system design and findings based on interviews, analysis and self-reflection are presented as contributions towards the relatively unexplored intersection between interactive art, immersive technology and live performance.

# Chapter 1

# Introduction

## 1.1 Introduction

This thesis explores the combination of interactive art and immersive technology with live performance. The interactive art explored in this thesis is focused on human to computer interaction where the physical movement of the human provokes an observable reaction in the computer's audio-visual display. The immersive technology, commonly associated with virtual reality, attempts to induce a state of 'presence' where the participants may believe that they are inhabiting some other virtual environment. This research is concerned with combining movement-based interactive art and immersive technology with the artistic practices of dance, theatre and live music performance. There is considerable literature examining interactive technology in the field of musical performance, as covered by the long running *New Interfaces for Musical Expression* (NIME) conference, a growing body of research around interactive technology in dance performance that has sparked the *Movement and Computing* (MOCO) conference and a large body of research around immersive technology in the fields of virtual and augmented reality. While there has been extensive research into many of the possible permutations of any two of these three fields, there has been relatively little examination at the intersection of all three.

This practice-based research aims to develop an understanding of how these three elements can be creatively combined and the effect that this combination has on each individual element. To understand how these elements can be combined, an immersive and interactive technological system is built and a number of live performances and interactive art works are collaboratively created with professional artists. The effect that this technology has on the practice of the professional artists and performers involved in these works is examined.

The aim of this research is to explore the combination of interactive art, immersive technology and live performance.

In order to achieve this aim, the following objectives have been identified:

- To create a technological system with immersive and interactive capabilities suitable for use with live performance.
- To use the system to develop performances and artworks that combine interactive art, immersive technology and live performance.
- To examine the effect of combining these fields on the development and production of these performative works.

## 1.2 Background

The work presented in this thesis is largely a combination of my own personal skills and interests in technology, musical performance, physical movement, visual animation and spatialization. After completing a Bachelor of Computing (Computer Science) at Monash University in 1996, I entered the workforce as a budding software engineer working on large industrial CNC grinding machines. While it was a steady job with reasonable pay, developing a product that I had no interest in actually using soon became tiresome and, after a year, I set off overseas in search of adventure. I found myself living and working in a backpackers hostel in the Southern Bohemian region of the Czech Republic in 1998 where, free from any career pressures, I could pursue more creative endeavors. Armed with a second hand PC and some old lectures notes, I ambitiously set about creating an audio/visual digital synthesizer where the music composition, sound synthesis engine and visuals were all driven directly from a unified 3D model. The system I built was able to draw some simple 3D objects and create simple synthesized sounds, but the single core Pentium 4 computer lacked a dedicated graphics or sound processor and in no way measured up to my ambitious aspirations for the project.

I returned to Sydney in 2000 and reconnected with my professional software engineering career, being careful to only work for companies that produced products that were of interest to me. This included creating audio and video post-production suites at DSP Media, AV Media & Fairlight, live television broadcast technology at Evolution Broadcast and theatrical lighting consoles at Jands. These were all very good jobs and I undoubtedly met interesting people through this work with whom I am still friends today. While these software products were used in the production of creative projects within the entertainment industry, unfortunately, the products themselves were merely tools and were not particularly creative or entertaining in their own right. Perhaps this is to do with the particular period of history when digital was only just becoming an industry standard, and it seemed like the main design imperative in these companies was “Here is some old analog gear that has been used in the industry for years, make a digital tool that does the same thing.” There was little to no exploration of what the new digital tools could creatively add to their mediums, they were simply a cheaper and faster alternative to the trusted analog product. This attitude was not born of laziness or lack of aspiration, but an actual design decision. Although it was obvious that the digital revolution was here to stay, there was a general consensus in the entertainment technology industry that people didn’t like such a radical change. We were instructed to replicate the established analog workflows as much as possible.

Finding this attitude and the products that they created somewhat underwhelming, I sought creativity in other areas. In 2003 I was inspired by the animation boom following Pixar's *Toy Story* and believed that this style of 3D animation had a natural affinity with stereoscopic 3D viewing. I developed a stereoscopic 3D renderer for the popular animation package 3DStudio Max and began modeling and animating in my spare time with aspirations to create a short film. Although making some progress towards this film, the animation process was very time consuming and progress was eventually halted to cater for escalating work commitments.

During this period I was also training in Shaolin style Kungfu and Tai-chi, and managed to obtain a black belt and become a senior instructor. My martial arts studies included extensive weaponry training, animal-style fighting methods and simple acrobatics. This martial arts training has provided me with both a respect and appreciation for movement-based art forms, inspiring my interests in motion capture and physical live performance.

In 2010, I quit my full time software engineering job and started the brand new Bachelor of Sound and Music Design degree at the University of Technology Sydney. This degree was a combination of music composition, sound design, sound engineering, sonic art and interactive technology. During this degree I began to explore spatialized sound, composing a dystopian 5.1 electroacoustic piece *The Post-Industrial Frogscape*, and developed a 10 channel cubic spatializer to enable the real-time horizontal and vertical panning of electroacoustic bird sounds in a one hour live performance entitled *Whips and Tendrils.* I used my software skills to explore technologically driven participatory works, creating the *Mobile Phone Orchestra* which creates a collaborative music composition using multiple iPhones and small samples of the participant's iTunes music library. I also combined my passions for Kungfu and Tai-chi to create simple interactive installations using a Microsoft Kinect camera (*The Art of Martial)* and multiple Android tablets (*Wagnerlicht).*

After a guest lecture by Andrew Johnston in which he showcased his initial experiments into interactive dance, I began work experience with his collaborators at Stalker Theatre. This included the development, rehearsals and debut performance of the 2012 work *Encoded.* Excited by the fluidity and complexity of movement exhibited by both physical performers and the interactive system in this piece, I wanted to explore its creative potentials even further. With a shared passion for sound exploration and the field of virtual instruments called New Interfaces for Musical Expression, I worked with Johnston to convert the interactive fluid software into an audio-visual instrument with a very simple granular synthesizer. The power of combining movement, sound synthesis and visuals was creatively intriguing and these early experiments, although a little rough around the edges, showed significant potential.

Whilst *Encoded* was a beautiful and well received work, the juxtaposition of live physical actors moving elegantly around a stage in front of a flat two dimensional screen seemed to create a logical divide between the human and the virtual. Stemming from my passion and experiments in spatialized sound, 3D animation and stereoscopic graphics, I felt that this divide between real and virtual provided a fertile ground for exploration. I felt that there could be creative and artistic merit in further blurring the lines between the human and the machine, combining them into one cohesive and fantastical mixed reality world. This thesis documents my initial attempts at melding these worlds and fusing my passions for creativity, computer graphics, human movement, sonic art and spatialization to realize, and in many ways exceed, the naive ambitions of a restless backpacker almost 20 years ago.

## 1.3 Definitions

As this dissertation is an exploration of the intersection between interactive art, immersive technology and live performance, there is a need to define these three crucial terms and explain how these seemingly disparate fields may be combined.

### Interactive art

> "Interactive art is distinguished by its dynamic 'behaviour' in response to external stimuli, such as people moving and speaking" - Ernest Edmonds (2011)

Interactive art is a specific type of art form where the art itself will in some way change or react to an external influence in an obviously observable fashion. While interactive art covers any type of responsive art, such as Duchamp's famous 1913 'readymade' work *Bicycle Wheel* which simply rotates as it is spun (Edmonds, 2011), this thesis is concerned with the more common practice of using electronic and computer technology to facilitate a human-computer interaction. Even within the more specific human to computer interaction, the variations in type of stimuli available to humans and the type of reactions that can be created by computers can also be quite overwhelming. In an effort to focus the scope of this research towards live performance, this dissertation concentrates on physical movement as the stimuli and audio/visual display as the primary computational response. There is perhaps some expectation that interactive art implies a participatory nature where the audience has some control or agency over the work. While some of the works created during this research do exhibit this participatory trait, the combination of interactive art with live performance has shifted the interaction from being audience <–> computer to being performer <–> computer in the majority of these works.

### Immersive technology

"The more that a system delivers displays (in all sensory modalities) and tracking that preserves fidelity in relation to their equivalent real-world sensory modalities, the more that it is 'immersive'." - Mel Slater (2003)

The word 'immersive' has been adopted by a variety of creative practices such as narrative immersion (Green et al., 2004) and immersive theatre (White, 2012). These fields imply that something is immersive if it transports its audience to some other location through the power of imagination, participation or storytelling. This research, however, embraces Slater's stricter definition of the term 'immersive' to describe technology that mimics the visual, auditory, haptic or other sensory modalities of the real world to create a sense of 'presence' in a human participant. Presence is then defined as the human reaction to the immersive technology, whereby a participant feels like they are 'present' within the virtual world portrayed by the immersive technology. Presence describes the *feeling*, while immersive describes the *technology* that can incite this feeling. This definition is commonly used in the research of virtual reality, where a head-mounted display (such as the Occulus Rift) can be described as an immersive technology because it has visual and auditory displays that mimic the way we perceive the real world.

Slater distinguishes between the *form* and the *content* when further defining these terms, suggesting that immersive technology is the form, irrespective of the content. He describes listening to a quadrophonic sound system that makes you *feel* like you are in a theatre listening to a real orchestra as a sign of *presence*. Whether or not the actual music is engaging or interesting is completely irrelevant. It is the *form* of the quadrophonic system that transports the listener, while the imaginative engagement or enjoyment of *content* is a completely separate thing. Whilst the separation of the form and content is arguably oversimplified by Slater, this view is useful to clarify the term 'immersive technology' as being any technology which is used to trick the senses (form), as opposed to a 'narrative immersion' which may aim to imaginatively engage the audience (content) (Slater, 2003).

When appropriating immersive technology for use within live performance, the term presence is no longer generally applicable. Here the technology aims to meld the computer generated virtual displays and the human live components into one cohesive mixed-reality world. Mixed-reality exists where neither the real world or a virtualized world is presented in its entirety and is described by Milgram and Kishino as a place where 'real world and virtual world objects are presented together within a single display' (Milgram and Kishino, 1994). Within the context of a mixed-reality live performance, the immersive technology might more aptly be described as seeking to produce a sensation of 'belonging with' rather than 'presence'. The audience may feel that the performers 'belong with' the virtual world, rather than any particular feeling that they are themselves 'present' inside the virtual world portrayed on the stage. Aside from the shift of perspective from first to third person, the immersive technology may actually be repurposed within the context of live performance to explore its artistic potential rather than its explicit ability to provide a feeling of 'presence'. To this end, the use of immersive technology with live performance, could perhaps be better described as the *repurposing* of immersive technology for use within live performance.

Some of the technologies explored within this research that are deemed to be immersive in nature are 360 degree displays, stereoscopic visuals, spatialized sound, haptic feedback, physical simulations and physical interaction. Physical interaction, which is the major component of the interactive art described in the thesis, can be seen as a subset of immersive technology because it attempts to mimic the way the real world responds to physical movement. Rather than being subsumed by the larger category of immersive technology within this dissertation, it is presented alongside immersion due to its established practice and considerable emphasis within the works presented.

### Live performance

The definition of 'performance' remains deliberately fluid within the field of Performance Studies. In his book *Performance Studies: An Introduction*, Richard Schechner describes the performance studies field as 'wide open' and states that 'anything and everything can be studied "as" performance' (Schechner, 2017). Whilst acknowledging that this 'wide open' approach to performance may be useful in allowing the field to adapt with the shifting trends of arts practice, the definition is too broad to be useful in the discourse of this thesis. To clarify the use of performance within this dissertation, we can instead look to Saltz's description of the 'performing arts' as:

> "the class of artforms in which one group of people, i.e., performers, perform live before a second group, i.e., an audience." - Saltz (1997)

This description is more suitable as it specifically addresses four key traits that are considered to be an essential part of the 'live peformance' that is presented in this dissertation:

1. it is concerned with artistic practice and can therefore be considered an artform
2. it contains designated performer(s) that perform to an audience
3. both performers and audience are described as people (humans)
4. the performance occurs live, that is in real-time.

While Saltz's description of the 'performing arts' may well be sufficient to describe the performances presented within this dissertation, the term 'live performance' is preferred as it emphasizes the importance of the real-time aspect to these works. Film techniques involving real humans that perform to a camera in order to be played back for an audience later is <u>not</u> considered live performance in the scope of this dissertation. Similarly, telematic performances that are transmitted directly to an audience through a medium of technology, such as video conferencing, are also not considered to be 'live' as they unavoidably restrict the immediacy and richness of information that is present in an unmediated live performance. As engaging as a live broadcast or recording of an artistic performance may be, it is inevitably a different experience from being physically present at that same live performance.

In light of this emphasis on liveness, the term ‘live performance’ will be used to denote any type of work where at least one human being is physically performing an artistic practice in real time, for, and in the immediate presence of, a human audience. In the works presented alongside this dissertation, the live performance takes the form of contemporary dance, theatre (both physical and traditional) and musical performance.

### Combining interactive art, immersive technology and live performance

The exact emphasis on interactivity, immersion and performance varies greatly between each of the works presented. The *Creature* works introduced in Chapter 4 clearly demonstrate this shifting emphasis. *Creature: Dot and the Kangaroo* is a traditional proscenium arch theatre show which uses movement-based interaction and immersive technology (physical simulations, depth of field blurs, 3D shadows and rendering) to visually augment the storytelling. *Creature: Interactions,* on the other hand, is an interactive art installation which uses live performance to improve the richness of physical interaction. It has been presented in three different versions, 2D projections on a single wall, 2D projections on a 360 degree display and stereoscopic 3D on a 360 degree display. These three versions vary greatly in use of immersive technology, to the extent that it could perhaps be described as an ‘interactive art installation’, an ‘immersive interactive installation’ and simply an ‘immersive installation’ depending on the exact format of its presentation.

Within these two works alone, we could describe these elements as being used in three different ways:

- interactive and immersive technology **in live performance** (*Creature: Dot and the Kangaroo)*
- live performance and immersive technology **in interactive art** (*Creature: Interactions* in 2D)
- live performance and interaction **in an immersive environment** (*Creature: Interactions* in 3D*)*

Although independent works in their own right, these two productions are companion pieces that are designed to be experienced together. In this respect the *Creature* body of work demonstrates a fourth combination:

- live performance (*Creature: Dot and the Kangaroo*) **with** immersive and interactive art (*Creature: Interactions)*

By employing the same core technological system in a number of different artistic and performance genres, this research explores the combination of interactive art, immersive technology and live performance from a number of different perspectives.

## 1.4 Significance

This research has significance to a number of different stakeholders.

The first stakeholders are the live performers themselves. The dancers, physical performers and musicians may be interested in the experience of interacting with a virtual system. When improvising, the real-time feedback from the system might elicit a different style of movement or musical reaction from the performer than a human otherwise would, pushing the performer into a new exploratory territory of their own craft. They may choose to accentuate their movements through real-time projection or sound synthesis to create a greater spectacle than possible without technological assistance. They may enjoy the transformative feeling of being immersed in a fantastical environment and use these feelings to bolster their own live performance.

Directors, choreographers, composers and performance artists concerned with constructing a production, dance or composition will be interested in the ability to expand their palette of aesthetics with the almost endless possibilities of digital imagery and sound synthesis. The ability to make a virtual environment tell a story or explore a theme through its reaction to the performer opens up a new mode of theatrical storytelling to be exploited. The analysis of developing these shows, along with the artefacts presented, suggest what is possible with interactive immersive technology and what approaches to developing such works may be fruitful.

Interactive artists will be interested in this research for a number of reasons. The presented artefacts provide documentation of what is possible with current technology and how it may be applied to live performance. The discussion provides insight into how interactive systems are interpreted by the performance artists and how developing interactive works with experienced professionals may be approached. The system and methodology chapters also provide a simple framework for technologists designing their own interactive systems to consider.

The combination of immersive environment, participatory interaction and live performer has significance to educators, galleries and museums. The participants of these virtual environments can engage with educational or cultural material in an entertaining and embodied fashion, whilst being transported to another virtual location, allowing the educational message an unprecedented level of context. For example, it is easier to understand the nature of Australian flora and fauna while being immersed in the bush. Similarly, Egyptian relics make more sense when standing in a replication of ancient Egypt rather than a sterile museum environment. The social nature of these shared mixed reality environments also provide an engagement in learning beyond that available in books.

The hardware, software and content creators currently exploring the blossoming field of virtual and augmented reality would be interested in the mix of immersion with the human element of live performers and crowd-based social interaction. Virtual reality provides an impressive sense of presence in a virtual environment but is currently an extremely solitary experience. The social language conveyed through nuanced physical movement is arguably unmatched by modern virtual technology and combining live performance with the virtual could be an important step in unlocking the storytelling potential of virtual and augmented reality.

Recent inquiries into the technology and artefacts which were produced during this research support these assertions on its significance. Festival directors and marketing coordinators have enquired about using the technology for high profile international events. Prominent cultural institutions, such as a leading museum and an environmental institution in Australia, are currently negotiating its adoption as a social learning environment. Stalker Theatre, the physical theatre company involved with much of this research, has recently rebranded their website with the slogan “Immersive Physical Theatre”, demonstrating their dedication to the continuation of this research collaboration. Several professional dancers, musicians and artists have stated their desire to collaborate on future productions as they strive to expand their own practice. While immediate interest in the artefacts and technology is evident, it is hoped that the research documented in this dissertation may seed future investigations into the combination of live performance, interaction and immersive technology as we embark on the undoubtedly rocky road to explore the potential of mixed reality within the artistic domain.

## 1.5 Structure

Chapter 2 (Literature Review) begins by examining the history of technology in the performing arts and the introduction of interactive arts. It then separates interactive art research into the three separate stages of motion capture, transformation and audio/visual output. Immersive technology is then explored and related to interaction before looking at some contemporary works which combine interaction, immersion and performance in a number of ways.

In Chapter 3 (Methods) the overall framework of practice-based research and reflective practice is discussed and some strategies for creative practice-based research is discussed. Devised theatre, bricolage programming and agile software design are presented as the actual methods by which the performance and technological artefacts are created. A grounded theory approach to data collection and analysis is then introduced to represent the observations and concerns of the artists and performers involved in actually creating the presented artefacts.

Chapter 4 (The Artworks) presents a selection of performance artefacts created during this investigation that best represent the findings of this research. These include the work that inspired this research (*Encoded*), two musical works (*Bluespace* and *Airstorm)* and the primary artefacts of this investigation (*Creature: Dot and the Kangaroo* and *Creature: Interactions*).

The technological system that was built to perform these works is described in Chapter 5 (The System). This chapter details the programming language and network architecture used to build the system before describing some key features of the motion capture, physics simulations and audio-visual displays that allowed the system to be both interactive and immersive in a range of performance situations.

Chapter 6 (Creature: Dot and the Kangaroo) discusses in detail the application of this interactive and immersive technology to the physical theatre show *Creature: Dot and the*

*Kangaroo.* The production's animated landscapes and interactive creature elements are discussed and their relationship to the script is explored. The more successful interactive scenes of the show are identified and contrasted with the remaining production to examine how this technology was used in the selected scenes.

Chapter 7 (Creature: Interactions) describes the interactive art experience of the companion show, *Creature: Interactions.* The setup of the installation is described and the effect of the immersive environment on this work is discussed. The application of live performance and facilitation to the installation is investigated, including steps taken to improve the diversity of physical movement and sculpt the energy flow throughout the 40 minute experience.

The performing artists' perception of the technology is discussed, in Chapter 8 (Performance Implications), including the role that it provides within a theatrical context and its interdependence with a multitude of elements across the performance genres of music, dance and theatre. Strategies for an improved development process with respect to both *Creature* works is also discussed.

The shift into a more immersive stereoscopic display for *Creature: Interactions* is described in Chapter 9 (Future Research), and the related 'phantom limb' phenomena is observed as an area to be explored in future research.

Finally, the contributions, implications and findings of this research project are summarized in Chapter 10 (Conclusion).

# Chapter 2

# Literature Review

## 2.1 Introduction

This chapter presents a literature review of the intersection between live performance, interactive art and immersive technology. The review suggests how these three fields may actually intersect and reveals some important design considerations that will be employed in the construction of the technological system and artworks. The review begins by examining the history of combining technology with live performance. Following this, an interactive system is broken down into three separate stages of input (motion capture), transformation (mapping) and output (audio-visual display). Strategies for implementing each of these stages are examined and their application to interactive artworks and live performances are provided. Immersive technology, the final element of our study, is now introduced and its strong relationship with spatiality and interaction is examined. Methods by which the interactive stages may be made more immersive is discussed and finally some contemporary live performances and interactive artworks with a strong immersive element are presented.

## 2.2 Technology in performance

There is a rich history of employing technology to augment live physical performance in the theatrical, musical and interactive art domains. Although often treated as separate mediums, sound and vision have shared a similar technological timeline, beginning with Richard Wagner's use of technology to portray his epic series of operas originally titled *Der Ring des Nibelungen* (often called *The Ring*). In order to present *The Ring* in all of its ambitious glory, Wagner designed and built a dedicated opera house called Festspielhaus in Beyrouth, Germany that was completed in 1876. The Festspielhaus contained bespoke mechanical technologies, acoustic design and a dynamic gas lighting system all devised to elevate *The Ring* to match his lofty desire for an all-encompassing artwork that he described as the 'Gesamtkunstwerk' (Salter, 2010).

In the early 20th Century, the Italian Futurist movement strove to mechanize many different forms of art in a deliberately unbridled embrace of technology. Enrico Prampolini, a budding painter, scenographer and futurist was buoyed by the recent developments of electrical lights and motors and led the charge to discard the statically painted backdrops of yesteryear for dynamically lit screens and motorized props (Salter, 2010). On the musical side of live performance, Luigi Russolo , another Italian Futurist, invented a series of sound creation machines that he called *intonarumori* to realize his grand vision of pure noise compositions. His machines were split into six different families of noise including 'booms, whistles, whispers, screams, percussive sounds and the voices of men and animals', all of which were detailed in his 1913 manifesto, *The Art of Noises* (Payton, 1976).

The technological advancements surrounding the second war heralded a new era in live performance augmentation – the introduction of media. The Czech scenographer Josef Svoboda projected slides and moving images onto kinetic mechanized screens that could move and rotate in three-dimensions. Debuting at the 1958 Brussels World Fair, Svoboda's *Laterna Magika* mixed live human performers with eight of his mobile screens, while the

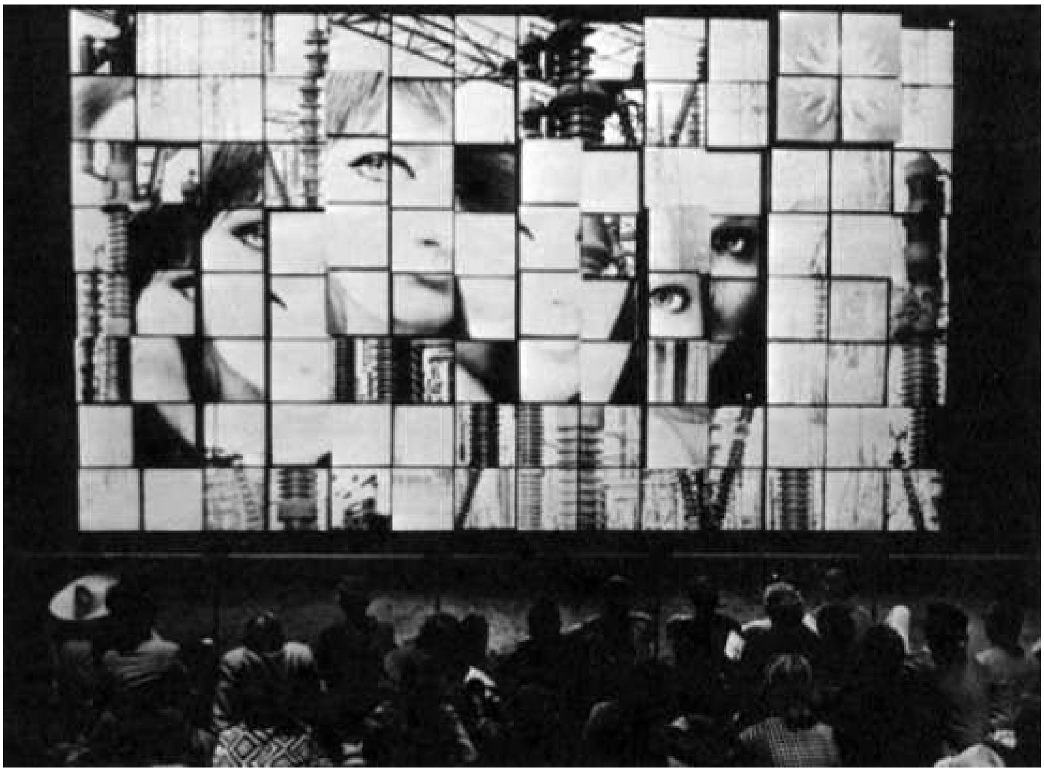

Figure 2.1: Josef Svoboda's *Diapolyekran* (Salter, 2010)

more technically sophisticated *Diapolyekran* (see Figure 2.1) was presented at the 1967 Montreal Expo with an impressive 224 automated slide projectors and 112 dynamic cubic screens to create a large scale video mosaic (Burian 1970). Sonically, Pierre Schaeffer's experiments with vinyl in 1948 and later with audiotape were the first examples of Musique Concrete, a musical genre where pre-recorded sounds are edited and mixed to create new compositions. The use of media as an instrument was such a new concept that Schaeffer had to invent his own classification or 'typomorphology' system to describe, compose and analyze the type of music that he was creating (Camilleri and Smalley, 1998). The introduction of portable video recording equipment further increased the popularity of mediatized live performance, with Nam Jun Paik leading the charge in the 1960's and 1970's. Paik's use of video technology in live performances often went beyond that of pure cinematography and video was manipulated to a state where the technology was played both visually and sonically as if it were an avant-garde audio-visual instrument (Salter, 2010).

Interaction was the next advancement in live performance augmentation, where the technology would in some form 'sense' the movement of a live performer and create media in response to this movement. Nicolas Schoffer's 1956 work entitled *CYSP1* is an early example of electronics in performance where a kinetic sculpture reacted to dancers by way of microphones and photovoltaic cells (Edmonds and Candy, 2011). The *Sound Activated Mobile (SAM)*, first shown in 1968, was a dynamic spine-like sculpture that used hydraulics to move in response to sound detected by four microphones (Reichardt, 1969). *SAM*'s creator, Edward Ihnatowicz, went on to develop a lobster-like robotic arm called *The Senster*, an early example of interactive sculpture being driven by a computer (Edmonds and Candy, 2011). In the 1980's David Rokeby created an interactive sonic installation called *Very Nervous System* that employed video cameras and image processing techniques to convert a user's body position and motion into musical sounds (Rokeby, 1998). Since the early

1990's, the ever-increasing power and affordability of computers have enabled the consistent exploration into dance married with computer-generated audio-visual content that continues to the present day.

Modern computers have also been employed behind the scenes to enhance dance and theatre in many different forms. There is software such as the *Choreographer's Notebook* to facilitate a choreographic collaboration outside of the rehearsal space (Singh et al., 2011), motion capture projects such as *Super Mirror* to improve the posture of ballet performers (Marquardt et al., 2012). Camera-based systems have also been used to evaluate a dancer's accuracy in performing a set piece of choreography(Alexiadis et al., 2011; Ferguson et al., 2014). While these technologies can certainly be used to improve physical performances in their own right, it is the creative combination of live performance with computer-aided visual and sonic content that is the main focus of this research.

There have been many different approaches to generating live audio-visual augmentation with digital technology. The most simple and widely used method today is to pre-compose audio-visual content that is simply used as a backdrop to set the scene of the live action, be it for an elaborate theatre production or a simple rock show. As this content does not react to the physical performance and vice-versa, it can be seen as a modern version of the painted backdrops used throughout the 19th Century that Enrico Prampolini tried to eradicate in his 1924 Technical Manifesto for Futurist Scenic Atmosphere (Salter, 2010). While modern performance artists like Blue Man Group and Freelusion can be seen to create the illusion of interaction with pre-composed video through very tightly controlling the choreography of the live performers, this type of pre-programmed interaction is described by Wu et al (Wu et al., 2010) as 'lifeless compared to the spontaneity and improvisation of a real performance'.

There also exists a growing body of research which concerns the real-time generation and display of audio-visual content in response to the live performers using various motion capture techniques. Commercial software tools such as Isadora[1], TouchDesigner[2] and Apple's Quartz Composer[3] also operate in this field of research. By responding to the performers in real-time, the audio-visual augmentation can allow for improvisations and rich human-computer interactions. Systems of this type will be built, extended and utilized within live performance for this research and will be explored in depth in the following section.

## 2.3 Interactive systems

While interactive systems can vary greatly in terms of complexity, aesthetic capabilities and the type of technologies used, we can simplify an interactive system into a three-stage framework (see Figure 2.2) including input (motion capture), transformation of data (mapping) and output (audio / visual). Although not exclusively the case for interactive art, this research is concerned with live physical performance and therefore motion capture is the primary mode of input and audio/visual display is the priority for the output stage. Each one of these three stages in the process can have profound effects on the final performance.

### 2.3.1 Motion capture

Motion Capture is the mechanism by which the system can understand the movements and shapes currently exhibited by the physical performers. This stage is primarily concerned with the extraction of correct and usable data and can therefore be seen as the most scientific

[1]https://troikatronix.com
[2]http://www.derivative.ca
[3]https://developer.apple.com/library/content/documentation...

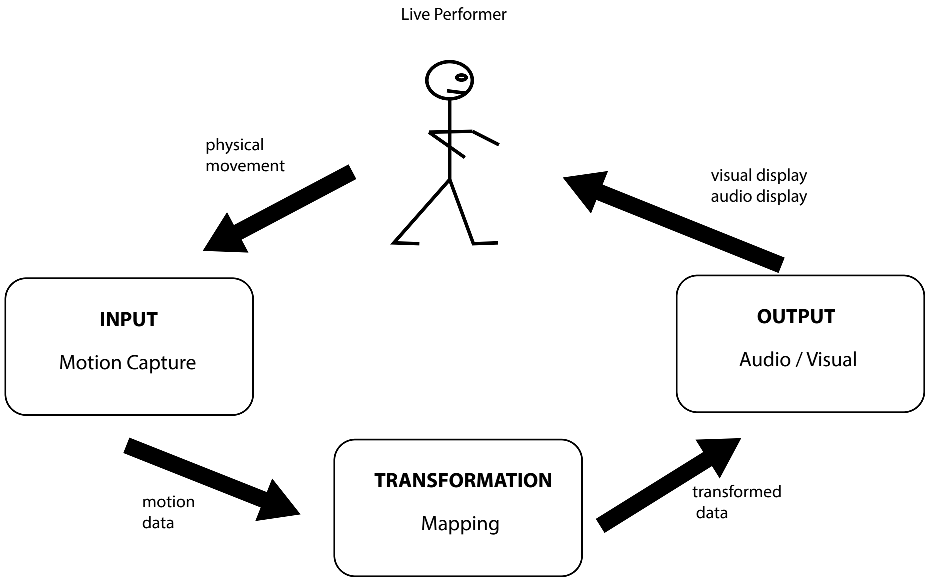


Figure 2.2: Simplified 3-stage system for real-time interaction

and least creative section of the process. Sadly, the choice of which technology to use for motion capture appears to be governed by a series of compromises where the correctness of data, range of movement and ease of installation are all at odds with each other. Some benefits and drawbacks of commonly used techniques are discussed.

### Depth sensing cameras and the Microsoft Kinect

The Microsoft Kinect is a depth-sensing camera that was introduced as a novel input device for home console gaming, but the creative coding community quickly embraced the camera as a cheap and easy way to work with motion capture (Langmann et al., 2012). Commonly coupled with a skeletal tracking software, the system can report the position of a human's arms, legs, head and major joints in real-time with no external attachments to the performer necessary. Whilst not directly restricting the movement of the performer, the system only has a 5x5 metre capture zone and the skeletal tracking only works effectively when the performer is standing upright and facing the camera. Despite these limitations and system being the most inaccurate of the popular tracking methods (Gabriel Vigliensoni, 2012), the

Kinect is used in many dance augmentation projects including *Time of Doubles* and *.cyclic* (Jung et al., 2012; Kuchera-Morin et al., 2014).

### Positional markers

The placement of position markers on a performer's body can produce more reliable results than the unobtrusive skeletal recognition of the Microsoft's Kinect system (Gabriel Vigliensoni, 2012). Some popular examples of position marker technology is the electromagnetic detection of the Polhemus Liberty[4], the optical tracking of the Vicon Vantage[5] and the accelerometer and gyroscopic technology used in the XSens MVN suit.[6] Whilst recording data quite accurately, the physical attachments to the performer can severely restrict movement and expression. The dancer involved in the 2011 augmented ballet performance entitled *The Care Project*, rated the physical obstruction of XSens motion trackers a 7/10 where a 10 indicated 'extreme disturbance' (Clay et al., 2012). The clinical look of these physical trackers attached to the performer's body can also be an unwanted distraction to the audience and an extra problem for costume designers to consider. The position tracking solutions described, while being relatively accurate, are expensive, physically obtrusive, cumbersome to install and difficult to calibrate.

### Model-free image processing

Image processing techniques such as optical flow and blob tracking are described by Nguyen et al. (2006) as model-free, meaning that they do not incorporate human kinesiology or skeletal systems. These techniques can detect certain movements by examining the difference between successive images captured on a video camera or simple webcam. Both the blob tracking and optical flow methods require very stable lighting conditions

[4] http://polhemus.com/motion-tracking/all-trackers/liberty
[5]https://www.vicon.com/products/camera-systems/vantage
[6]https://www.xsens.com/products/xsens-mvn

to work effectively and therefore infrared cameras can be used to remove any dynamic lighting caused by projection, monitor displays or dynamic LED lighting. As no skeletal or three-dimensional depth information is obtained using these methods, they are better suited to the more abstract augmentation of human movement such as the particle system used in *Encoded* (Johnston, 2013) or the swarm-based visuals of *SwarmArt* (Jacob et al., 2007).

#### Summary

The motion capture systems described all have severe shortcomings. The best solution should be based on the desired physical movability of the performer, the size of the performance space, the lighting requirements, desired accuracy and cost of the system. Unfortunately most situations will require some concessions to the physicality of the performance to accommodate a successful motion capture, but hopefully the virtual augmentation gained can significantly outweigh these concessions.

### 2.3.2 Mapping (transformations)

When splitting the interactive system into the three distinct stages of motion-capture, transformation and output of data, it is the translation (or mapping) stage that allows creative control over the style of interaction in the system.

#### Direct mappings

The interaction style of the system, or what Edmonds and Candy (2011) describe as the ‘interaction aesthetic’, is directly linked to how this motion capture data is processed. Very simplistic and direct mappings where, for example, the height of one’s hand describes the exact pitch of a generated sound tone or the direct location of a rendered graphical shape will tend to dictate the hand to move in a vertical motion. Such interactions invite the performer to tightly control the system and play it like a basic musical instrument. This style of interaction is described as 'direct manipulation' in the field of human-computer interaction (HCI) and is commonly associated with the WIMP (window, icon, menu, pointing device) user interfaces found on desktop computers since the late 1980's. This type of mapping focuses on the 'computer-as-tool' paradigm which gives the user direct control over the system's output to achieve a specific task (Beaudouin-Lafon, 2004). While the performer can easily learn such a system, the simplistic interaction and output aesthetic from such a mechanism can produce an 'impoverished experience to the player and listener' (Hunt and Kirk, 2000, p 235).

### Gestural mappings

Gestural mappings are often employed to add a slightly more sophisticated mediation between performer and augmented audio-visual output. These gestures could include waving a hand back and forth, lifting one foot above the opposite knee or visiting a particular spatial region on stage. Such gestural translations often require multiple parameters of input data, for example knowledge of where both the foot and knee are in relation to one another. With the aid of clever machine learning algorithms, like Hidden Markov Models, gestures can be tracked over time, enabling the detection of movement-related gestures like waving ones hands in a clockwise motion (Caramiaux and Tanaka, 2013). Although relatively complicated to correctly detect from the input data, gesture recognition can often produce a series of canned interactions and very simplistic outputs. Gestures are often applied to what Jorda (2005) describes as a high-level or compositional style of control where sound, video or special effects playback are simply triggered by the performers movement. Although being very responsive, when Clay et al. (2012) used gesture recognition to transform dance into music, the majority of their audience believed that the relationship between the physical gesture and sonic output was too direct.

### Physical simulations

A certain level of non-determinism in a system's mapping from input to output can allow the system to have a more 'conversational' interaction aesthetic where both the performer and augmented output have equal footing and are reacting to one another (Chadabe, 2002). Creating a rich dialogue between the performer and system can be seen to significantly improve the importance of the virtual augmentation as it shifts from being the static backdrop that was so despised by the early Italian Futurists, to become an active participant in the performance itself.

Physical simulation models mimic the behaviors of the real physical world such as gravity, ballistics, springs, newtonian collisions and fluid dynamics and can be used in the transformation stage to give the performer a direct level of influence over the system, whilst providing a seemingly non-deterministic and yet physically feasible output (Momeni and Henry, 2006). In the field of HCI, physical simulations form a major part of reality-based interfaces (RBI) which aim to exploit a user's common knowledge of *'naive physics'* and *'body awareness'* to extend the usability of the interface beyond that of direct manipulations and WIMP (Jacob et al., 2008). Interfaces with a more conversational relationship to the user employ a computer-as-partner paradigm (Beaudouin-Lafon, 2004), that boosts the role of technology from that of a tool, to being more of an artistic partner in the work.

Physical simulations have been used in a number of contemporary interactive performance works. Mass spring systems were introduced to the *Double Skin/Double Mind* masterclass movement workshop where a gesture recognition system set parameters of a simple spring system to reflect the movement qualities of dancers (Fdili Alaoui et al., 2013). Similar spring-based models were also employed to create a 'conversational' music interface entitled Partial Reflections in which a number of virtual balls connected by springs would respond to virtual forces injected sonically by a live musician (Johnston, 2009). The resulting movement of the masses would then in turn create sound as a response to the live musician's input. Art research groups Sponge and FoAM mimicked real-world physics as a method to recover a sense of physicality to their digital interactive play-space entitled *TGarden*. Premiering at Siggraph 2000 in Athens, *TGarden* invited participants to wear different costumes with embedded sensors to interact with the space. The virtual physics engine would represent the jumping, bouncing and dragging gestures of the users with visual and musical extensions of their movements (Salter, 2010).

Based on observable real-world behaviors, virtual physical systems can also be exaggerated to operate in an otherworldly fashion whilst still appearing to be physically plausible. An obvious example of this would be to change the gravity to simulate the properties found on the moon, or in a more extreme case the gravity could actually accelerate upwards away from the earth. Using a dynamic fluid simulation to mediate the transformation from motion capture to visual output, Stalker's 2012 *Encoded* allowed the physical theatre performers to effectively 'stir' a virtual fluid simulation with their movements. A mass of virtual particles were suspended in this fluid simulation which augmented and exaggerated the movement of the physical performers. This approach was reused in Johnston's *Sound Stream* which added audio synthesis to the fluid mapped visuals to create an interactive audio-visual performance. While impossible in the real world, the physical properties of the virtual fluid could be changed at run-time to significantly alter the associated visualizations and sonifications and create an 'extensive expressive pallet' in both of these works (Johnston, 2013).

### Organic systems

Complex systems that emulate the organic behavior found in nature can add yet another layer of non-determinacy to mapping translations. The flocking behavior witnessed in various species of birds can achieve a level of self-organization that can be mimicked by simple algorithmic simulations. These simulations contain a large number of independent agents communicating with each nearest neighbor through a number of very simple rules. Such

Figure 2.3: *SwarmArt*, (Boyd et al., 2004)

rules might be to stay in close proximity to as many neighboring birds as possible without ever actually colliding. This flocking behaviour was used to create *SwarmArt* (Figure 2.3), a motion-capture based interactive work where each of the 50 agents appeared to act independently whilst the flock as a whole would form a cohesive unit that was attracted to the motion of the audience (Boyd et al., 2004). Cellular automata is another type of complex system which can produce unified global behaviors which emerge from the individual interactions of many simple units (Burraston and Edmonds, 2005). Jakovich and Beilharz (2007) combined optical flow motion tracking techniques with cellular automata to add a level of complexity to their 2005 interactive audio-visual artwork, *Sonic Tai Chi* (Figure 2.4).

### Summary

Direct transformations and gestural mappings can provide a high level of control to the performer. The resulting output and interaction aesthetics of such a system can feel over simplistic, and unable to sustain the interest of either audience or performers for more than a brief period of time. Increasing the level of non-determinism and complexity in the system by engaging physical and organic simulation algorithms can create a more 'conversational'

Figure 2.4: *Sonic Tai Chi,* (Jakovich and Beilharz, 2007)

type of interaction where both physical performers and virtual augmentation are seen as independent actors influencing one another, rather than relegating the virtual elements to the role of a mere garnish of the main live performance.

### 2.3.3 Audio-visual output

The final element in the three-stage process for real-time augmentation is the visual and/or sonic output of the transformed motion-capture data. The final output aesthetic can marry the virtual augmentation with the central themes of the interactive artwork or performance.

#### Shapes and tones

A direct one-to-one mapping style is commonly used with simple lines and geometric shapes. As the performers move about the stage, their bodies will trace simple shapes

Figure 2.5: *Dance Draw* (Latulipe et al., 2010)

onto a projected canvas. When these shapes are not immediately cleared from the visual canvas, visual trails evolve that can clearly portray a short history of the performer's motion. Geometric shapes were used in the early performances of *DanceDraw* in 2008 where rings and polygons would represent the movement of the dancers holding wireless mice devices, and a motion tracing effect could display these movements over time (Latulipe and Huskey, 2008). The same one-to-one mapping can also apply to sound where position of the performer's hand directly controls the frequency or volume of simple sine-tone generators or synthesizers. Salter et al. (2008) argue that such techniques are more often used as a scientific tool than for artistic composition as they place importance on clarity and efficiency over audio-visual aesthetics.

### Pre-composed media

Pre-composed audio or visual elements can be triggered by a gestural style of interaction to give the performer what Jordà et al. (2007) describe as a high-level compositional control over the virtual augmentation. The advantage of such an approach over the more direct one-to-one mapping is that emotionally complex and expertly composed sections of vision or music can be introduced to the production with the illusion of real-time control. The real-time control, however, is very simplified and the output aesthetic is very much limited to the sum of pre-composed media and predefined gestures. It is not possible to explore past these pre-defined parameters in the heat of live improvisation. While these predefined elements can elicit a short-term wonder, such as the 'magical' creation of graphical flowers in the 2010 virtual theatre piece, *Trickster at the Intersection*, the limited number of preprogrammed gestures and outputs prevent the interaction with virtual elements from sustaining interest over the extended duration of many theatrical works (Salter et al., 2008; Wu et al., 2010).

### Particle systems

Employing organic and physics simulations at the mapping stage can produce a large number of small and autonomous agents (or particles) that can collectively portray global behaviors. Visually, flocks and particle systems can be displayed with simple graphics primitives like dots, triangles or simple 3D polygons as presented in the 2003 interactive artwork, *SwarmArt* (Boyd et al., 2004). While each agent is quite simple in its own right, emergent behaviors can make quite complex and engaging patterns when viewing the entire particle system.

To further embellish the complexity of the output, each individual particle or agent can also possess a unique micro section of some pre-recorded material. When applied to audio, this process is called granular synthesis and has been quite comprehensively detailed by Curtis Roads in his seminal 2004 book, *Microsound* (Roads, 2004). When the output of each individual particle is recombined, the emergent behaviours of the complex system are present, whilst still possessing certain qualities of the individual grain samples. For example, taking all of the individual grain samples from a pre-existing saxophone solo will likely result in an output that resembles the timbre and sound quality of a saxophone, but has the overall structure and texture of the swarm itself. Granular synthesis has been coupled with cellular automata in the interactive 2005 artwork *Sonic Tai Chi* (Jakovich and Beilharz, 2007), and with a fluid-based particle system for the 2013 virtually augmented live performance *Sound Stream* (Johnston, 2013).

Granular synthesis has its roots in the domain of sound, but the visual counterparts to this technique are also being explored by artists and researchers alike. Where sonic techniques slice a piece of audio into tiny chunks of around 1-100 milliseconds, the video counterpart slices the canvas of a moving image into many small sections, each slice having it's own spatial and temporal positions in the original source video (Batty et al., 2013). Slit scan photography is a type of video-centric granular synthesis which, judging by the size of Golan Levin's 'An informal catalogue of slit-scan video artworks and research' (2014), is quite popular amongst digital artists and researchers. Some quite simplistic interactive artworks using rudimentary motion capture and granular video techniques were examined by Villegas and Forbes (2014). The results were promising enough that they postulate on trialling more sophisticated motion capture techniques, swarm and flocking behavior models and the addition of an associated audio output in future research.

#### Linking output modalities

The output aesthetic of augmented live performance is almost exclusively reserved for the sonic and visual modalities, and it can be advantageous to output to both mediums simultaneously. In an attempt to improve audience engagement at electronic music concerts, Berthaut et al. (2013), created a 3D visualization application dubbed Rouages (Figure 2.6) to coincide with the sonic output of electronic instruments. They found that the additional visual representation significantly helped the audience identify and appreciate the subtle gestures performed in the creation of this live electronic piece.

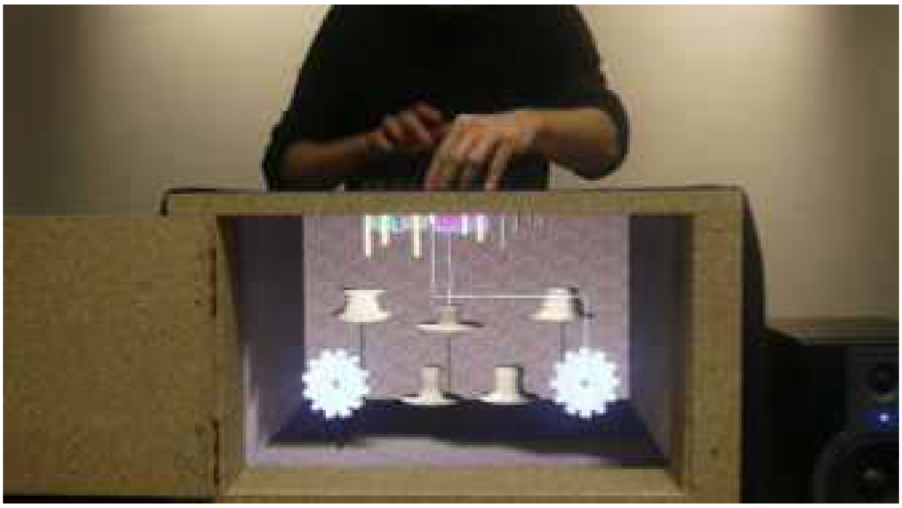

Figure 2.6: *Rouages* (Berthaut et al., 2013)

A sonic representation can also illuminate and disambiguate an otherwise misleading visual output. Watanabe and Shimojo (2001) have found that where visual cues are ambiguous, in that when two objects could be seen to either bounce off or pass through one another, the addition of a well timed sound event could reenforce the visual illusion of bouncing. Linking both the sonic and visual output modalities to a unified physical system has been found to create a more cohesive output in audio-visual instruments (Caramiaux et al., 2011). The positive effects of both sound on vision and vice versa are compelling arguments to consider the inclusion of both audio and visual modalities when augmenting live performance.

**Summary**

The final output aesthetic is an important choice for any type of artwork and an interactive mixed reality live performance is no exception. The audio and visual components can be linked to help disambiguate and enhance the clarity of each individual modality. Direct mappings and simple geometric rendering can give the performer a strong level of control over the output, but a very limited palette. Gesture recognition coupled with high-level pre-composed media elements can produce moments of wonder and rich emotional content, but the ability to improvise is highly diminished. The combination of complex organic and physical simulations with granular synthesis techniques can offer diverse textural material within each grain or particle and an overarching cohesion that emerges from the global behavior of the swarm or system as a whole.

## 2.4 Immersive technology

### 2.4.1 History

The concept of virtual reality arguably stems from ancient philosophy where Plato's *allegory of the cave* describes the distorted reality perceived by slaves who are chained up inside a dark cave and are unable to see anything other than mischievous shadows being projected onto the cave wall. Unable to perceive anything of their own bodies or their surrounds, the slaves take the movement of the disconnected shadows to be their own version of reality (Plato and Cornford, 1945). While virtual reality may conceptually have roots in ancient philosophy, immersive technology can be traced back to the 1960s. In 1962, the cinematographer Morton Heiling created a multisensory vehicle simulator called the *Sensorama* which featured a 3D slide display, stereo sound, wind and smell generator. In 1968, Ivan Sutherland built a head-mounted display (HMD) that tracked the user's head movements and rendered 3D objects as simple lines with separate left and right eye displays. In the 1980s researchers at NASA's Ames Research Center attempted to create pilot training simulators, eventually developing the *Virtual Interface Environment Workstation (VIEW)*, which had stereoscopic display, glove-like devices, gesture tracking, spatialized audio, speech synthesis and computer graphics. In the late 1980s VPL research owner Jaron Lanier coined the phrase 'Virtual Reality' to describe his company's exploits in the creation of data gloves, head-mounted displays and graphical rendering technology. (Gutierrez et al., 2008)

### 2.4.2 Popular display types

#### Head-mounted displays

Head-mounted displays gained popularity in the 1980s but eventually lost favour due to the heavy and large size of the 'wearable' technology, the low resolution displays and poor computer rendering quality (Gutierrez et al., 2008). Head-mounted displays use separate displays for each eye to produce a stereoscopic display with very little overlap or ghosting. They commonly include head tracking devices to ensure that the display moves realistically as the user tilts or rotates their heads. These head-mounted displays have had a resurgence in popularity of late with consumer products such as Occulus Rift[7], HTC Vive[8] and Playstation VR[9] far exceeding the technology available in the 1980's with respect to display quality and head tracking lag.

While these immersive products provide a relatively high level of presence, they are virtual reality technologies that portray a purely virtual view of the world to the user. Wherever possible, there is a desire within this research to provide a direct and unmediated view of the live performer alongside the virtual component. Unfortunately, this requirement prevents the virtual reality head-mounted devices from consideration during this research.

Mostly for technological reasons, head-mounted displays have been associated with a purely virtual representation of the world. Recent research into head-mounted displays for augmented reality is set to change this association. Microsoft released the much hyped Hololens[10] in 2017 which superimposes stereoscopic computer-generated graphics over a

[7] https://www.oculus.com
[8] https://www.vive.com/anz/
[9] https://www.playstation.com/en-au/explore/playstation-vr/
[10] https://www.microsoft.com/microsoft-hololens/en-us

direct (albeit through glass) view of the real world. The as yet unreleased and very secretive Magic Leap[11] promises to augment reality by projecting stereoscopic visuals directly onto the retinas of the user (Stein, 2016). While these immersive devices excitingly promise to meld an unmediated view of reality with real-time 3D visuals, their release post-dates the research presented in this thesis and has therefore been included in this literature review purely as an exciting possibility for future research.

### Mobile augmented reality

The advent of the smartphone has brought mobile augmented reality technology to an unprecedented number of users with the ability to superimpose virtual computer-generated visuals on top of the real visual images captured in real-time by the in built video camera. The accelerometer, gyroscope, gps and compass technology commonly included in these phones allows the virtual images to be aligned with the camera view in real time. The augmented reality potential of these phones has been exploited by the game *Pokemon Go* which, at its height of popularity, had 50 million monthly users hunting real world locations to capture and train virtual characters (Barrett, 2016). The ubiquitous and mobile nature of these devices make them an attractive technology to harness. These devices, however, require the live performance to be viewed through video capture and display technology, which is contrary to the desire for unmediated live performance. Augmented reality devices such as mobile phones, have therefore not been considered for further use within this research.

### The CAVE

In 1992, the Electronic Visualization Laboratory at The University of Illinois at Chicago unveiled their seminal attempt at an immersive mixed reality environment given the recursive acronym, CAVE or CAVE Automatic Virtual Environment (Cruz-Neira et al., 1993).

[11] https://www.magicleap.com/#/home

The CAVE features multiple projectors arranged to create a box-shaped virtual environment that is large enough for the participants to walk around in. Since then the CAVE has inspired considerable research into virtual reality immersion and the term ‘cave’ has become synonymous with mixed reality environments constructed of multiple stereoscopic projectors. The CAVE environment uses head tracking to dynamically correct for misalignments of binocular vision due to movement within the projected box. Although this head tracking technique can only be used for one person at a time, and is therefore unsuitable for the audience of a traditional theatre show, many of the techniques developed for the CAVE can still be applied to live performance.

### 2.4.3 Immersive considerations

While no single immersive technology device is suitable for live performance on its own, the individual components or factors which make these devices immersive can be identified and combined to make our own interactive system more immersive. We shall now examine some of these factors which may be applicable to live performance.

#### Field of view

An increased field of view (FOV) in virtual displays has been found to increase the feelings of presence within a virtual environment (Lin et al., 2002). In projected displays, the field of view can be increased by curving the screens around the observer or stitching multiple screens together at angles to approximate a curve. This has the most effect when coupled with an *egocentric* view where the observer is positioned inside the curved or multi-screen display. The immersive CAVE environment can often contain projections on the side, front, top and bottom surrounding the viewer, creating an extensive field of view. When not able to produce a full egocentric CAVE environment with projections surrounding the audience at all angles, the scale of projection and distance from the display surface will affect the field of view. Larger screens and closer viewing positions will provide the audience with a larger field of view, and are therefore seen as more immersive than smaller or more distant displays.

## Depth

Depth perception is one of the biggest factors in creating a sense of presence in virtual displays. Wann and Mon-Williams (1996) describe the perception of depth inside a three-dimensional virtual environment as being an essential ingredient to any virtual reality display and an important factor in producing a feeling of presence. There are many factors that humans use to detect the depth of their surroundings, we will now examine some of these factors in the realm of audio-visual displays and how these may be realized in live performance.

### Stereoscopic vision

Stereopsis is the process by which the slightly different perspectives obtained by the left and right eyes are combined to create a perception of depth. Stereoscopy is the process by which two images are produced at slightly different perspectives and then displayed to each eye separately to reproduce the depth as found in normal unmediated binocular vision. Some of these techniques are far from perfect and can produce cross-talk where the left eye can still see some of the image created for the right eye and vice versa. Large amounts of cross-talk can reduce the perception of depth and result in blurry visual displays. There are a few different technologies that have been developed to provide stereoscopic displays. Kim (2005) has surveyed some of these techniques:

- **Anaglyph** - Popularized in the cinema in the 1950's, anaglyph technology uses glasses with different coloured filters over each eye, and similar colours over the projected image. Red and cyan are commonly used for each eye as they are complimentary colours, and filtering out the red spectrum will leave the cyan intact and vice-versa. This simple colour filtering technique allows each eye to see a different image. Anaglyph provides a cheap and effective stereoscopic effect, although the final image has bad colour reproduction and creates a relatively large amount of cross-talk.

- **Polarized** - The two images are projected through polarized lenses with opposing hair-line grooves. The audience wear special glasses that also include opposing polarized lenses over each eye. Each lens will only let through the light from the corresponding filtered image, creating a stereoscopic effect. The polarized image will commonly disperse when projected on standard materials so projection screens need to be made from a special silver reflective surface to facilitate this type of projection. This type of projection provides a better colour reproduction and stereo separation than the anaglyph method and is the most common system seen in 3D cinemas today.

- **Active shutter** - The audience wear glasses that can blank out each eye alternatively at very high speeds. The blanking of each eyeball is synchronized with a high speed projector which is outputting the image for each eye in alternate frames. When running at high frame rates, the flickering of each eye is unnoticeable and the technology can produce a high quality of stereoscopic effect with a good colour reproduction. Active shutter glasses are relatively expensive and are therefore suitable for small audience sizes. They are commonly used in 3D home cinema projectors and immersive CAVE environments.

- **Auto-stereoscopy** - Auto-stereoscopy describes a range of techniques that attempt to separate the images seen by each eye without the need for specialized glasses. A common type of auto-stereoscopy is the lenticular displays that uses small ridges or slits to separate an image into many different images which are only visible from a certain angle. While these can be effective solutions, they require viewing from very specific angles and are therefore not suitable for shared displays with many viewers.

**Stereophonic sound**

In a similar fashion to the perception of depth through two separate images, humans also perceive depth by processing separate sonic representations through each ear. As sound passes from a single point of origin to each ear independently, a number of subtle differences are detected by the brain. The sounds will take a longer time to reach the ear that is further away from the object, certain frequencies will be muted if the sound must pass through the mass of the head to reach the ear, and one ear might hear a greater emphasis of reflected sound if it is pointing at a reflective surface such as a window and away from the source of the sound itself. These subtle differences are used by the brain to produce a mental representation of depth and spatial position (Carlile, 2013). While stereophonic sound is commonly linked to the use of two speakers, it actually refers to any solution that uses multiple auditory displays to create a illusion of depth and includes technology such as:

- **binaural** - binaural sound represents depth by placing two separate sonic displays separately into each ear through the use of headphones. The content for binaural sound can be recorded by placed two microphones into the fake ear cavities of a dummy modeled on an actual human head. The sound picked up by each microphone will include the small changes that occur in unmediated human listening. These acoustic effects can also be synthesized by using a group of technologies described as head-related transfer functions (HRTF). These effects mimic the transformation that occurs as each sound reaches each ear independently. (Kistler and Wightman, 1992) As each individual needs to wear headphones for binaural effects to work, this technology is suited for use with a head-mounted device.

- **ambisonic** - Ambisonics is a system to effectively combine multiple speaker panning and psychoacoustic effects and has been shown by Cannon and Favilla (2010) to evoke clearly discernible spatial trajectories in live performance situations. The sounds are first encoded with spatial information, either by recording with a specialized configuration of microphone equipment, or synthesized through complex digital signal processing techniques. An encoded recording can then be decoded to be played on different speaker configurations, commonly using eight or more speakers in a horizontal plane. Ambisonics is a flexible and scalable technique that can create holographic projections of a horizontal and vertical nature and produces a relatively large 'sweet spot' where the effect can be cleared observed compared to other techniques. (Daniel, 2003)

- **vector-based amplitude panning (vbap)** - VBAP is a relatively simple method of amplitude panning between any number of loudspeakers. The speakers are all placed at a equal distance from a central position and can be arranged in any horizontal or three-dimensional configuration as desired. The system calculates the vectors between the central position (or 'sweet spot') and pairs of speakers to determine how much each speaker should adjust its amplitude of the given signal based on its 3D positional space. This approach is more computationally efficient to compute than ambisonics and allows for a flexible speaker arrangement. (Pulkki, 1997)

### Monoscopic depth perception

While stereoscopic and stereophonic technology is incredibly important to the virtual reproduction of depth perception, there are numerous other visuals and auditory cues which inform our perception of depth. Cutting and Vishton (1995) have performed an extensive review of literature documenting these visual cues for depth perception (in addition to stereoscopy):

- **occlusion** - An object will hide (or partially hide) a more distant object from view.
- **relative size** - A distant object will be smaller than a similar sized object at a closer perspective.
- **relative density** - A cluster of objects will project a different retinal density depending on distance.
- **accomodation** - the change of the lens shape of an eye necessary to bring an item into focus.
- **aerial perspective** - distant objects will become bluer and decreased in contrast due to air pollutants in the atmosphere.
- **convergence** - the angle between the optical axis of the two eyeballs.
- **height in visual field** - the vertical height at which the base of an object appears on a similar ground plane. For example, when viewing two people of similar height and standing on the same flat ground, the more distant person's feet will appear higher in the retinal image.
- **motion perspective** - as an observer moves, distant objects will move more slowly across the viewing plane than near-by objects. For example, when walking, a nearby tree will quickly move across your vision while a distant mountain will move very slowly, almost imperceptibly.

- **linear perspective** - the way parallel lines will converge through distance.
- **light, shading and shadows** - the brightness of objects and the interplay and occlusion of light to form shadows has been found to convey information about depth.
- **texture gradients** - the compression, size and density of texture gradients can provide important information about depth and shape of an object.
- **kinetic depth** - as an object moves or rotates through space, a construction of depth information is created, revealing the shape and form of an object.

Similarly, monophonic depth cues can be produced from audio sources. A literary survey by Zahorik et al. (2005) has revealed the following audible cues (in addition to binaural cues) as contributing to depth perception:

- **Intensity** - More distant sound sources will have less intensity (quieter) than closer sources of the same intensity.
- **Direct-to-reverberant energy ratio** - A closer object will have a bigger difference between the direct sound and any reflected sounds than more distant objects.
- **Spectrum** - For distances greater the 15m, the air significantly modifies the sound at different frequencies. More distant sounds will have less high frequency content than identical sounds at a close proximity.
- **Dynamic cues** - Movement of sound sources can create pitch shifts known as the Doppler effect which can inform an observer of the distance of moving objects over time.

Output systems which can represent the majority of these audio-visual depth cues are considered to be more immersive and are to be used wherever possible.

## Interactivity

Interactivity is an important aspect of producing and maintaining a feeling of presence and can therefore be labelled as an immersive technology in its own right. While interactive systems for artistic expression have already been described in Section 2.3, it is important to note that some styles of interaction may be deemed more immersive than others.

Gerard Jounghyun Kim (2005) describes three important factors when designing interaction to facilitate presence in a virtual reality system:

1. It should be based on **three-dimensional space.**
2. It should involve the **whole body.**
3. It should take advantage of the **multimodality** of human sensory organs.

In order to satisfy the first point, the entire three-stage interactive system of mapping, transformation and output should respect data in three dimensions where possible. Involving the whole body is largely a concern for motion capture, where a model-free representation is preferred as it will detect any movement, regardless of the body position. If using an accelerometer or marker-based system, markers should be attached to as many body parts as feasibly possible. To take advantage of the multimodality of the human sensory organs, both multi-modal input and displays are to be used concurrently where feasible.

Kim (2005) also recommends that the movement of virtual objects in response to human input should be a realistic as possible. This includes three major factors:

1. **Collision detection**
2. **Physical-based motion**
3. **Collision response**

Collision detection is the ability to detect when two objects (either virtual <-> virtual or real <-> virtual) collide with one another. The physical-based motion governs how the virtual

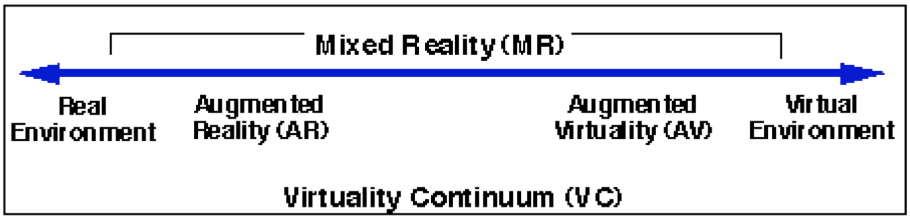


Figure 2.7: The virtual reality continuum (Milgram and Kishino, 1994)

objects move throughout the space and includes real world physics such as mass, inertia, spin and gravity. The collision response determines exactly how an object will respond to a collision, and can be seen as simply a response to the collision detection with a feasible physical-based motion. All three of these factors concern the transformation (or mapping) section of the interactive system. While physical simulations are preferred for their ability to convey expression in a believable but complex manor, they are also important immersive technologies.

## Mixing realities

The immersive technologies described so far have been largely positioned in the field of virtual reality. While virtual reality was described by Milgram and Kishino (1994) as covering the entire range of technologies that include a virtual element, it has since become synonymous with the large body of research in pursuit of depicting a purely virtual world through head-mounted displays. The other large body of research covered by Milgram and Kishino's virtuality contiuum (see Figure 2.7) is augmented reality, in which virtual objects are depicted inside a real world environment. Neither of these popular standpoints adequately describe the combination of real world performers within a virtual environment, as virtual reality is purely virtual and augmented reality is strictly related to virtual objects inside a real world environment. This leaves the combination of virtual world with live performer in the relatively vague and therefore poorly researched area of mixed-reality, which covers any technology that combines real and virtual elements. As there is little actual research specifically on this middle ground, we look to combine the relevant elements of both virtual reality and augmented reality research. This includes the notion of immersion from virtual reality as already described, but also includes methods by which the real and virtual elements can be influenced by augmented reality.

In a survey on augmented reality technology, Azuma et al. (2001) have identified four important and defining points for augmented reality:

- it **combines real** and **virtual** objects in a real environment,
- runs **interactively**,
- in **realtime,**
- and registers (**aligns**) **real** and **virtual** objects with each other.

While the combination of live performance (real) and immersive technology (virtual) is not strictly augmented reality because it does not necessarily occur in a real environment as stipulated, the remaining points offer useful information on how best to actually combine the real and the virtual. We see in this definition another reference to interactivity, confirming the importance that we have placed on interactivity in this research. We also see that operating in realtime is very important when combining real and virtual objects. Although interactivity does imply a certain responsiveness in the computing system, when blending realities we should also place an importance on the system working in real-time, that is without any perceptible lag.

Perhaps the most important point raised by this definition of augmented reality is the notion of alignment between the real and virtual objects. In order to create an acceptable blending between the real and virtual worlds, they need to be similarly aligned in three-dimensional space. Within standard proscenium arch performance settings, where the audience is in preset seating banks, this alignment can be relatively two-dimensional as the perspective of the audience is largely fixed. As the audience is given more autonomy and the blended world is portrayed from a more egocentric perspective, this alignment will increasingly need to be addressed in three dimensions.

### 2.4.4 Summary

Physical interaction can actually be seen as a requirement for immersive systems and the three-stage interactive system, as described in Section 2.3, can be updated in a number of ways to make it more immersive.

The following factors have been identified to make an interactive system more immersive:

**Input**

- full bodied motion capture
- three-dimensional
- multimodal input (motion capture + audio input or other)

**Transformation (mapping)**

- physical-based motion (Physical systems)
- collision systems
- three-dimensional transformation

**Output**

- stereoscopic visuals
- stereophonic audio
- rendered with depth cues (occlusion, relative size, shadows, lighting, focus related blurring)

- sound produced with depth cues (intensity, doppler effects, variable reverberations, etc)
- multi-modal output (audio + visuals)
- large field of view displays
- good alignment between real and virtual objects

## 2.5 Immersive live performances

Interactive systems and immersive technologies that may be plausible for use in creative performance works have been examined. Contemporary works that employ these technologies will now be investigated to understand how these technologies are currently being used in the context of live performance.

### 2.5.1 Stereoscopic live performances

While there is considerable literature surrounding both interactive systems for live performance and the pursuit of increased presence in CAVE environments, there appears to be very little detailing the combination of using immersive techniques within live interactive performance. There are some notable exceptions to this, stemming all the way back to 1991 when experimental music performance artist George Coates teamed up with Silicon Graphics to create a theatrical extravaganza called *Invisible Site: A Virtual Sho* (Breslauer, 1992). The show debuted at the Siggraph '91 conference, ambitiously including opera singers, actors, martial artists and interactive graphics that followed the actors in real time. The interactive graphics showcased the advanced rendering capabilities of the powerful Silicon Graphics machines and were projected in stereoscopic 3D. The audience wore special polarized glasses to experience the immersive mixed reality augmentations.

Dedicated CAVE environments in academic institutions have been exploited for the purposes of live musical performance. Mäki-Patola et al. (2005) created four separate interfaces to investigate three-dimensional virtual interfaces for musical expression including a virtual xylophone, theremin-inspired FM Synthesizer, virtual membrane and air guitar. Although they displayed potential, the interfaces suffered from an unacceptable amount of latency that hampered their usability as musical instruments. In another marriage of live performance and CAVE environments, Victor Zappi and his colleagues created what they call a 'hybrid reality' where stereoscopic visuals are created in response to a live musical performance and manipulated through physical gesture by both musician and audience members alike (Zappi et al., 2011). Although this series of three concerts were met with very positive reviews from the audience, the facility had a minuscule capacity of only nine audience members, highlighting a typical problem with many CAVE environments. While the virtual space of a CAVE is boundless, the physical space is generally too small to house even the most modest of live performances. (Kuchera-Morin et al., 2014)

Rather than restricting the performance to the physical confines of the CAVE, taking elements of the CAVE to traditional performance venues can be a more appealing proposition. For *Corpus Corvus* (2011), Heather Raikes created a mixed reality dance performance, combining stereoscopic graphics and motion capture with a live contemporary dancer (Raikes, 2011). She created a large-scale elliptical semi-transparent screen, or scrim, coupled with active shutter stereoscopic technology. Performing both in front and behind the scrim, it appeared as though the performer was engulfed in the three-dimensional visuals (see Figure 2.8). Despite including elements of motion capture in an immersive environment, the graphics (including motion capture sequences) were actually pre-rendered elements created before the event and as such it lacked the spontaneity and believability that real-time interactive systems can produce.

In 2010, Kim Vincs and John McCormick presented *Touching Space* (Figure 2.9), a real-time performance including interactive three-dimensional projections. Although the

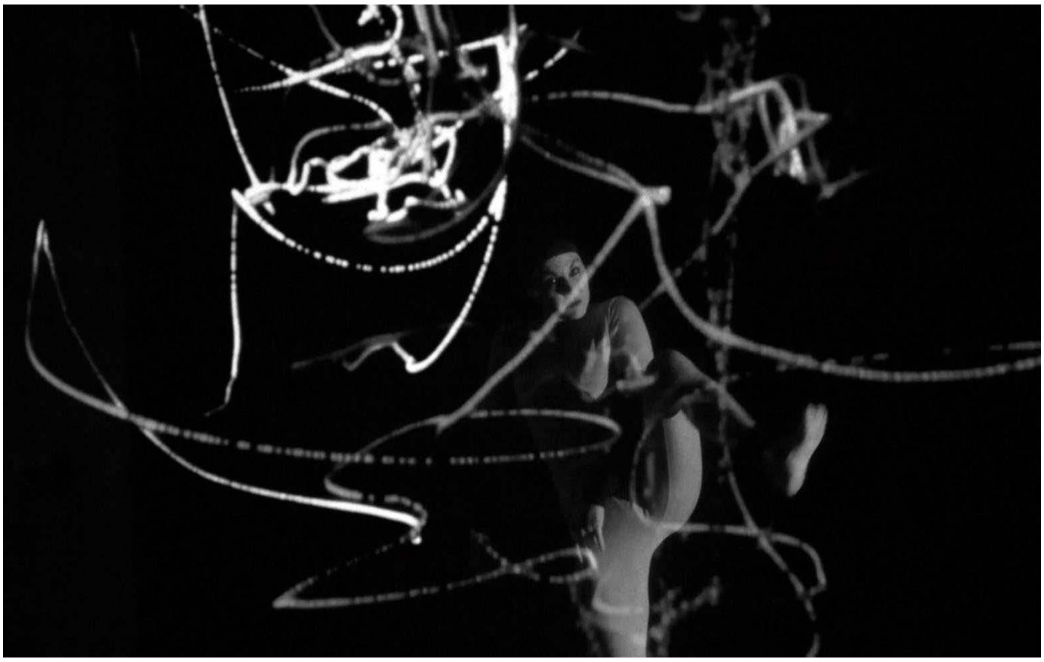

Figure 2.8: *Corpus Corvus* (Raikes, 2011)

Figure 2.9: *Touching Space* (Vincs and McCormick, 2010)

premise of real-time reactive graphics being dubbed 'virtual haptics' by Vincs and McCormick is somewhat dubious, the work presented is a very good example of combining real-time motion-capture and stereoscopic graphics in a live dance performance. Using a 24-camera motion analysis system, a 10m x 10m performance space was captured and a semi-portable 400inch silver screen was used to project polarized 3D images into the space in real-time. Using both Unity3D and Motion Builder software to generate the graphics in response to the dancer(s) they produced a series of short vignettes to showcase the technology. These visuals included dynamic geometric shapes, particle trails and virtual motion traces which all responded to shape and motion of the live performers. (Vincs and McCormick, 2010)

### 2.5.2 Immersive theatre

While investigating the use of immersive techniques within live performance that includes theatre, we should address the similarities and differences between this research and the blossoming field of immersive theatre. Immersive theatre has become popular in the United Kingdom since the early 2000's with companies such as Shunt, Punchdrunk and Blast Theory drawing considerable audiences to their performances (White, 2012). Immersive theatre is often practiced in large unused spaces such as defunct railway tunnels and abandoned warehouses and are 'site-sympathetic' in that they use the peculiarities of their locations as a part of their theatrical set, but the performance and narratives themselves are not particularly concerned with the history or context of their location. Audience members are invited to roam multiple locations or sets from the story where they are able to witness portions of the play unfolding in a non-linear manner. The audience is able to investigate props inside these sets at their leisure, but are often drawn to the next space by the desire to witness as much of the story as possible. With its emphasis on questioning the traditional audience to performer paradigm, immersive theatre can be seen as a resurgence and extension of the participatory theatre that was popularized in the 1960s and 1970s.

The ‘immersive’ component of immersive theatre refers to the audience’s position inside the sets and locations of the performance, rather than the inclusion of any type of immersive technology. Blast Theory often includes technology as a key part of their works, such as the *2003 Uncle Roy All Around You* that splits the performance into two sections, where players are sent into the street with dedicated PDA devices to communicate with players accessing an online city from an office. (Benford et al., 2004) This technology is not ‘immersive’ in the traditional notion of virtual reality, but it facilitates the audience to be immersed in the story and game as they physically participate by traversing the city streets. The key to this immersion is again the participatory nature of the theatre and the use of extensive real world spaces as a part of the theatrical set, rather than the use of any particularly immersive digital technology.

The immersive and interactive techniques described in this research aim to transform or extend the performance space through digital virtual environments, rather than audience to actor participatory engagement and physical prop making, and are therefore quite different than the genre of immersive theatre. Whilst making this distinction, the two are by no means mutually exclusive and it may prove fruitful to actually utilize digital immersive technologies within the genre of immersive theatre to further transform the spaces in which they inhabit.

### 2.5.3 Interactive art in immersive environments

Immersive CAVE environments have existed inside highly technical academic institutions since the 1990s, but CAVE-like immersive environments are now beginning to be installed in public museums and galleries. Unlike their CAVE forefathers that are built to house a range of projects, these installations are attached to dedicated artworks and are specifically designed for the space they are installed in. These works feature a large number of projectors working in unison to immerse the audience in an impressively large shared space. They are often designed by dedicated multimedia companies and commissioned by the institutions that house them. They tend to explore the content and/or themes of the associated institution that they are installed in.

*Connected Worlds* by Design I/O is housed at the New York Hall of Science and explores how ecosystems are connected through a water resource management game. The space features floor and wall projection and is interactive through a series of prescribed hand gestures and the movement of large physical 'logs' around the floor (Design I/O, 2015).

*Story of the Forest* by teamLabs is housed at the National Museum of Singapore and draws inspiration from the museum's prized William Farquhar Collection of Natural History Drawings. The audience walk the enormous space and interact by taking pictures of various animals in the digital forest with a bespoke iphone application (teamLab, 2016).

Both of these works present large scale immersive environments for multiple users using 2D projection mapping technology. Projection mapping is a technique where artists project digital images onto three-dimensional structures such as building facades to both give the projections an element of depth and to transform an every day surface into a giant projection screen *(Rowe, 2014)*. These works use simple projection mapping techniques to make dedicated physical structures (the waterfall in *Connected Worlds*), or simple architectural features (the bridge in *Story of the Forest)* become a part of the work.

## 2.6 Conclusion

The literature review has revealed a deep history of using technology with live performances such as dance, music and theatre. There is also considerable literature around the combination of interactive technology in both music and dance with the *New Interfaces for*

Figure 2.10: *Connected Worlds* (Design I/O, 2015)

*Music Expression (NIME)* and *Movement and Computing (MOCO)* academic conferences addressing interaction in these performance areas.

The literature review on interactive systems has revealed the following design considerations:

- The system can be broken into three separate stages of motion capture, mapping and audio-visual output.
- Motion capture appears to be a trade-off between accuracy, physical restrictions, size of the performance space, setup time and cost. The exact motion capture system used will need to be examined for each artistic project individually.
- Mediating the mapping through a physical system can provide a 'conversational' interaction that is both intuitive and transparent while adding an aspect of non-determinism.
- Physical systems can reflect the movement qualities of dancers, rather than simply the pose or spatial position.
- Complex organic systems can also provide an understandable level of non-determinism in the mapping layer.
- Geometric shapes and sine-tones provide a high transparency but a limited complexity when using direct mappings.
- Precomposed media can be used to add sophisticated narrative to a piece, but severely limit the interaction when coupled with discreet gestures.
- Geometric shapes and precomposed media can be combined with complex physical simulations and particle systems to produce emergent behaviours.

Immersive technology has also been reviewed and the importance of spatiality to immersive technology was discussed. The following considerations when combining immersive technology with live performance have been identified:

- Respecting three dimensions in all stages of the system.
- Displays using depth enabled technologies are more immersive. This includes stereoscopy, stereophony, occlusion, shadows, perspective etc.
- A wide field of view display is more immersive.
- The entire system should be real-time.
- Realistic physics and collision systems are important for the interactivity.
- Multimodal input and output is preferred.
- CAVE multi-screen projection environments are more suitable than head-mounted displays or mobile phone devices because they provide an unmediated view of the live performer.

While revealing a scarcity of research that successfully combines interactive art <u>and</u> immersive technology with live performance, this review has presented a large variety of technologies that are worthwhile investigating. These include motion capture systems (free form, marker-based, camera tracking, accelerometer), complex mapping techniques (fluid simulation, spring systems, flocking), output methods (particle systems, shapes, granular media), and immersive technologies (stereoscopy, spatialized sound). Given this large number of technologies, a flexible system is preferred which could potentially facilitate a combination of all these technologies, as suitable for each individual performance.

A system that incorporates these varied technologies is described in Chapter 5 and some of the performances created with the system are introduced in Chapter 4, but first the approach to combining practice (building a system and developing performances) with research (how this technology is applied and received by the performance artists) is detailed in Chapter 3.

# Chapter 3

# Methods

## 3.1 Introduction

The literature review has demonstrated a strong body of research into the creation of interactive live performances. It has also revealed considerable research around interactive immersive technologies. There was, however, a relative scarcity of information to be found at the intersection between all three fields of interactive art, immersive technology and live performance. The aim of this research is to further explore this intersection through the following objectives:

- To create a technological system with immersive and interactive capabilities suitable for use with live performance.
- To use the system to develop performances and artworks that combine interactive art, immersive technology and live performance.
- To examine the effect of combining these fields on the development and production of these performative works.

This chapter details the methods and methodologies utilized to achieve these objectives through **practice-based research** (Section 3.2) and **reflective practice** (Section 3.2.1). Whilst each stage of the research did not necessarily occur independently and without overlap, we can categorize the research in the following manner:

1. **Literature review** (Chapter 2): Search the literature and existing artworks to identify what type of technology design may be suitable.

2. **Artefact design** (Section 3.3):

   (a) **Software design** (Section 3.3.4): Create a prototype immersive and interactive system that is capable of use in live performance.

   (b) **Devised theatre** (Section 3.3.3): Collaborate with expert artists and performers to develop a new performance utilizing the technological system.

   (c) **Software design** (Section 3.3.4): Extend and refine the technological system with new features inspired by the theatre performance.

   (d) Iteratively repeat steps (b) and (c), developing new performances and improving the technological system, refining both the system and its use in live performance from a technical and **embodied** (Section 3.3.5) perspective.

3. **Grounded theory** (Section 3.4):

   (a) **Data collection** (Section 3.5): Observe and interview the artists involved in developing the artworks and performances.

   (b) **Data analysis** (Section 3.6): Analyze the data and final system to derive a framework for immersive system design and use in live performance.

## 3.2 Practice-based research

In the book *Interacting: Art, Research and the Creative Practitioner*, Linda Candy describes the term ‘creative practice’ as combining “the act of creating something novel with the necessary processes and techniques belonging to a given field of endeavour, whether art, music, design, engineering or science.” Candy (2011, p 33) The research detailed in this dissertation is concerned with the application of immersive and interactive technology to the live performing arts of dance, music, theatre and interactive installations. This new technology is mixed with the traditional practices of each field to generate new performative works and places the research firmly within Candy’s definition of ‘creative practice’. Candy goes on to describe a strong link between research and the creation of new work within creative practice:

> “Research within creative practice is inextricably bound up with creating works and investigating the implications of them.” - Candy (2011, p 39)

Researching the use of interactive and immersive technology within live performance can therefore be seen as being ‘bound up’ with the creation and examination of new live performances and aptly describes the bulk of the research presented in this dissertation.

Research that is based upon and derived through the practice of the researcher is commonly called ‘practice-based research’. Candy (2011) states that although often used interchangeably, the terms practice-*based* and practice-*led* describe a different research focus. Practice-*led* research attempts to find new understandings about practice, while practice-*based* describes research where the process is ‘primarily based on the making of an artefact.’ (Candy, 2011) The term artefacts is used to describe an artistic outcome or object which is made by the creative practitioner during the period of research. These outcomes could take the form of installations, exhibitions, objects or performances. In the field of this dissertation, live performances and interactive art installations are the obvious artefacts to be created and are used as conduits for investigation.

The artefacts do not represent the entirety of the research itself, but may encompass a large proportion of this research and are essential to the understanding of the greater research presented.

> "In practice-*based* research, any claims of originality and contribution to knowledge may be demonstrated through artefacts created during the research process such as artworks, musical compositions, performances and interactive new media installations. A full understanding of the significance of the research can only be obtained with direct reference to the artefacts in whatever form they may take." - (Candy, 2011, p 36)

### 3.2.1 Reflective practice

When undertaking practice-based research it is prudent to understand how the act of practice can be seen as a rigorous undertaking, contributing to the generation of knowledge. Scrivener proposes that, although oriented towards the practice of problem-solution based design, Schön's theory of reflective practice (Schön, 1983) provides many useful ways to understand the process undertaken in a 'creative-production' task.

> "Schön's (1983) theory of reflective practice provides us with ways of thinking about the nature of the creative-production process, the way past experience (both personal and collective) is brought to bear on it, the assessment of action, rigour in creative-production, and the stance of the practitioner" - (Scrivener, 2000)

Schön describes a process of reflection in creative design practice that naturally occurs while the practitioner is actively engaged in her own act of professional practice. The act of practice in a creative realm involves constant moments of self-reflection where the practitioner will assess the outcomes of their practice and adjust their processes to see how this may affect the outcomes of their practice. As this process of action, observation and reflection is occuring so immediately and is so tightly coupled with the process of actually creating, Schön has described it as ‘reflection-in-action’. The immediate nature of ‘reflection-in-action’ distinguishes it from a ‘reflection-on-action’ which may occur after the act of creation to assess what has been created and how successful it is. Schön has posited that this type of immediate ‘reflection-in-action’ generates an intuitive or ‘tacit’ knowledge within the practitioner.

> "reflection tends to focus interactively on the outcomes of action, the action itself, and the intuitive knowledge implicit in the action." - (Schön, 1983, p 56)

### Reflection-in-action

The process of reflecting-in-action is somewhat akin to researching on a micro time scale. The practitioner is not concerned with finding unified models or frameworks at this stage, but they are rapidly exploring multiple aspects of the one specific task that lays before them. The reflection-in-action practitioner relies on previous expertise to guide their actions, but the knowledge gained within this process is seen to be problem specific.

> "When someone reflects-in-action, he becomes a researcher in the practice context. He is not dependent on the categories of established theory and technique, but constructs a new theory of the unique case" - (Schön, 1983, p 68)

The process of reflection-in-action is most prevalent when the creative task at hand ‘talks back’ to the practitioner with an unexpected outcome providing some element of surprise in response to the actions undertaken. In a problem-solution type of project where the exact nature of the problem is clearly known, this back-talk is what triggers a moment of reflection. If the outcome of an action corresponds precisely to the expected result, a moment of reflection is not needed and the practitioner may move on to the next task. Only when the situation talks back with unexpected results is it necessary to reflect and reassess the situation, generating intuitive knowledge about the results of a given action and forcing the practitioner to rethink or reframe the task at hand to attack it from a different direction.

"Through the unintended effects of action, the situation talks back. The practitioner, reflecting on the back-talk may find new meanings in the situation which lead him to a new reframing. Thus he judges a problem-setting by the quality and direction of the reflective conversation to which it leads. This judgement rests, at least in part, on his perception of potentials for coherence and congruence which he can realize through his further inquiry." - (Schön, 1983, p 135)

While the reframing of the situation is an important part of problem-solution projects, it is absolutely vital in artistic and creative projects where the exact nature of the task is often discovered through the process of undertaking the task itself. The back-talk is vital to the discovery process, where artists use the practice of creation to understand the greater or potential meaning of the content that they strive to create.

**Reflection-on-action**

Reflection-in-action occurs within the process of practice as a reaction to the back-talk of the situation at hand. In opposition to this, a reflection-on-action occurs after the process of practice has halted. Reflection-in-action will only exist until the back-talk of the situation has been addressed or the situation reframed, while reflection-on-action occurs after the fact and can therefore occur over a larger time-scale. Scrivener describes the underlying purpose for reflection-on-action as being more deliberate and quite distinct from that of reflection-in-action.

> “In contrast to reflection-in-action and practice, reflection-on-action and practice is not driven by the unexpected per se but by the desire to learn from experience: it is a discipline rather than a necessity for further action.” - (Scrivener, 2000)

The process of reflection-*in*-action allows creative practitioners to quickly expand or refine their works while forming tacit knowledge about what types of actions are likely to be fruitful in the future. The process of reflection-*on*-action will then increase the body of knowledge by reflecting on the practice itself, hopefully generating a more complete theory as it is informed by the many instances of reflection-*in*-action.

### 3.2.2 Strategies for creative practice-based research

Johnston (2014) posits that a core question to be answered in practice-based research is: ‘who is this research for?’. The answer to this question will guide the methodologies undertaken throughout this research. Closely following Johnston’s own research into interactive dance, the research undertaken in this dissertation is primarily aimed at artists and designers who are engaged in creating and performing live works. In order to ensure that practice-based research is aligned with the concerns of these practicing artists, Johnston has outlined a number of strategies which include:-

- “Working with experienced and high-calibre artists.
- Iterative development in close collaboration with artists.
- Meaningful examination of the impact of interactive systems on the creative practice and experiences of performers.
- Engaging performers in reflection on all aspects of the work, usually in interviews.
- Analysing data gathered during interviews as a final reflective step to generate theory linked to practice.” (Johnston, 2014)

These strategies were designed by Johnston in his pursuit to keep his research “grounded in creative practice” (Johnston, 2014) and have similarly been used to guide the methodologies selected within this practice-based research.

While Johnston may appear to distinguish between 'artists' and 'performers' in these strategies, the performers within the context of music, dance and theatre can all be considered artists in their own right, and non-performing artists (such as choreographers, composers and set designers) may also have their creative practice impacted by the interactive systems. The use of the word 'performer' is therefore to be replaced by the word 'artist' within all of these strategies where the term artist is to include that of the performers.

These strategies for research can then be split into two separate categories in pursuit of this objective:- reflection-*in*-action and reflection-*on*-action.

The strategies for reflection-*in*-action are:

- working with experienced and high-calibre artists
- iterative development in close collaboration with artists

These strategies informed the choice and application of artefact design methods detailed in Section 3.3.

The strategies for reflection-*on*-action are:

- meaningful examination of the impact of interactive systems on the creative practice and experiences of artists
- engaging artists in reflection on all aspects of the work, usually in interviews
- analysing data gathered during interviews as a final reflective step to generate theory linked to practice

These strategies informed the choice and application of reflection-*on*-action methods described in Sections 3.4, 3.5 and 3.6.

## 3.3 Artefact design

We have discussed Schön's concept of the reflective practitioner and how the act of practice itself can generate new knowledge and understandings when the practitioner is engaged in reflection-in-action. Johnston's strategies for a practice-based research that remains grounded in the creative practice details two key points with regards to reflection-in-action:- collaboration and iterative development. We can now describe the exact nature of the artefacts themselves and the methods that were used to collaboratively and iteratively construct these artefacts.

### 3.3.1 The artefacts

#### The performances

Chapter 4, describes many of the artefacts produced as a part of this practice-based research, including the two major works:- the physical theatre show *Creature: Dot and the Kangaroo* and the interactive art experience *Creature: Interactions.* These two complementary works are both themed around the Australian children's novel *Dot and the Kangaroo,* premiered simultaneously, share digital assets, have a duration of around 40 minutes, were built and performed with the same technological system and were produced by *Stalker Theatre* in collaboration with this researcher. Although sharing much in common, the works are significantly different in terms of performers, scripts, music, and performative format with *Creature: Dot and the Kangaroo* being a traditional proscenium arch theatre show and *Creature: Interactions* being a participatory interactive experience inside a 360 degree immersive space. Among the many performative artefacts produced during this research, these two were selected for deeper analysis as they are both medium-large scale productions that have been performed multiple times in exemplary venues (*Queensland's Performing Arts Center* and the *Sydney Opera House)* and include the combination of many interactive and immersive techniques developed during this research. The inclusion of the two different performance formats offers an ability to investigate the application of interactive technology within traditional proscenium arch theatre and the application of theatre within immersive interactive art experiences. Table 3.1 displays the similarities and differences of these two major artefacts.

Further artefacts were created during the cause of this research, but as their contribution to knowledge was significantly less or was better described through the two major works, they have been included in the Appendix A as evidence of research undertaken rather than their individual contributions to knowledge.

The performance artefacts produced by research were developed in collaboration with professional physical performers, dancers, choreographers, playwrights, singers, composers and musicians all of whom are experienced and are high-calibre within their own unique professions. The quality of the artists within these collaborations satisfies Johnston's creative practice strategy of "working with experienced and high-calibre artists" (Johnston, 2014). Johnston argues that this expertise can help to generate a better artefact, and can also provide deeper insights within subsequent interviews as the practitioners have a better understanding of the situations at hand.

### The technology

Interactive art and immersive live performances are new interdisciplinary or hybrid art forms that rely as much on new technological advancements as much they do on the established practices of art, music and theatre. The development and use of new technology to explore these hybrid art forms is a relatively common occurrence of practice-based research.

> "Emerging forms of art are breaking new ground on a number of fronts and making something new technologically is often as much a part of the creativity as the concepts and visions that drive the creative process in the first place. In interactive art research, innovation in the art forms drives innovation in the

| | *Creature: Dot and the Kangaroo* | *Creature: Interactions* |
|---|---|---|
| **Genre** | physical theatre / musical | interactive art experience |
| **Interaction mode** | performer <--> projection | audience <--> projection |
| **Interaction type** | embodied | embodied |
| **Theme** | Dot and the Kangaroo | Dot and the Kangaroo and Australian Bush |
| **Narrative** | retelling of novel | exploration of ecology and social physical movement |
| **Performance style** | strongly scripted and choreographed | loosely scripted with audience participation |
| **Setting** | Australian bush | Australian bush |
| **Interactive systems** | ParticleStorm | ParticleStorm |
| **Duration** | 42 minutes | roughly 40 minutes |
| **Performers** | professional acrobats, musicians and actors | lead actor and volunteer facilitators |
| **Target audience** | children | children |
| **Music** | composed soundtrack and song | ambient electroacoustic with sound effects |
| **Visuals** | interactive particle systems and pre-rendered animation | interactive particle systems and pre-rendered animation |
| **Format** | proscenium arch | immersive 360 degree interactive display |
| **Produced by** | Stalker theatre | Stalker theatre |
| **Premiere date** | June 2016 | June 2016 |
| **Premiere Venue** | Queensland Performing Arts Centre | Queensland Performing Arts Centre |

Table 3.1: *Creature: Dot and the Kangaroo* vs *Creature: Interactions*

> technology and, conversely, new technologies facilitate the creation of novel art forms." - (Candy, 2011, p 39)

While much of the technology used to create the artistic artefacts within this dissertation is based on 'open-source' software algorithms and 'off the shelf' hardware, a significant effort was undertaken to meaningfully assemble the existing technologies into a usable system for live performance. Many of these existing algorithms were extended to facilitate their use in more immersive environments and custom tools were built by the researcher including:

- real-time 3D composting
- warping effects
- depth-based stereoscopy
- surround sound processing
- granular synthesis, and
- distributed user interfaces.

The custom built portions of the software consisted of roughly 100 files and 20,000 lines of purpose built C++ source code which operated in conjunction with the many open source libraries and algorithms used.

The extent of custom made software created for this research make the technological component to this research worthy of being treated as an artefact in its own right. Just as the significance of the research cannot be justly conveyed without an adequate description and documentation of the accompanying artworks, the contributions of the artworks and greater research are intrinsically interwoven with the development of the technology itself. As such the technological system itself is treated as an artefact of the research and is described in detail in Chapter 5. It is presented alongside the two major performances to support the text-based component of the thesis.

To differentiate the different types of artefacts constructed for this research, the terms ‘performance artefact’ and ‘technological artefact’ will be used to distinguish the live performance outputs from the technical tools which were developed to realize these ‘performance artefacts’.

### 3.3.2 Role of the researcher

As a researcher involved in collaborative practice, it is necessary to describe the exact role of the researcher within these projects. The author of this practice-based research dissertation, assumed the non-specific role of ‘digital artist’ throughout all of these performances. This involved creating and operating immersive software that could be used interactively in live performances. It involved conceiving and refining interaction and visual aesthetics. In many cases it involved photography, video composition and the production of simple 3D models to be used as elements within the interactive works. It also involved sound design, music composition and lighting design in certain productions. Relying on the expertise of trained professionals, the researcher never assumed the role as a live performer on stage, despite technically operating most of these performances to some degree from a technical desk. Many of these productions were in collaboration with interactive designer Andrew Johnston, including the *Creature* series of works, where various visual and sound artists were also used. The works are all very much collaborations with various performance and digital artists, but (with the exception of *Encoded)* this researcher was the primary interactive artist involved. This researcher was also the sole software developer throughout this body of work, significantly extending the system beyond the capabilities originally developed by Andrew Johnston for the *Encoded* production.

### 3.3.3 Devised theatre

To ensure that this research adheres to Johnston's assertion of keeping the research 'grounded in creative practice' (Johnston, 2014), iterative methods of creating both the performance and technological artefacts that are aligned with the fields of physical theatre and creative coding are sought.

Whilst each artefact arguably belongs to a different genre of performance including musical performance, dance, interactive installation and physical theatre, all of the artefacts are constructed from the similar elements including a strong visual presence, music and embodied interaction with a real-time virtual environment. Each project or artefact may have its own individual focus, but as they all share the same basic construction we can place them all under the larger performance category of theatrical production. Theatre is a conveniently broad category in which to place these works, as it commonly includes live human performance, musical scores and visual support. Although less common, theatre can also include participatory interaction from the audience. Whilst musical performance can include visual elements, and interactive artworks may include a live performance element, these are perhaps often seen as extraneous to the core performative genre.

The diversity of these works may seem slightly at odds with more traditional theatre genres but are positioned well within the practice of devised theatre. Devised theatre became a popular medium for artistic exploration in the 1960's and 1970's when performance artists sought to collaborate with music, dance, visual and technical arts. It is an inclusive genre of theatre which combines many diverse art forms including sculpture, music, film and dance. It also embraces the integration of technology within the performance medium. The openness to new art forms and technologies is an obvious requirement given the highly technical nature of the interactive artworks developed during this research.

Devised theatre is not categorized by the style of production itself, but primarily by the processes by which the production is developed. Traditional theatre has well established hierarchies and defined roles as the theatre company largely serves the visions of the playwright and directors of the given play. Devised theatre is a more collaborative experience where roles are less defined and the entire company will work together to realize not only the production, but the actual structure of the show itself. The exact procedure of devised theatre will depend on the nature of the production at hand, but will often include a series of workshops, improvisations, discussion and experimentation.

> "Devised theatre can start from anything. It is determined and defined by a group of people who set up an initial framework or structure to explore and experiment with ideas, images, concepts, themes, or specific stimuli that might include music, text, objects, paintings, or movement." Oddey (2013, p 1)

The devised theatre practitioners will commonly experiment with the nature of performative space and the audience to performer dynamic, both of which are important for realizing immersive and interactive performances which may not naturally fit within traditional 'proscenium arch' theatrical settings. While one of the major artefacts (*Creature: Dot and the Kangaroo)* was developed for a traditional theatre venue, other works developed within this research have been performed in alternative environments such as immersive CAVE environments (*Creature: Interactions / 3D),* on the side of sky scrapers (*Pixel Mountain)* and a historical train station (*Frameshift).* The willingness and ability to experiment with alternative spaces and participatory modes of interaction are essential to the research undertaken in this dissertation.

The practice of devised theatre aligns with the collaborative and iterative strategies for practice-based research and is grounded in the traditions of creative practice in the following ways:

- emphasis on collaborative exploration
- workshopping, experimentation and discussion correlate nicely with the action and reflection cycles of reflective practice

- openness to include diverse art forms
- openness to technology within live performance
- flexibility of performative space
- experimentation of audience to performer dynamic

### 3.3.4 Software design

As the system has evolved alongside the body of artworks its features and design are intrinsically linked to these works. Symbiotically, the system has dictated the aesthetics and scope of the artworks, while each artwork has in turn steered the development and capabilities of the system. Perhaps reflecting this symbiotic relationship, the task of creating software for the system has itself been a mix of two different programming styles, both possessing distinctly different objectives.

#### Bricolage programming

In their 2012 chapter on *Computer Programming in the Creative Arts,* Mclean and Wiggins (McLean and Wiggins, 2012) describe a style of software programming that is particularly common in the area of creative coding. This style has been dubbed 'bricolage programming*'* and is distinguished by its highly iterative process where the steps of design and evaluation are often occurring simultaneously. The end goal of a bricolage programming exercise is often loosely defined as finding something 'interesting', indicating that it is more concerned with exploration and discovery than the problem-solution paradigm of more traditional software engineering. Mistakes are commonplace during the development of software systems, but contrary to traditional software design, a bricoleur will often embrace these mistakes and prefer the unexpected outcomes to that of the originally intended design. Software objects will be deliberately pushed outside their intended operating range to embrace and explore unplanned outcomes. This willingness and desire to explore the unplanned and erroneous is at direct odds with mainstream programming methodologies and makes bricolage programming both unique and well suited to the creative arts.

Whilst the bricoleur will know the general area that they are interested in, they will work on hunches and constantly test their theories as they progress. This type of programming was used heavily when creating the ParticleStorm series of works, where a certain beauty and complexity is a desired response to improvised human interaction. It is difficult to predict or design the exact outcome that will emerge from the thousands of simple agents (or particles) in response to human interaction. Designing the interactive system therefore becomes the implementation of a series of small algorithms which can be controlled from a unified user interface. Each algorithm itself might not have a pleasant outcome on its own, but may combine with other algorithms in interesting ways. With each small addition to the interactive system, a large period of interactive testing is undergone to determine how each algorithm responds to human behavior and how it can be used in conjunction with other algorithms already existing in the system. For example, a feature was added to the fluid system during *Encoded* development which attracts particles to a central point. This feature was initially designed as a way to transition from a full screen of particles to another particle state. While the feature had some mild success as a transitioning agent, its main use was discovered when placing a negative value in the attraction force. This negative attraction forced the particles to slowly fly off screen and the result appears as though you are looking at night stars in a constantly expanding universe. A positive attraction combined with particle generation can cause these particles to swarm around the performer organically. These attraction side-effects were used prominently in *Encoded* where performers would summersault across the stage in mid air to spectacular effect. These unintended side-effects are embraced by the trial and error mentality of the bricoleur and have accounted for many of the more successful moments in the presented works.

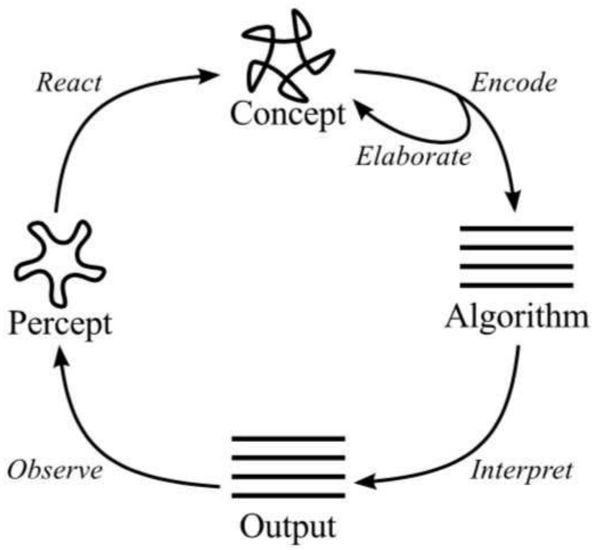


Figure 3.1: The bricolage programming cycle (McLean and Wiggins, 2012, p 239)

The speed of development and exploration that is possible with **bricolage programming** makes it ideal for use in **devised theatre** where the iterative development cycles can occur at an extremely rapid pace.

### Agile programming

Bricolage programming was used to build and discover many creative algorithms within the ParticleStorm software. While the quick turnaround of this style of programming is effective for discovering new creative techniques, the haste and lack of forward planning can often lead to badly structured code. The ParticleStorm suite of software is of a significant scale such that a more structured style of programming is necessary to keep the system efficient, robust and flexible. Sections of the software such as networking, preset manipulation and real-time 3D video compositing require an emphasis on design prior to implementation. As a more robust approach, Agile programming methods were adopted for the design of these parts of the software. Agile methods can be seen as a mid-point between the haste and pure discovery of bricoleur, and the overbearing rigidness of design and pre-planning prevalent in traditional software lifecycle models such as the waterfall technique. Agile software development is described by Erickson et al (2005), as a "means to strip away as much of the heaviness, commonly associated with traditional software-development methodologies, as possible to promote quick response to changing environments, changes in user requirements, accelerated project deadlines, and the like". Agile methods are similar to bricolage, in that they involve an iterative cycle of design, implementation and reflection but differ largely on the time-scale that is involved in each of these iterations. A bricoleur may complete an iterative cycle in a matter of minutes, while the agile programmer can take days, weeks or even months to finish a task. These agile tasks can morph and be refined with each iteration but each task will have a clearly defined goal in mind before the task is undertaken. This is in stark contrast to the exploratory nature of bricolage where even the goals are developed through an experimental trial and error process.

The agile method of 'refactoring' was used extensively to improve the software design, making the system more efficient and robust. Refactoring is the process of changing the internal structure of software without adding or changing to the actual functioning of the system.

> "A good design is essential to maintaining speed in software development. Refactoring helps you develop software more rapidly, because it stops the design of the system from decaying." - Fowler and Beck (1999, p 49)

As a software system grows in complexity, any flaws or weaknesses in the design and implementation will compound and the overall integrity of the system will decay. This damages the overall stability of the software, and makes adding any new features very difficult and time consuming. In the book *Refactoring: Improving the Design of Existing Code,* Fowler (1999), outlines a number of ways to spot poorly implemented sections of code and provides steps to correct these problems. These steps aim to improve the efficiency and readability of the code and helped to keep ParticleStorm a maintainable piece of software, despite its constantly evolving feature-set.

The agile and bricolage methods nicely coexist in a project of this scale where ideas and structures that are discovered using bricolage methods are often refactored using agile methods to be more robust, efficient and reusable. A lot of the technological system has evolved in this manner, where a rapid period of bricolage during the performative development will bring to light useful functionality. Once the artefact has been developed and successfully performed, a period of reflection-on-action will be used to decide which algorithms implemented or desired during devised theatre development might be useful to other projects in the future. As the true benefit and scope of this functionality becomes more defined, agile methods are employed to refactor the code, making it more robust and reusable in future artworks. Using this format (shown in Figure 3.2) the technological artefact is constantly evolving and growing over the entire body of performative works. Each performative work is associated with a unique snapshot of the technology that has branched off for a period of bricolage discovery. The agile cycle will incorporate the bricolage additions in a more organized and stable fashion. It will also add new features to be explored and augmented in the next project and branch of bricolage programming. Without the constant agile iterations, the bricolage software design could become so messy and entangled that adding or altering the simplest of tasks would become a dauntingly difficult and confusing process.

### 3.3.5 Embodied interaction

The agile and bricolage methods were used to creatively explore and develop a robust software system. While the live performances were created collaboratively using devised

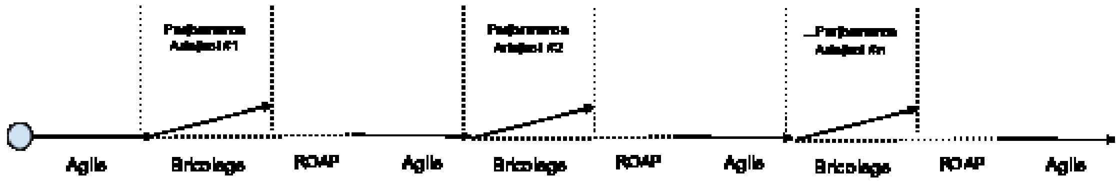


Figure 3.2: The software development cycle alternating bricolage, reflection-on-action (ROAP) and agile methods.

theatre, the potential for interaction within these works was inexorably linked to the capabilities and design of the technological system. A system that can successfully combine immersive technology, interactive art and live performance should not only be robust and flexible, but it should facilitate an expressive and full-bodied interaction that will be of interest to the performers involved in the productions. To focus on the interaction design from the perspective of the performers, we can employ the concept of 'embodied interaction' which considers that all human actions, including cognition, stem from the body. Dourish (2004) describes embodied interaction as an attempt to unify the research streams of tangible and social computing through the field of phenomenology, considering the context and real-world setting in which the human-computer interactions take place. It is argued that designers creating prototypes and tangible interfaces can take advantage of the tacit knowledge that is formed by physically performing actions and gestures in the real world (Klemmer et al., 2006). Placing further importance on the role of physical movement in computational interaction, Loke and Robertson (2013) created their 'Moving and Making Strange' framework to aid the design of interactive experiences through the somatic practice of movement and felt experience. This framework views the embodied experience of the performer in equal proportions to that of the audience and the perspective of the interactive technology. It introduces a number of steps to provoke an exploration of movement that can be coupled with more traditional and technological interaction design methodologies. The embodied approach aims to create a holistic and coherent design process by including perspectives from the bodies of the performers and the audience, in addition to that of the machine.

In order to understand and facilitate the interaction from the perspective of the performer (or participant in the case of interactive installation art), physical interaction was frequently engaged throughout the entire design process. When developing a specific performance artefact, this physical interaction was contributed by the expert physical performers as they improvised with the system. Outside of these development periods, my own full-bodied physical movements were used in combination with pre-recorded expert motion capture to test, design and extend the interaction capabilities. This two-pronged approach ensured that an expert's richness of movement was being utilized to full capacity by the system, whilst also providing myself with an embodied appreciation of this interaction from a participant's perspective. At various stages throughout the entire design process, I have experienced the interactive system:

1. from the perspective of the participant/performer when personally interacting with the system,
2. from the perspective of the audience when using expert movers or pre-recorded motion capture, and
3. from the perspective of the machine when designing through the agile and bricolage programming methods.

These three perspectives align with those described by the 'Moving and Making Strange' framework. Designing the system from both a technological and embodied perspective has promoted an interaction aesthetic that is complex (of interest to audience and performers), robust (from the perspective of the system) and naturalistic (suited to human physical movement).

### 3.3.6 Summary

The artefacts described in this **practice-based research** were developed using the collaborative and iterative methods of **devised theatre, bricolage programming** and **agile programming** and explored through the perspective of **embodied interaction.** These methods can fit within the broad category of **reflection-in-action** within this entire research project. The collaborative and iterative nature of these methods allowed the performative and technological artefacts to emerge naturally, as their exact direction was largely determined through the practice of creating them rather than being dictated by a specific design problem.

## 3.4 Grounded theory

When creating artistic artefacts, the exact nature of the problem or enquiry is not known from the outset. The experimentation, observation and reflection used within devised theatre and bricolage programming allow problems to be discovered as much as they allow solutions to be found. Such is the nature of creative inquiry where initial concepts are often overly simplistic and singular in direction when compared to the results of iterative and reflective design.

As a practice-based researcher embracing the idea of research through practice, it is logical to embrace research methodologies that are consistent with the nature of the practice undertaken. Just as the complementary agile programming has been used to bolster the ideas and algorithms discovered through the reflection-in-action of bricolage experimentation, reflection-on-action can be used to refine and support the conceptual ideas and concerns generated by way of reflective practice. To complete the reflection-on-action portion of this research, we look to the complementary and well established methodology of grounded theory that was introduced by Glaser and Strauss in their 1967 book *Discovery of Grounded Theory* Creswell (2007).

According to Barney Glaser, one of the founders of grounded theory,

> "The grounded theory approach is a general methodology of analysis linked with data collection that uses a systematically applied set of methods to generate an inductive theory about a substantive area." Glaser (1992, p 16)

The theories developed through grounded theory are said to be 'grounded' in the data generated through research. Rather than bringing preconceived notions of the problem that need to be tested, grounded theory is a way to actually discover the problem in the first place. Grounded theory attempts to understand what is actually happening in a given situation, rather then simply evaluating how well a given situation aligns with a certain preconceived hypothesis.

> "the research problem is as much discovered as the process that contributes to resolve it, and indeed the resolving process usually indicates the problem. They are integrated." - Glaser (1992, p 21)

This 'discovery' of the research problem aligns very well with the iterative processes of devised theatre and bricolage programming used for reflection-in-action and can therefore be seen as a suitable approach to the reflection-on-action of creating performance artefacts. Grounded theory will be used to understand not only how interactive and immersive techniques may be applied to live performance, but what the implications of introducing these technologies are to the performing and creative artists involved in these productions.

The grounded theory methodology was originally conceived by both Barney G. Glaser and Anselm L. Strauss in their 1967 book, *Discovery of Grounded Theory*. Whilst both parties have produced further texts that refine the ideals and usage of the methodology, the two originators have significantly diverged from each other in their approach, forming two separate branches of grounded theory. In Glaser's 1992 book *Basics of Grounded Theory Analysis*, (a passionate and thoroughly scathing dissection of Strauss' own *Basics* *of Qualitative Research)* he describes the logic of Strauss as being destructive to grounded research.

> "It is a logic that thwarts and frustrates the discovery of what is truly going on in the substantive area under study, and undermines grounded theory at every turn by preconceived forcing of the data." - Glaser (1992, p 3)

This research will assume Glaser's stance that relies heavily on the emergence of theory through constant comparisons to keep it well and truly grounded in the data at hand.

Glaser describes three separate stages of grounded theory which will be represented within this research.

1. **Data collection** (Interviews, surveys and a scene analysis) as documented in Section 3.5.

2. **Method analysis** to make sense of the data collected (Section 3.6).

3. **Written and verbal presentations**, resulting in the production of this very dissertation.

## 3.5 Data collection

### 3.5.1 Observations

During the development, rehearsals and public showings of the performative artefacts, observations were made of how the artists related to the interactive virtual components and how they incorporated the new technology into their everyday craft. These observations helped to explore the technology in useful ways through bricolage programming, formed the basis for refinement through agile software development and provided moments of insight to be further explored through in depth interviews. These observations included video recordings of development sessions and rehearsals in addition to general field notes.

Observations were also made during public showings of how the audience either engaged or disengaged with the works, particularly the participatory works of *Creature: Interactions* and *Creature: 3D*. This allowed for the subtle refinement within the season to increase the enjoyment for large crowds of small children. Such refinements could only occur in vivo through reiterative observations and reflective action as the social behaviour of a large group of children is difficult to replicate in a laboratory setting.

### 3.5.2 Interviews

The performative artefacts examined are large scale collaborative efforts that contain professional levels of acrobatics, dancing, live musicianship, singing, sound composition, script-writing, 3D animation, interactive technology, software engineering, lighting, costume design and choreography. Given the diverse nature of these skills, the researcher can not and should not claim to be an expert in all of these areas. Instead, the researcher should respect the expertise of the professionals within their particular domain and use interviews to reveal this knowledge as it relates to the immersive technology.

Rossman and Rallis suggest that “Elites respond well to inquiries about broad topics and to open-ended questions that allow them the freedom to use their knowledge and imagination.” (Rossman and Rallis, 2011) As such, the interviews will be conducted in person with what Patton describes as a ‘General Interview Guide’ which provides the interviewer a suggestive basis for the direction of the interview, but the ability to branch away from this structure as interesting information is provided by the interviewee (Patton, 1990).

The General Interview Guide aligns with Glaser's view of grounded theory as it seeks to minimize forced data by allowing the experts to give their own specific account of the events rather than framing the interview with preconceived ideas and specific questions.

> "the researcher never, never asks the question directly in interviews as this would preconceive the emergence of data. Interview questions have to relate directly to what the interview is about empirically, so the researcher maximizes the acquisition of non-forced data." - Glaser (1992, p 16, underlining in original text)

For this research a total of 15 interviews were conducted, in person where possible and via video chats using Skype[1] where distance and professional schedules proved problematic. These interviews were roughly 45 minutes to 1 hour in duration and were all undertaken shortly after the premieres of the major performative artefacts in reflection of both the development and performance of these works. The interviews were undertaken with as many participants of the collaboration as possible including performers, composers, directors, educators, costume design and production. The general manager of *Stalker Theatre* (the collaborating company) was also interviewed to understand the greater business implications of introducing immersive technology to the company. The interviews followed the 'General Interview Guide' format and were audio-recorded and transcribed for later analysis.

There was an effort made to use and respect the nomenclature specific to each participant's field of expertise. Patton argues that "Using words that make sense to the interviewee, words that reflect the respondent's worldview, will improve the quality of data obtained during the interview." (Patton, 1990, p 363) Using the expert's own natural words (or emic language) is also a trait of grounded theory where the language of the interviewee is preferred over sociological description to keep preconceived ideas from forcing the data at hand.

[1] https://www.skype.com/en/

A sample interview has been provided in Appendix D, to demonstrate the application of the 'General Interview Guide'.

### 3.5.3 Questionnaires

The *Creature: Interactions* installation featured a live actor/guide and four volunteers to help the children participate and interact with the artwork in a safe and engaging manner. These volunteers are not necessarily experts in this particular field, although they all did possess some amount of prior theatrical knowledge. As participants in the performance and having worked directly with the children as they navigated the work, these volunteers were an important source of knowledge into how the children engaged with the interactive artwork and each other during the experience. As they were both non-experts and volunteers, an hour long personal interview was seen as an unethical use of their precious time.

Instead of a lengthy interview, a short online questionnaire was constructed in Google Forms[2] and sent to the volunteers to complete at their own free will and in their own free time. The questionnaire featured six questions to be answered with a ranking scale (1-5) including:

- How would you rate the workshop as an educational experience for children?
- How would you rate the workshop as an entertaining experience for children?
- How would you rate the interactive component to the technology?
- Do you think the children were engaged with the virtual world in the workshop?
- Do you think the adults were engaged with the virtual world in the workshop?
- How immersive do you feel the experience was?

[2]https://www.google.com.au/forms/about/

These six questions were designed to provide a general feel for how well the experience was received for both children and adults. While the small sample size prevented them from being used as solid quantitative data, the results did provide feedback for planning future iterations of the project.

The last four questions were open-ended questions that provided considerable qualitative data, given the small investment made by the participants in completing the survey. These questions were:

1. What was your favourite part of the workshop and why?
2. What do you think could have been improved?
3. What were the most interesting child interactions that you observed in the workshop?
4. Any other comments or suggestions

Three of the four volunteers filled in the questionnaire. These questionnaires revealed that the volunteers did possess critical information about the performance of the installation. In particular, the volunteers had intimate knowledge of how the children interacted with one another on a social level. These questionnaires did provide information which was useful to the construction of this thesis, but upon reflection these questions may have been framed too positively. Instead of utilizing the restrictive questionnaire format, it may have been worthwhile extending the full interview process to encompass these volunteers to gain a more saturated view of the underlying data.

### 3.5.4 Self reflection

The technological artefact developed during this research is intrinsically entangled with the performative artefacts produced. The technological artefact was constructed for the purpose of facilitating the performative artefacts documented in this research. It contains features that have been created in response to the specific desires of each performance.

Similarly each performance was constructed, to a certain degree, as an exploration of what the technological artefact was capable of achieving in a live context. As the research progressed and the body of work expanded, the technological artefact grew in scope with each new performance piece.

The technological component was not designed to be a universal tool for creative design such as Max/MSP, PureData or TouchDesigner and should therefore not be evaluated as such. It was designed solely for use by the researcher for the purpose of constructing and performing the documented works. It has evolved to a point at which there may be merit in converting the technology into a suite that is usable for other creatives in other projects, but that would involve considerable work to the user interface which is outside the scope and aims of this research. In research that examines the effects of using interactive and immersive technology on live performing arts, documentation of the technological system can be seen as a reflection of *how* this was achieved. It is the product of reflection-in-action and Chapter 5 is provided as a reflection-on-action of the development process of an interactive technological system from the perspective of a digital interactive artist.

While the technological artefact itself is not the primary output of this dissertation, the description and reflection on its construction may be of particular interest to digital artists looking to build their own interactive or immersive systems. In recent years of academic and professional practice in the field of interactive and technology-based art, this author has encountered numerous creative-coders that have introduced technology and software engineering to their creative and artistic practice. As far as I am aware, I am the only one of these practitioners who started with solid professional experience as a software engineer and added creativity to their technology-based practice at a later stage. This is not to say that I am unique, or that this is in any way a better approach, but it does appear to be a rarer circumstance and therefore the approaches undertaken to build the system may be of particular interest to creative coders. Many of the approaches taken in designing the system (with respect to networking, reusability, modularity and scalability) may be obvious and simplistic to a trained software engineer, but of interest to an artist entering the realm of technology design. Similarly, many of the creative methods used (such as bricolage programming) may confuse and even frustrate many experienced software engineers but will already be at the core of many creative-coder's established practice. In addition to describing exactly how the performances were technically constructed, the reflection-on-action and technical description is presented in Chapter 5 so that fellow creative-coders may learn, adopt or criticize the methods as they see fit.

## 3.6 Analysis of data

The qualitative data collected by way of observation, interviews and the questionnaire was analyzed using the grounded theory notions of saturation, coding, memos and sorting to allow the theories to emerge from the data, rather than forcing a preconceived construct.

### 3.6.1 Theoretical sampling and saturation

Theoretical sampling is the process by which data of interest is collected in grounded theory methods. Data is collected and analyzed until the point at which no new codes or meanings can be extracted from the data. Data is not collected for the purpose of confirmation or negation of a hypothesis, it is collected for the emergent formation of a hypothesis or theory. The over-collection of data with repeated results is viewed as both pointless and harmful to the grounded theory practitioner, as they can easily get swamped by the process of analyzing an over-abundance of data without the promise of new meaningful insight.

"Theoretical sampling results in an ideational sample, not a representative sample. It is about an area of interest, a conceptual about, not a numbered about." - Glaser (1998, p 159)

When new codes or theories emerge from the data, it may spark a new line of enquiry in an effort to gain more data about a certain idea or topic of interest. In this way the sampling of data is itself an emergent process of the analysis where new enquires are undertaken until the researcher is satisfied that a topic is saturated and no new information is being produced. The interviews undertaken in this research did not follow a predefined structure but instead were guided by observations made during development, issues raised in previous interviews and new data identified during the interview itself. An example of this was the observation that during the early *Creature: Interactions* performances, the experience was both very loud and even chaotic whereas subsequent performances became iteratively more controlled. This led a line of enquiry in the interviews into the measures taken to tame and sculpt the physical energy levels of the children throughout the experience. This enquiry generated a fruitful sample of data that may not have been examined if sticking to a strict pre-determined interview script. The analysis of interview data also revealed that certain scenes in the theatre show were being discussed more than others and were generally viewed as the scenes that utilized the interactive visuals more successfully. This led to an in-depth scene analysis using the recorded video footage of one of the live performances to determine how these scenes were different from the other scenes in the show and therefore why they may have been more highly regarded. This line of enquiry was the direct result of the emergent data revealed by grounded theory analysis and once again proved an important source of data to the research.

### 3.6.2 Coding and memoing

The interviews were all transcribed and placed into a large Google Sheets[3] document. The interviews were analyzed line by line and where a new concept or concern was identified a new 'code' was generated. This new code was placed into a separate sheet within the same Google Document which would then automatically become available for further use as the analysis progressed. Multiple codes were made available to each line of the interview as the artists would often discuss multiple concepts in one sentence as they attempted to relate

[3] https://www.google.com.au/sheets/about

their complex relationship with the interactive and immersive technology in practice. As the analysis progressed, the generation of new codes began to stabilize as the data began to saturate. This process, called the 'constant comparative method' by Glaser (1992), is both elegantly simple and deeply involving as the iterative process allows more and more patterns to emerge from the data.

> "The grounded theorist should simply constantly code and analyze categories and properties with theoretical codes which will emerge and generate their complex theory of a complex world! And in turn they will produce simple or complex explanations along the way of the processing of the concerns of a substantive area." - Glaser (1992, p 71)

As each line was analyzed and codified, the relationships between the codes and the concepts related by the interviewees was constantly compared and any interesting patterns that emerged were documented next to the transcription in a dedicated 'memo' section. The memos are miniature theories inspired by the coding process and the data at hand. They are in nature quite incomplete, personal and even nonsensical notes which allow the researcher to jot down their ideas at the time of analysis in some free form shape. They prompt the researcher to remember the theories that have emerged from the data without the clouding of all the data en masse. The codes produced during this research are listed in Appendix D and a sample of memos are included in Appendix C to demonstrate this process.

### 3.6.3 Triangulation through multiple analysts

Triangulation is the process of repeating data collection or analysis by utilizing multiple methods, analysts, data sources or theories to contribute to the verification or validation of qualitative data. In his 1990 book *Qualitative Evaluation and Research Methods*, Patton states that:-

> "Triangulating observers, or using several interviewers, helps reduce the potential bias that comes from a single person doing all the data collection and provides means of more directly assessing the reliability and validity of the data obtained." - Patton (1990, p 468)

To improve the reliability, validity and richness of data collected and analyzed, triangulation was used in two separate forms throughout this investigation in the form of dual interviewers and dual analysts. Wherever feasibly plausible, dual interviewers were used to collect the data. Nine out of the fifteen interviews were undertaken with dual interviewers, with the remaining interviews conducted solely by the primary researcher. While this may have improved the reliability and validity of the data collected, the biggest benefit was the increased ability to react to interesting information with follow up questions where a solo researcher may have failed to instantly recognize an interesting angle to pursue further. This allowed the researchers to effectively saturate the data with theoretical sampling at a faster rate than if only one researcher was present, and minimized the time investment required by the interviewees.

This emergent coding and memo creation phase was independently undertaken by both this researcher and a secondary researcher. The secondary researcher, although not unfamiliar with the field of research, was not engaged in the practice of creating the artefacts or collecting data for the research. She was purely engaged in the process of analysis using grounded theory. This was undertaken as both a support and adjunct to the analysis undertaken in this research and as an opportunity for the secondary researcher to learn grounded theory through the application of real-world data. The resulting codes, memos and evaluations detailed in the independent researcher's report largely confirmed the original analysis, supporting the notion that the theory has actually been 'grounded' in the data at hand. While generally complementary, the independent research did offer some small differences which were combined with the primary analysis for a final comparison and sorting round.

### 3.6.4 Sorting

The memos produced through Glaser's constant comparison method and written into the Google Sheets document were sorted to improve the ability to find links between the potentially disparate theories. Glaser describes a process of sorting memo piles by starting with a large pile of memos and a large empty space like a table-top. The grounded theory analyst takes the first memo from the pile and places it anywhere on the table top. The researcher then picks each successive memo off the top of the randomly sorted memo pile and places each memo in a position spatially that relates to the memos already positioned. This practice is repeated until all memos are placed and a pattern starts to emerge. Glaser (1998, p187-193)

In the absence of a large empty table-top, a large section of floor was used to arrange the memos which had been sketched into Post-it notes. These notes were arranged and sorted into logical groups to find further relationships. Vertical alignment was roughly used as a hierarchical structure from broad to specific while general proximity was used to showcase related or similar concepts. The locations of each Post-it were continually re-arranged until each Post-it successfully adhered to the basic rules of verticality and proximity. After several iterations of this sorting procedure (see Figure 3.3), a general structure emerged and memos were arranged in a document as an outline to the writing of this dissertation. The outline was then filled in with the concepts and data captured by the memos before a final phase of editing clarified each section with an understandable and scholarly level of English diction.

The iterative grounded theory methods of **sampling, coding, memoing** and **sorting,** allowed theories to be developed that were grounded in the data collected. Many themes have emerged through this analysis that might have been overlooked or trivialized without this extended reflection-on-action portion of the research. The iterative and emergent nature of Glaser's grounded theory have complimented the iterative processes used to reflectively create the performative and technological artefacts.

Figure 3.3: Progressive sorting of memos on Post-it notes

## 3.7 Ethical considerations

All of the data collected for this research was undertaken in accordance with the University of Technology Sydney's strict ethical guidelines. The aims, methodology, significance, location, number of participants and potential risks of this research were all outlined and peer reviewed before approval. All parties involved in the creation of these artefacts were informed both verbally and in writing of the research procedure and the implications of their participation before embarking on the development process. The participants were able to withdraw their participation at any time, without any question or repercussion. All participants and interviewees were selected for their expertise and involvement in the creation of the artefacts and were enrolled on a volunteer basis.

The application for the ethical approval of this research is documented with the project number 2016-2 * HREC 2013000135. The consent and information forms provided to the volunteer artists is provided in Appendix E.

## 3.8 Conclusion

The **practice-based research** into immersive and interactive technology in live performance has been performed collaboratively following the **reflective practice** of reflection-in-action and reflection-on-action, as summarized in Figure 3.4. Following a literature and open-source software review, an initial technological system was developed using agile software development methods. This system was used collaboratively to produce the first performative artefact in a period of **devised theatre** development. During this period, the interactions were refined with an **embodied** design perspective, while the system was further extended with **bricolage programming** to meet the needs of the collaboration. Following the first performance season, **agile software design** was used to rigorously refine and upgrade the technological artefact in preparation for the development of the next performance work. These actions were then repeated to build up a body of performative works and sophisticated technological system, continually learning from the experience of the previous works. Two of these major works, *Creature: Dot and the Kangaroo* and *Creature: Interactions* were selected for further reflection. **Interviews**, **questionnaires** and **observations** were taken to capture the various perspectives around the development and performance of these works. The qualitative data gathered was then analyzed using **grounded theory** methods to generate theory about the usage and impact of the interactive and immersive technology on these live performances.

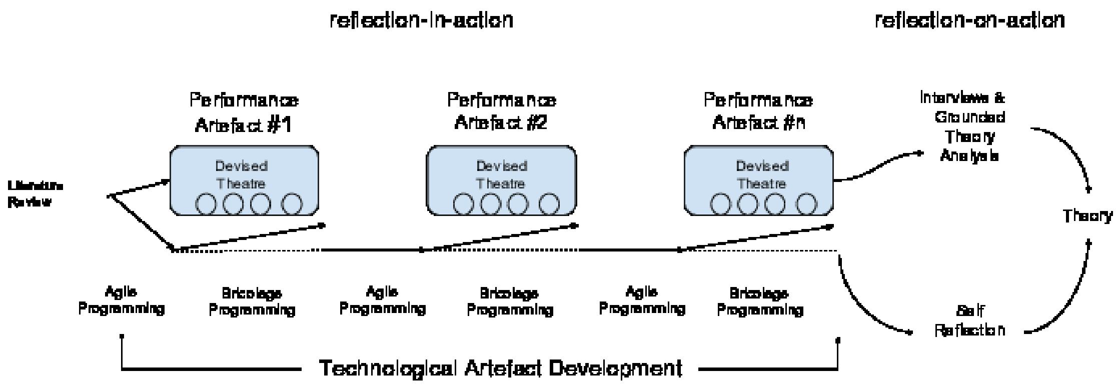


Figure 3.4: An overview of the practice-based research undertaken

# Chapter 4

# The Artworks

## 4.1 Introduction

To examine the use of immersive technology within live performance, a series of dance, theatre and musical works were designed and performed alongside the development of a bespoke interactive system. These works were conceived, created and presented in collaboration with performers, choreographers and artists with sufficient professional experience to be considered experts in their respective fields. While various roles were performed by the researcher, the major contributions to these works were in the development, design and operation of the interactive digital elements. All of the works demonstrate a variety of immersive techniques and have been performed in front of live audiences at concert halls, theatres, music venues and outdoor festivals both internationally and throughout Australia.

In total, 16 separate artworks and productions were created during this research. This chapter documents a selection of these works which best demonstrate the evolution of the system and provides different varied combinations of interactive art, immersive technology and live performance within music, dance and theatre productions. Details on the remaining productions can be found in Appendix A.

## 4.2 Encoded

Running time: 45 mins
Total Audience: 10,000
Collaborator: Stalker Theatre
Director: David Clarkson
Performers: Lee-Anne Litton, Miranda Wheen, Rick Everett, Timothy Ohl
Visuals: Andrew Johnston, Alejandro Rolandi, Sam Clarkson
Video: http://vimeo.com/55150853

Carriageworks, Sydney, Australia (2012)
Hwaseong Fortress Theatre Festival, Suwon, South Korea (2013)
Noorderzon Festival, Groningen, Netherlands (2013)
Gwacheon Festival, Gwacheon, South Korea (2013)
Uijeongbu Theatre Festival, South Korea (2013)
Regional Tour, Frankston, Paramatta, Sale & Healseville, Australia (2014)
Kwai Tse Theatre, Hong Kong (2015)
Regional Tour, Newcastle & Dubbo, Australia (2016)

The *Encoded* performance fused contemporary dance elements and physical theatre acrobatics with digital technology to explore the human's relationship with physical and digital space. It featured interactive graphics using a real-time fluid simulation that was projected onto a large 20m wide by 10m high wall behind the performers. The movement of the performers was amplified by the interactive graphics by injecting force into the virtual fluid, causing a number of projected digital particles to float about the projection surface. The work also included simple pre-rendered visuals and miniature projectors attached to custom made harnesses to create mobile digital costumes.

This performance was developed prior to this doctoral research project but features the author in the role of digital production and operation. The interactive fluid-based projections, developed by Andrew Johnston, proved to be an inspiration and influence to the artworks and technological system developed throughout this research. It is included in the body of work as it provides a suitable starting point for this research, and demonstrates the use of interactive graphics in a dance-orientated performance.

Figure 4.1: *Encoded*
Photo: Matthew Syres

## 4.3 Blue Space

Running time: 17 mins
Total Audience: 200
Collaborator: Linda Walsh
Performer: Linda Walsh
Visuals: Andrew Bluff
Video: https://vimeo.com/157974674

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Newcastle Conservatorium of Music, Newcastle, Australia (2016)

*Blue Space* was a semi-improvised electro-acoustic music performance in collaboration with oboist Linda Walsh and explored her fascinations with water as a source of inspiration to musical composition and performance. The fluid system from *Encoded* was extended to become an immersive audio-visual instrument where the sound from Walsh's oboe was recorded into the virtual particles in real-time. The particles would then playback the recorded sound depending on the motion and position of the particles floating on top of the virtual fluid simulation. The fluid simulation responded to Walsh's movements in a similar manner to *Encoded,* but also responded to sounds produced by Walsh through her oboe. The resulting system was an almost synaesthesic blurring of sound, visuals and physical movement where particles appeared to flow from Walsh's instrument and float about the stage. Walsh performed behind a scrim, creating an immersive illusion of a ghostly performer that blended into the visual particle display. This piece forms a significant part of Walsh's practice-based research into music and metaphor and is documented in detail throughout her thesis, *Water and Dreams: Exploring Bachelard's concepts through new audiovisual works for the oboe*, Walsh (2017).

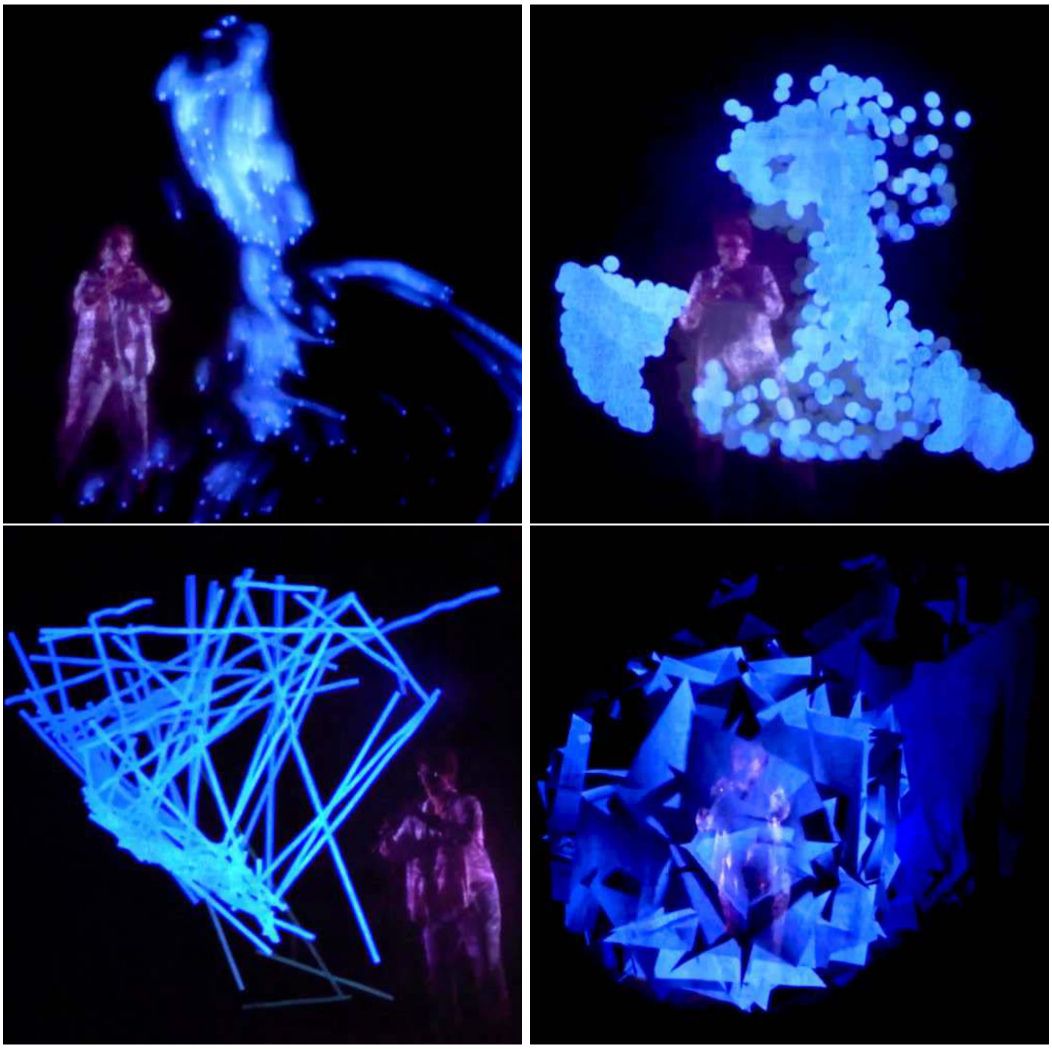

Figure 4.2: *Blue Space*

## 4.4 Airsticks

The Airsticks are a gesture-driven electronic virtual drumkit developed by percussionist Alon Ilsar. Using the *Razer Hydra*[1] hand controllers, the Airsticks combine Ilsar's arm movements through 3D space with trigger buttons and a midi foot pedal to musically control a unique hybrid of electronic synthesizer and percussion sounds. The controller's positional, rotational and velocity data were combined with physics simulations and visual effects to create real-time visualizations strongly linked to Illsar's physical gesture and sonic output.

### 4.4.1 Airstorm

Running time: 10 mins
Total Audience: 1,000
Collaborator: Alon Ilsar
Performers: Alon Ilsar
Visuals: Andrew Bluff
Video: https://vimeo.com/157508804

Creativity and Cognition Conference, Glasgow, Scotland (2015)
ZKM App Art Awards, Karlsruhe, Germany (2015)
Digital Storytelling Symposium, Sydney, Australia (2015)

*Airstorm* was the first performance to incorporate the Airsticks with immersive visuals, using a rigid body collision simulation to allow particles to bump, roll and collide with each other in a virtual 3D environment. The three-dimensional particles were projected onto a two-dimensional screen behind the performer. Whilst rendered in two dimensions, the work featured a progression in dimensional representation from a relatively flat and two-dimensional smoke effect, into a succession of particles that trailed back behind the performer and finally climaxed with Illsar freely guiding a group of tiles and spheres around three-dimensional space.

[1] *http://sixense.com/razerhydra*

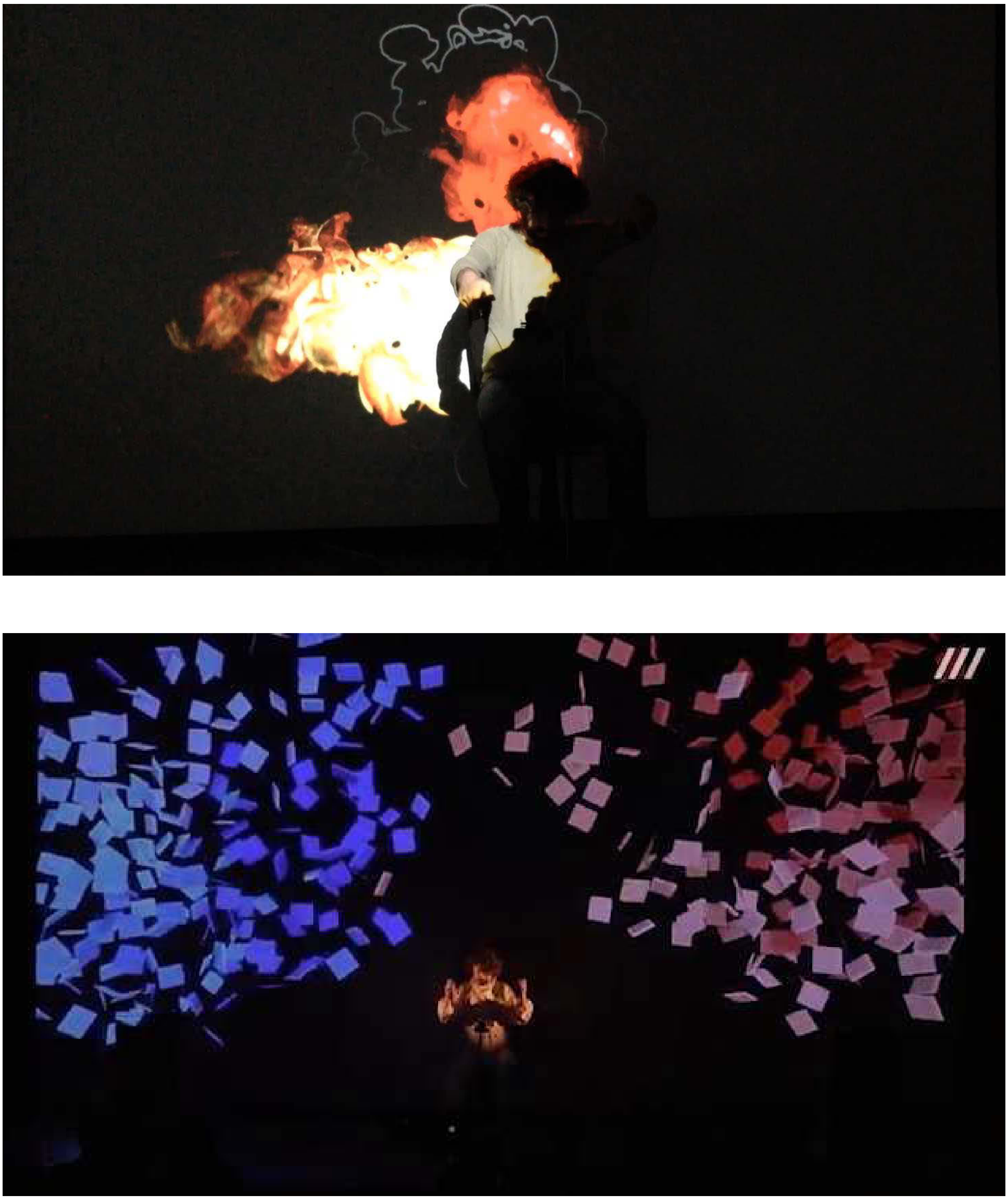

Figure 4.3: *Airstorm*

Video Still (top): Andrew Bluff
Video Still (bottom): ZKM

### 4.4.2 Sticks with Viz

Running time: 60 mins
Total Audience: 450
Collaborator: The Sticks
Performers: Alon Ilsar, Daniel Pliner, Josh Ahearn
Visuals: Andrew Bluff, Andrew Johnston
Video: https://www.youtube.com/watch?v=JN3Q04ewao8

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Red Rattler, Sydney, Australia (2015)
Lebowskis, Melbourne, Australia (2015)
Red Rattler, Sydney, Australia (2016)

The *Sticks with Viz* project saw the aesthetics developed in *Airstorm* extended in a number of ways to create a full one hour immersive concert. Musically, Illsar's electronic percussion was joined by Daniel Pliner on keyboard and Josh Ahearn on electric bass. The sonic output from these live musicians was analyzed and input to the visual system alongside the data from Illsar's Airsticks. The rigid body collisions used in *Airstorm* were combined with the output of the fluid simulation system used in *Encoded* and extended for *Blue Space*. The *Sticks with Viz* project incorporated many real-time visual effects such as blurs, soft shadows, trails and kaleidoscopes which were dynamically controlled by the Airsticks instrument, adding to the immersive connection between physical action and digital reaction. As with *Blue Space*, the band performed behind a semi-translucent projection scrim and dynamic lighting was added to reveal or hide the performers at will.

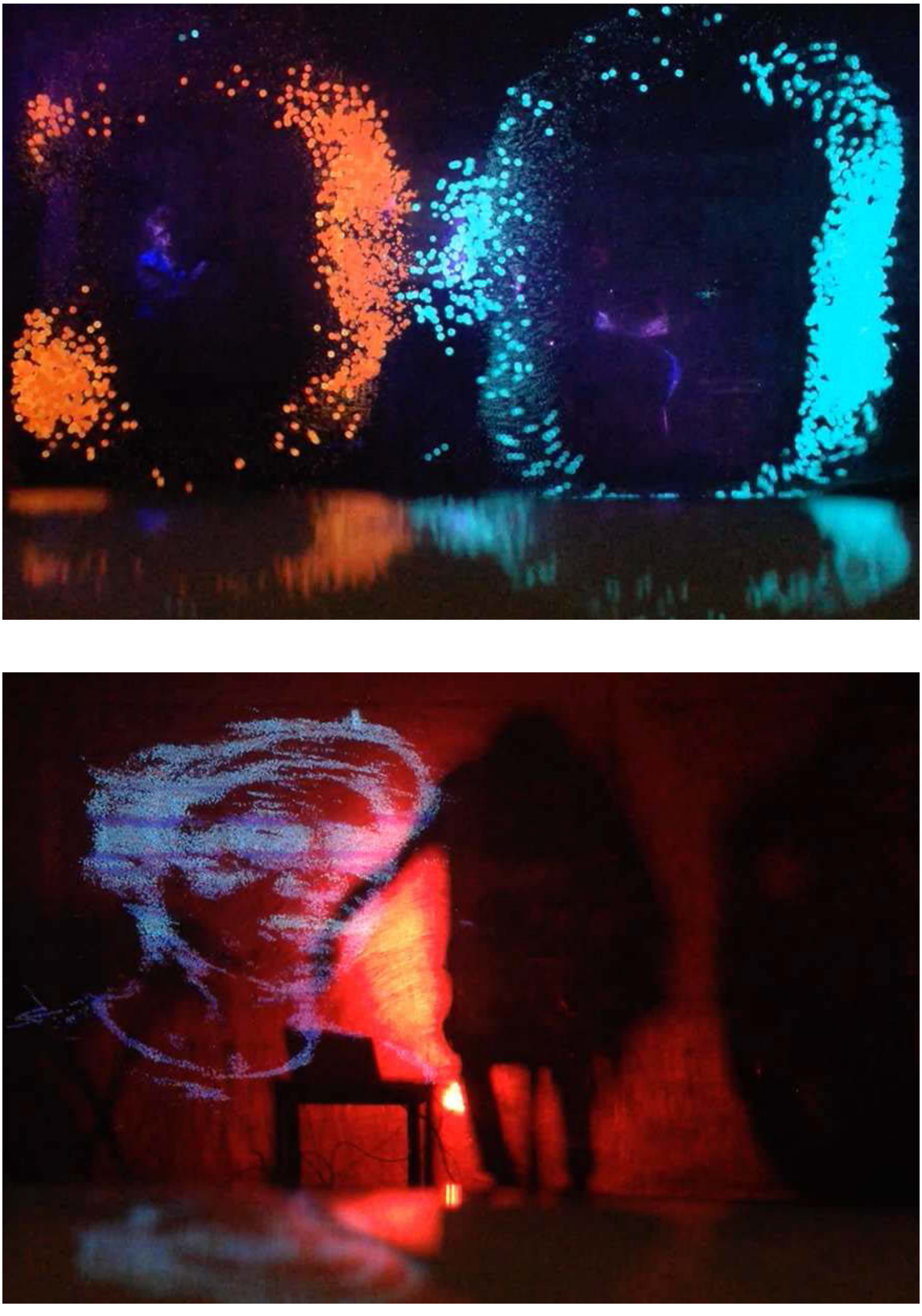

Figure 4.4: *Sticks with Viz*
Video Stills: Andrew Bluff

## 4.5 Creature

*Creature* is a major body of work that combines physical theatre with participatory interactive art and introduces various narratives around the overarching theme of ecology. The works were commissioned by Stalker Theatre under the direction of David Clarkson, and showcase the technology already developed for *Encoded*, *Blue Space* and *Airstorm.* The interactive system was extended in a number of ways during *Creature* development to enable narrative driven interactive storytelling with a scalable flexibility, polished aesthetic and tour-worthy robustness. The *Creature* body of work includes performances at venues spanning from Queensland's Performing Arts Centre and the Sydney Opera House to cutting-edge immersion laboratories. The works have already enjoyed a combined audience of over 10,000 people and are currently in negotiations for an international tour in 2018.

The scope and breadth of the work necessitated collaboration with numerous artists, performers, educators, researchers and professionals. Many of these collaborators were interviewed to gain multiple perspectives on the development and production of these new works. The findings from these interviews are presented in Chapters 6, 7 and 8.

### 4.5.1 Creature: Siteworks

Running time: 10 mins + installation
Total Audience: 300
Collaborator: Stalker Theatre
Director: David Clarkson
Performers: Alison Plevey
Visuals: Andrew Bluff
Video: https://vimeo.com/108033499

Siteworks Festival, Bundanon, Australia (2014)

The first performance in the *Creature* series of works was at Bundanon's annual *Siteworks* festival, where artworks and scientific discussions are mixed to create an informative and fun, family friendly event. Following the success of *Encoded*, Stalker was approached to create an interactive artwork that addressed the festival's theme of biodiversity. The *Encoded* system was upgraded to allow the particles to attract to simple wireframe models of native animals. This simple attraction system was combined with the fluid simulation to create complex particle clouds that blended the abstract particle system with simple but recognizable models of Australian fauna. The strength of this attraction was manually adjusted throughout the piece, allowing a dynamic shift between literalism and abstraction. Models were dynamically swapped during the piece which would cause the particles to slowly morph between different animal shapes. Rigid body collision simulation was mixed with the fluid system to depict falling leaves and flowers which would respond to movement and collide with each other and the ground in a semi-realistic fashion. The output from the fluid-based fauna system and the rigid body flora system were combined with a simple video mixer to create a cohesive graphical output.

The work opened with Alison Plevey performing a short improvised dance routine that would 'stir' the virtual fluid and cause the animal shapes to dissolve into particle abstraction before morphing into a different creature-themed shape such as a kangaroo, wombat, sugar glider and heron. After the short performance, the audience were invited into the performance space to interact with the artwork themselves as a giant ecologically themed play-space. The work was particularly well received by the children in the audience as they vocally identified the simplistic representations of Australian animals that were magically 'evoked' by Alison's movements. When the stage opened up for the audience to interact with the system, the space erupted with the joyous sounds of children playing with unbridled enthusiasm.

Figure 4.5: *Creature: Siteworks*
Video Stills: Sam James

### 4.5.2 Creature: Dot and the Kangaroo

Running time: 45 mins
Total Audience: 7,500
Collaborator: Stalker Theatre
Director: David Clarkson
Performers: Lee-Anne Litton, Rick Everett, Ursula Yovich, Kate Hosking, Jordan O'Davies
Visuals: Andrew Bluff, Boris Bagattini, Andrew Johnston, Stefan Wernik
Video: https://vimeo.com/199996091

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Queensland Performing Arts Centre, Brisbane, Australia (2016)
Joan Sutherland Performing Arts Centre, Penrith, Australia (2017)
Sydney Opera House, Sydney, Australia (2017)

The overwhelming response to *Creature: Siteworks* suggested that mixing abstract and literal visuals with interactive technology had a huge potential to engage children of all ages. To capitalize on this, Stalker Theatre embarked on a major theatrical retelling of Ethel C. Pedley's classic Australian children's book *Dot and the Kangaroo*. The book was selected for its ecological themes, depicting a young girl's magical journey as she befriends native Australian animals and comes to understand the devastating impact that humans can have on the natural environment. The show involved acrobatics, physical theatre, live music, song and spoken narrative with a significantly more involved script and literal narrative than had previously been attempted by *Stalker Theatre*. The interactive system used in *Creature: Siteworks* was further developed to allow the mixing of pre-rendered video with multiple fluid and rigid body simulations with a variety of different masking, warping and compositing techniques. The real-time composition effects were used to combine literal graphics with the abstract particle systems to create a blend of character and scenery elements that could support the narrative structure while still reacting to the movements of live performers. The stylistic creatures that featured heavily in *Creature: Siteworks* were used as 'totem' or 'spirit' creatures supporting the actors on stage, while colourful pre-rendered CGI backdrops were blended with interactive particles to depict the magic of Dot's transcendental understanding of the animal kingdom. Particles were animated with 3D models and combined with rigid body physics to create flocks of birds and moths that interactively illustrated key narrative points in the script.

Figure 4.6: *Creature: Dot and the Kangaroo*
Photo: Darren Thomas

### 4.5.3 Creature: Interactions

Running time: 40 mins
Total Audience: 2,400
Collaborator: Stalker Theatre
Director: Ben Knapton
Performers: Dan Crestani, Tricia Clark-Fookes
Visuals: Andrew Bluff, Boris Bagattini, Andrew Johnston
Video: https://vimeo.com/175791648

Queensland Performing Arts Centre, Brisbane, Australia (2016)
Sydney Opera House, Sydney, Australia (2016)

Inspired by the juxtaposition of professional physical performance with interactive participatory installation displayed in *Creature: Siteworks*, a large-scale immersive playspace was created to complement the *Dot and the Kangaroo* theatre show. Originally designed as a short self-guided playspace for children, *Creature: Interactions* evolved to become a full forty minute ticketed event involving live actors and facilitators to provide an educational and theatrical arc to the interactive experience. Upon entering the room, the children were instructed to use their imagination in a bid to transform the empty theatre space into a naturalistic bush landscape. The children's imagination provided a willing sense of disbelief, and the 18m x 12m space was then transformed into a bush landscape by projecting an immersive mix of interactive and pre-rendered visual content onto all four walls. The children were encouraged to try a range of different movements and dances both individually and as teams to magically create, warp and dissolve totemic and photo realistic depictions of Australian native animals. Designed for 3-8 year old children, the environmental impact of bushfire, rain and human intervention were loosely explored with the emphasis placed firmly on teamwork, physical movement, imagination and fun.

Figure 4.7: *Creature: Interactions*
Photos: Darren Thomas

### 4.5.4 Creature: 3D

Running time: 20 mins
Total Audience: 120
Collaborator: Stalker Theatre
Visuals: Andrew Bluff, Boris Bagattini, Andrew Johnston, Danielle Bluff

UTS Data Arena, Sydney, Australia (2016-2017)

As an investigation into the future of immersive live performances, the digital content used in *Creature: Interactions* was redesigned to become a full stereoscopic experience, to be hosted in the Data Arena[2] at the University of Technology, Sydney. The Data Arena is a 360 degree stereoscopic projection system coupled with 16 channel speaker system and a high calibre marker-based motion tracking system. The pre-rendered bush scenery was recreated from the perspective of each eyeball to create a believable sense of depth when viewed through active shutter 3D glasses. A real-time stereoscopic render system was developed which allowed the interactive butterflies, birds and moons to fly through the arena with a sense of realism that had the audience ducking and weaving in response to the virtual particles. The sound playback system was upgraded to sonically portray the position and velocity of particles as they reacted to the movements of the audience in three-dimensional space. Soft hand puppets of Australian native animals were augmented with optical markers and provided for all participants. These augmented puppets allowed three-dimensional motion tracking to occur in a fun and ecologically themed manner. The installation was very well received by adults and children alike and proved to be a very successful teaser for the immersive potential to be explored in future live performances.

[2] *http://www.dataarena.net*

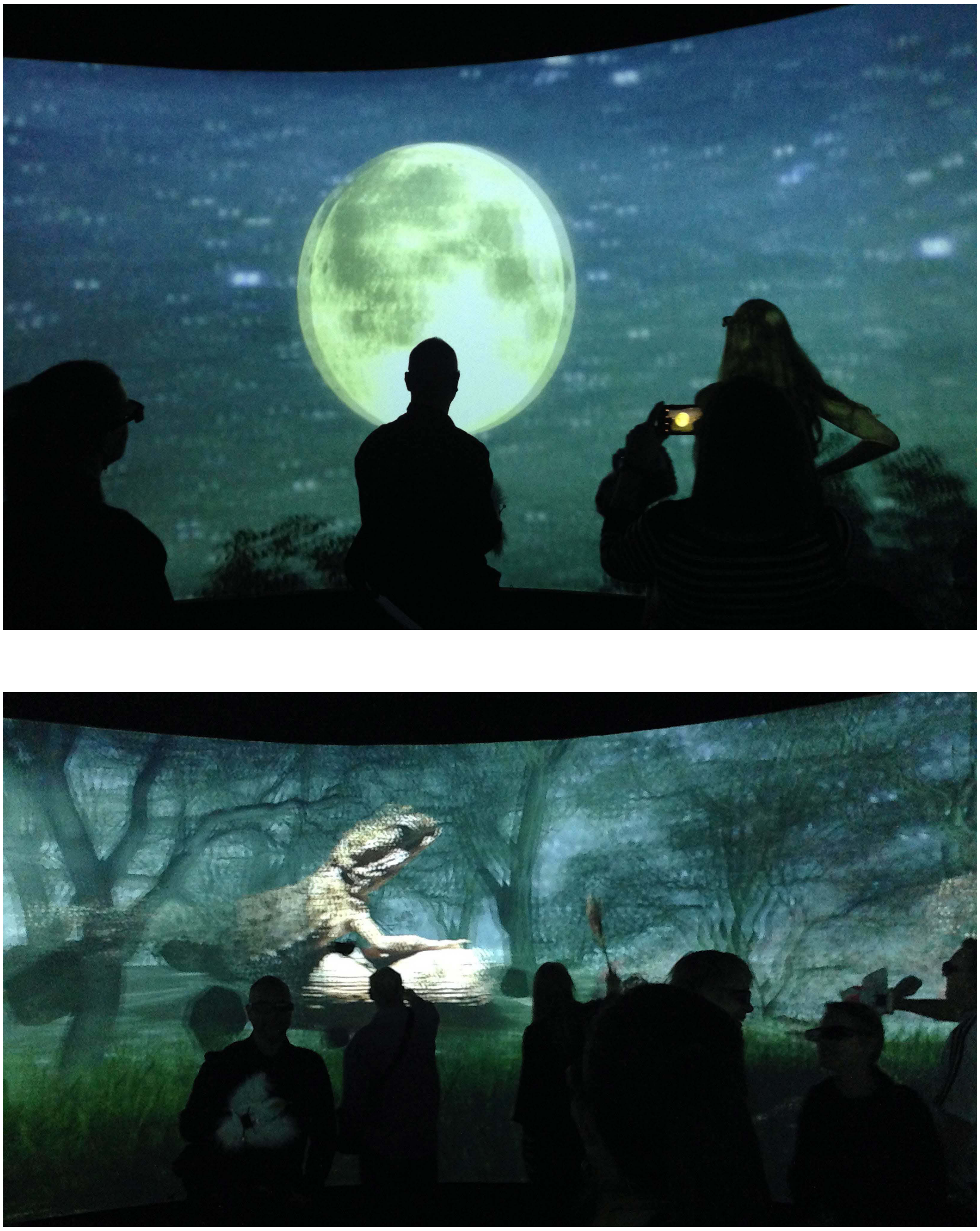


Figure 4.8: *Creature: 3D*
Photos: Andrew Bluff

## 4.6 Conclusion

The series of artworks and live performances documented throughout this chapter display an evolving use of immersive technology and visual aesthetics. The particle-based interactivity first introduced in *Encoded* has proven to be an adaptable technique that has been used for interactive installations, physical theatre, dance and live music performances. The development of these works to a touring standard has provided many insights into use of immersive techniques for live performance and forms the basis for discussion within this dissertation. For a more complete list of immersive works developed during this research please see Appendix A.

# Chapter 5

# The System

## 5.1 Introduction

The artworks detailed in the previous chapter were created using a constantly evolving suite of custom made software that is collectively entitled ParticleStorm. The system contains a set of OpenFrameworks C++ applications that were purpose-built by the author for this research. This software is in many ways an evolution of the system developed by Andrew Johnston in 2012 for the *Encoded* physical theatre show. The ParticleStorm suite retains much of the original source code from this 2012 system but has been rebuilt from the ground up to create a more modular, flexible and scalable solution. The capabilities of the system were significantly extended during this research, adding many new features such as rigid body physics, stereoscopic visuals, 3D motion capture, real time visual effects, video compositing, networkable displays, granular synthesis and surround sound processing. The ParticleStorm system was developed alongside the interactive artworks detailed in Chapter 4 and its evolution parallels the aesthetic and immersive progression evident within these works.

This chapter describes many aspects and capabilities of the system including the implementation of many immersive techniques and their link to the presented artworks.

## 5.2 Software development

There is a plethora of powerful coding platforms available to modern creatives and the precise technology selected to realize a project can seriously influence its outcome. Significant time and resources are invested in developing software for a creative outcome and it is important to use a technology that is both supportive to your current goals and flexible enough to allow extensions or alterations to these goals. Here we will examine the technology and methodology used to design and implement the ParticleStorm system.

### 5.2.1 OpenFrameworks and C++

The system was developed in the C++ programming language, and heavily uses the OpenFrameworks open-source library. The C++ programming language was originally developed and implemented by Bjarne Stroustrup in the early 1980s and became commercially available in 1985. Based heavily as a superset of the systems programming language 'C', C++ was designed to retain the efficiency and flexibility of C, while adding an object-oriented type of abstraction that makes it possible to program reusable code in style more relatable to humans. While the development time needed to create applications in C++ can be considerably longer than more recent languages such as Java and Python, the resulting application runs faster and uses less memory than these newer languages (Fourment and Gillings, 2008). Despite its age, C++ is still very much in use today with the language constantly evolving under the International Standards Organization (ISO) with minor updates as recently as 2015 and more proposed for publication in 2017. (Zamir, 1998; International Organization for Standardization, 2016; Standard C++ Foundation, 2016)

Graphical programming languages such as Max/MSP[1], PureData[2], Isadora[3] and TouchDesigner[4] are all extremely powerful and easy to use, facilitating very quick and elegant solutions to creative audio visual artworks. These graphical environments are largely designed to process streams of digital information (either audio, video or control parameters), both very elegantly and efficiently. Initial experiments within each of these languages quickly revealed that despite their ease of use and efficiency for manipulating streams of data, they lack the power and flexibility of C++ when it comes to processing larger and more complex systems. The interactive artworks created for this dissertation contain thousands of individual agents (or particles) which all behave autonomously, needing to be computed in real-time. Processing data of this nature does not neatly fit into the streams that the graphical programs are designed to manipulate and simple experiments soon became slow to compute and cumbersome to program. Despite its steep learning curve, the object-oriented nature of C++ is designed to handle this scenario efficiently and elegantly. As an experienced C++ programmer, the steep learning curve was of no issue, and the flexibility, scalability and efficiency of C++ proved the most suitable choice for the complex particle systems which are the foundation of this work.

OpenFrameworks[5] is an open-source suite of libraries that have been written in C++ to facilitate creative audio-visual programming. Although in many ways it is a very thin wrapper around many other technologies (OpenGL, POCO, OpenCV, RTAudio, etc) it seeks to provide a unified framework with which to access all of these different technologies. The core functionality simplifies 3D rendering and, via addons, has support for many input devices such as the LeapMotion and Microsoft Kinect motion tracking systems that are commonly used in interactive artworks. OpenFrameworks has a multi-platform code base which runs on Mac OSX, Windows, Linux and the mobile platform iOS, all of which have

[1]Max/MSP by Cycling 74. https://cycling74.com/products/max
[2]PureData by Miller Puckette, https://puredata.info
[3]Isadora by Troikatronix, http://troikatronix.com/isadora/about/
[4]TouchDesigner by Derivative, http://www.derivative.ca
[5]OpenFrameworks, http://openframeworks.cc

been used throughout this project. New input devices and vision processing algorithms are quickly supported by the OpenFrameworks community which, along with the power and flexibility of C++, makes it a suitable foundation for creating complex creative artworks.

## 5.3 Network architecture

The ParticleStorm software system was designed from the ground up to be fully scalable. All of the components have been designed to run in a great range of configurations and situations, ranging from single laptop performances all the way up to large-scale immersive stereoscopic environments using a dedicated network of highly powered graphics computers. By allowing the system to be as flexible as possible, works can be trialled and built in small-scale laboratory situations and then scaled up for larger installations with a minimum of recoding.

### 5.3.1 Network topology

To enable the desired flexibility, the system was divided into four logical components:- motion capture, physical transformations, display and user interface control. The user interface controls all other components directly, but the majority of information flows from motion capture through to physics simulation and finally onto display, as shown in Figure 5.1.

Splitting up the system in this manner has five major benefits:

1. Any component of the system may be easily replaced or upgraded to account for specialized hardware. For example, the system has been made to work with Microsoft Kinect, LeapMotion, infrared tracking, Airsticks midi input and the Optitrack marker-based system to account for different installation settings.

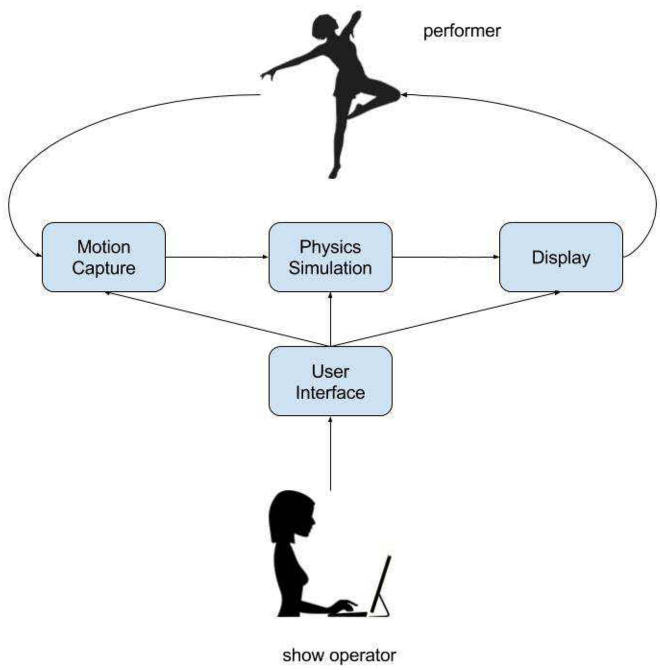



Figure 5.1: The four logical components of the ParticleStorm system

2. The components of the system can be spread across multiple computers or run on different CPU cores on the same computer, depending on the scale of the solution. ParticleStorm debuted by running all four applications on the same quad-core laptop for the *Airstorm* project (Figure 5.2), but was expanded to run across three networked computers for the original *Creature: Interactions* single wall demo (Figure 5.3) and nine networked computers for the stereoscopic *Creature: 3D* experience (Figure 5.4).

3. There can be a unified virtual world which is simultaneously displayed over multiple output displays. A unified physics engine ensures that the world remains consistent over each display node which can be key to a convincing immersive experience.

4. There is a certain amount of robustness gained during live shows. As the system is a product of creative coding and has been used in live performances during its development, it is often being alpha tested live on stage. Whilst never ideal, there have

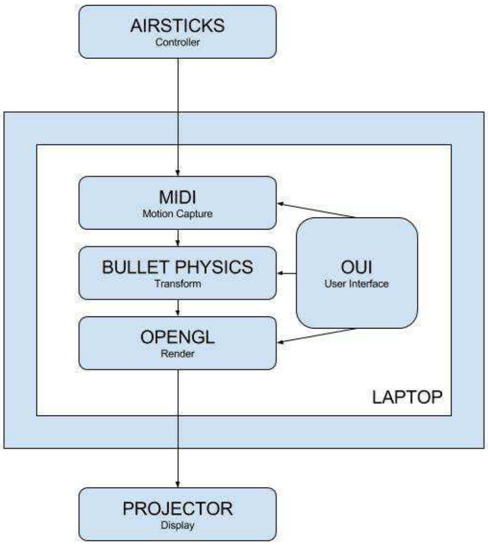



Figure 5.2: *Airstorm* Network Topology

been situations where the physics engine, motion capture or the user interface have crashed during a live performance. Traditionally, the audience would see a large error screen and the computer desktop projected onto the stage as the artist scrambles to rectify the problem. When an error occurs, the visual render application continues to output its last valid data, making it easy to restart the motion tracking, user interface or physics applications during a live performance, all without the audience becoming aware of the problems.

5. The code for each component remains simpler, restricting the entanglement that can occur in large integrated project and helping with software maintenance, extendability and portability.

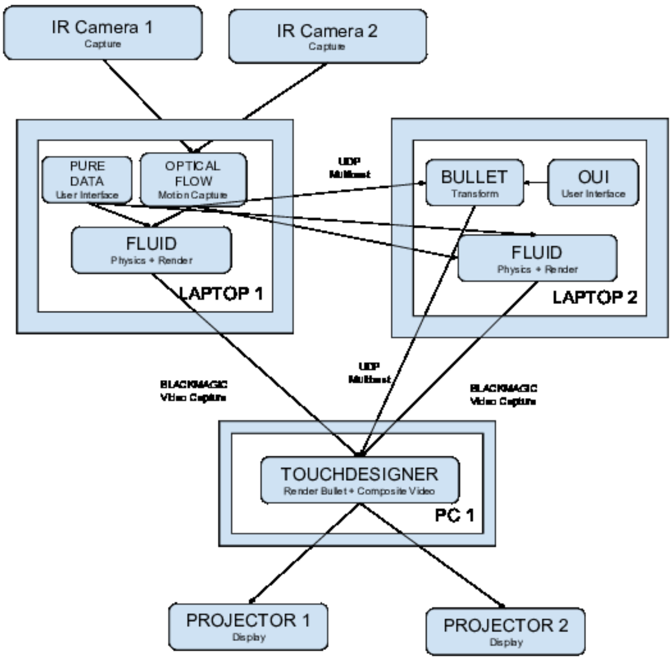



Figure 5.3: *Creature: Interactions* Network Topology

### 5.3.2 Network technology

Where possible, ParticleStorm uses standardized, open source or 'off the shelf' technology to speed the development process and promote technology reuse. The network messaging used to support the flexible nature of the ParticleStorm architecture are of no exception to this rule. Unfortunately, the amount and type of data passed between nodes is different for each part of the system and therefore slightly differing technologies have been used throughout the ParticleStorm architecture. Figure 5.5 shows the network technologies used in each section.

#### OpenSoundControl

OpenSoundControl(OSC) is a simple type of network messaging originally designed for controlling digital synthesizers, and is widely used by creative coding applications such as

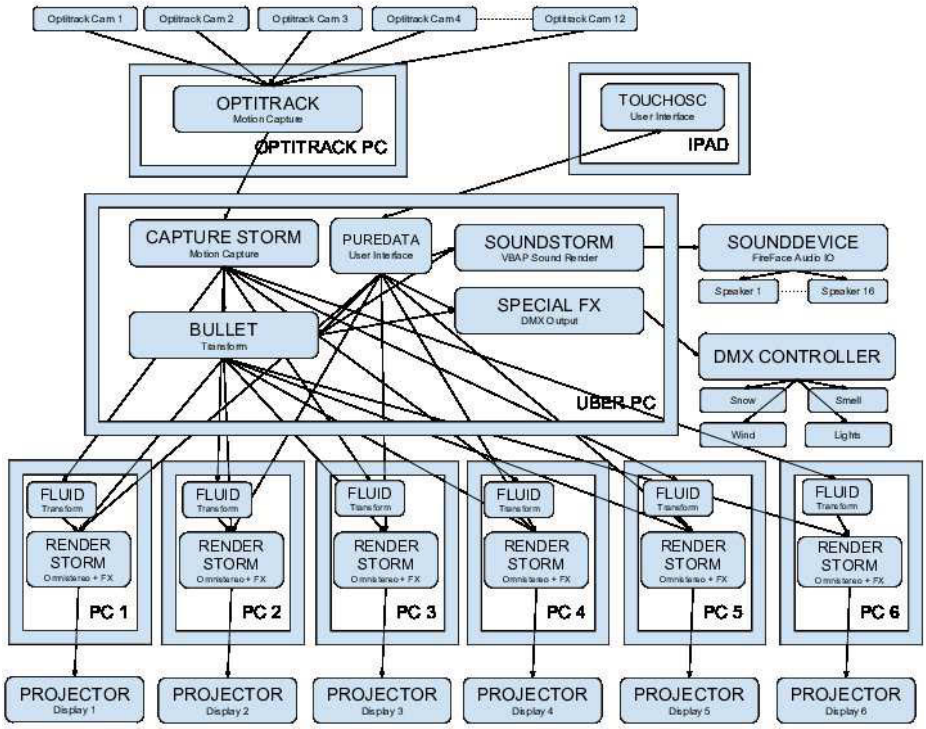



Figure 5.4: *Creature: 3D* Network Topology

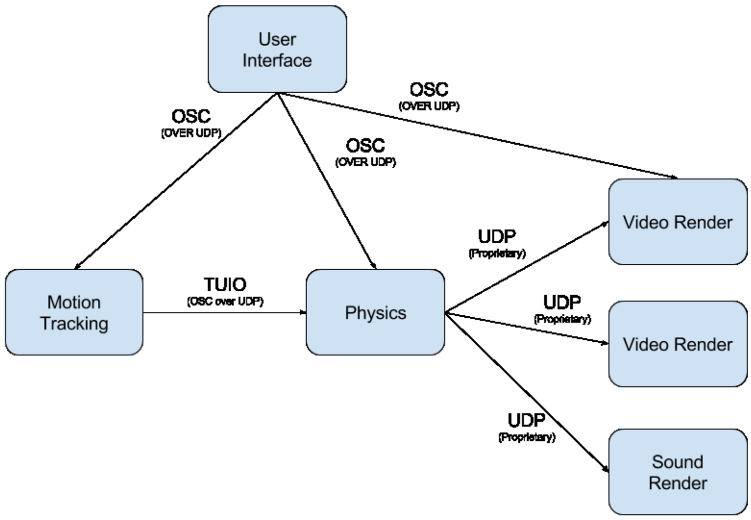



Figure 5.5: The network technologies used in ParticleStorm

Max/MSP, PureData and SuperCollider *(Wright et al., 1997; Wright, 2005).* The OSC protocol has been used extensively in ParticleStorm, particularly in the user interface, which ensures that any component can be easily controlled or even replaced by these creative programming languages. At various points during development, Max/MSP was used for motion capture, PureData and TouchOSC were used as a user interface and TouchDesigner was used as a visual render node, all communicating with the ParticleStorm system by way of simple OSC messages. This flexibility has allowed for rapid prototyping and facilitated the bricolage development process.

### TUIO motion data

To standardize the data passed from the motion capture device (Kinect, LeapMotion, Optitrack) to the ParticleStorm physics engine, the Tangible User Interface Object (TUIO) format has been used. The TUIO protocol was developed by Martin Kaltenbrunner et. al

(2005) for use in multi-user tangible user interfaces and debuted in the highly successful *reacTable*. Originally designed for table-top interactions, the protocol was extended in TUIO v1.1 to include the position, rotation and velocity of any number of markers in three-dimensional space. The format is built on top of OpenSoundControl messages and is therefore easily interpreted by any programming language which supports the OSC protocol. TuioChimp, a new addon for OpenFrameworks, was developed during this research to allow the interchangeable reading and writing of TUIO data in both 2D and 3D formats. The TUIO standard for motion capture data promotes reuse and allows the ParticleStorm suite to be used with any motion capture system that outputs the TUIO format. This marker-based protocol is multi-user and has been successfully used in ParticleStorm artworks to disseminate the motion tracking data from the OptiTrack, Kinect, LeapMotion, blob tracking and optical flow motion tracking systems.

### UDP messaging

The OpenSoundControl messaging protocol dictates the way that a message is encoded, but it does not specify which technology should actually transmit these OSC messages. The User Datagram Protocol (UDP) is a common method for transmitting OSC messages over computer networks and its low latency and ease of use have made it ideal for the ParticleStorm software suite. A major consideration when using UDP messaging is that it is not guaranteed to be transmitted in order of transmission, or actually at all. When network traffic starts to become congested, networking hubs, switches and routers are free to simply drop UDP packages as they see fit. In practical terms, UDP messages can be quite reliable when using a localized network, but expanding this solution to wireless or large networks (such as at a university) can result in a greater amount of packet loss. The system is built with the possibility of packet loss in mind, although it works more efficiently with minimal packet-loss and therefore a closed and ethernet cable connected LAN network is the preferred setup for the ParticleStorm suite. (Schmeder et al., 2010)

The OpenSoundControl messaging format, despite being quite simple and portable, is not necessarily the most efficient type of network message. Unfortunately, the real-time dissemination of roughly 3,000 - 10,000 3D particle positions from the physics node to the render applications could not be achieved at the desired 60 frames per second using OSC messages. For this situation a much more condensed, albeit proprietary, format was developed to deliver the messages over UDP more quickly. This format bundles the information for each particle in the system together as a tightly packed byte-stream which, although not standardized like the OSC message format, provides the efficiency needed in this situation.

#### UDP multicasting

The UDP messages have the ability to be delivered in three different ways; unicast, broadcast or multicast. Unicast is the simplest of UDP protocols where a single destination IP address and port number is specified for each packet sent out. Broadcast transmits the packet to every suitable computer on the network and multicast outputs messages only to those applications that subscribe to receive that particular message type. Unicast is simple to understand but tiresome to setup, where the destination for each message needs to be known in advance. This is suitable for simple network structures, but the ParticleStorm suite is more sophisticated and can output data to multiple render machines at once. Requiring all of these complex destination addresses to be manually entered is tiresome, error-prone and inefficient, as the same data must be sent to multiple render nodes simultaneously. UDP broadcast pushes messages out to every computer with a similar network address and is more efficient and easier to setup when outputting to multiple render nodes on the one network. (Deering and Cheriton, 1990)

While initially seeming ideal, there were two major drawbacks of using UDP broadcast in the ParticleStorm system:-

1. The UDP listening port could only be used once for every single computer. This meant that only one render node could be run on the same computer and that multiple apps could not share user interface information on the same computer.

2. The host network address had to be specifically named when broadcasting the message. This meant that sending a message to 192.168.0.255 would go out to all computers on the 192.168.0.xx network. While this is fine, constantly swapping between different networks installed at different sites with different addresses requires reconfiguration for each different site and network setup soon becomes a tiresome chore.

Multicast messaging is similar to UDP broadcast, but rather than just broadcasting to the entire network, the listener must explicitly subscribe to an address that they want to listen to. Unlike UDP broadcast, the subscription address is unrelated to the underlying network and multiple applications can subscribe to the same multicast feed, either on one machine or any number of machines (Deering and Cheriton, 1990). This solves the aforementioned problems with UDP broadcast and provides an efficient messaging system where the nodes don't require any prior knowledge of the rest of the system. Multicast messaging was instrumental in developing the system for *Creature: 3D* where any number of visual, sonic, haptic or other display nodes could be added to the system without changing (or even restarting) the physics simulation application. During development, any component of the complex system could be run on a local laptop and debugged, saving the considerable time necessary to recompile and restart the entire system.

Structuring the ParticleStorm system as a distributed web of applications has allowed the system immeasurable flexibility and kept the complexity of implementation within each module to a minimum. The use of multicast messaging to communicate standardized

TUIO, OSC and UDP packets has allowed the system to work with third-party components and minimized the amount of network configuration necessary.

## 5.4 Motion capture

The information flow within the interactive system begins with the input from the human performers. This input can come in many forms such as movement, sound analysis, voice commands, eye tracking, heat sensors, heartbeat monitors and brainwave sensors. The works presented in this dissertation are all concerned with creating an immersive environment where the performer feels physically connected to the virtual elements of the system and as such the position and movement of performers (motion capture) is the main input to the system. To make a mixed-reality artwork as immersive as possible, Section 2.4.3 postulates that any reaction from the system should occur instantaneously and align accurately with the human movement in terms of position, direction and scale. As motion capture is the first point of contact between the physical and virtual worlds, the data captured by the system needs to be as accurate and timely as is feasibly possible. Inaccuracies in the motion data with respect to position, direction and scale can cause a diminished sense of immersion while any missing or erroneous reactions can make the system appear totally unresponsive or erratic. Alongside the correctness of data received, the physicality of any system also needs to be considered. Certain motion capture systems can also be cumbersome to use and can physically hinder the movement of the physical performers. Table 5.1 shows the different motion capture methods that have been used in the ParticleStorm interactive performances, each one having its own pros and cons to do with scale, portability and movement type.

While the alignment, scale and quality of motion capture data is integral to the entire immersive experience, exact motion capture conditions of a performance are difficult to reproduce and venues are rarely available to the artists prior to any major performance. This


Figure 5.6: Prerecorded movement in the motion capture system

has great implications for an interactive performance where the entire artwork must be developed with a different motion capture setup than that of the performance. At best this can mean a simple scaling of the performance data when developed in a smaller rehearsal space, but it can also mean using completely different lighting conditions (performing in daylight can provide very different camera tracking data than performing at night), or even using a completely different system. This can often occur where the target system is prohibitively expensive or difficult to setup in rehearsal situations. Figure 5.7 shows the difference in scale and motion capture setup than can occur between initial development of an artwork to a final performance. Ideally an interactive system can handle different motion capture systems and interaction types with a minimum of adjustment.

A number of features have been added to the ParticleStorm software to allow the system to be developed independently of the final motion capture setup as much as is feasibly possible. These features include:-

1. **Abstraction of motion capture device** - The use of TUIO standardized network messages has allowed the ParticleStorm system to remain independent of the motion capture technology, which often runs on different computers and operating systems as required by the scope and type of motion to be captured. The type of motion capture can be changed from development to performance, or even between different performance venues with only a minimal of fine-tuning required.

2. **Real world coordinates** - The system allows motion capture to be measured in metres which allows like-for-like movement to have similar responses at a human performance scale. When using a normalized (0 - 1) scale for motion capture, the reaction of an arm wave will have much greater effect in a small venue than a large hall. Measuring these velocities in respect to real world coordinates ensures that an arm wave creates a similar response at any scale of performance.

3. **Scaling of movement** - The motion capture components of ParticleStorm contain simple sliders to artificially scale the motion data captured. This allows a development system to more closely mimic a performance setup, especially when comparing hand movement from a leap-motion controller to full body motion capture. This scaling occurs before conversion to TUIO to ensure that motion capture scaling does not factor into the physics presets used to define responses or interaction aesthetics for each artwork.

4. **Record and playback of movement** - When collaborating with dancers or acrobats the movement of the performers is very hard to replicate in development environments. Often development of the interactive system will occur in parallel with the

| Technology | Artwork | Range | 2D vs 3D | Operating System[6] |
|---|---|---|---|---|
| Optical Flow | *Encoded, Creature* | 30m | 2D | OSX |
| Optitrack | *Creature: 3D* | 30m | 3D | Windows |
| Blob Tracking | *Blue Space* | 30m | 2D | OSX |
| Airsticks | *Airstorm, Sticks with Viz* | 2m | 3D | OSX |
| LeapMotion | Development | 0.6m | 3D | OSX, Windows |
| Kinect | Development | 5m | 3D | OSX, Windows |
| Webcam | Development | 2m | 2D | OSX, Win, Linux |
| Mouse | Development | 0.5m | 2D | OSX, Win, Linux |

Table 5.1: The types of motion capture used in ParticleStorm

choreography and unfortunately performers are not always at hand to test the system. Recording the motion capture from a rehearsal performance allows the interactivity to be fine tuned at a later stage without the performers being present. ParticleStorm has the ability to record and playback raw infrared camera feeds (see Figure 5.6) as well as any TUIO data that is generated by the motion capture device.

5. **Smoothing of motion capture data** - Motion capture systems differ in accuracy and optical-based systems are very prone to occlusions that can prevent markers from being tracked. The ability to smooth out spurious data points and persist the tracking of occluded markers for a short period of time was added to the motion capture system. This smoothing was used extensively with the Optitrack system in the UTS Data Arena where the optical-based marker tracking is of high precision, but is prone to occlusions when used with a large number of participants.

## 5.5 Physics simulation

Immersive techniques seek to mimic our own perception of the real world to create the feeling of presence within a virtual environment. While high quality stereoscopic visuals and spatialized sound are extremely important techniques, a large part of this realism can

Development: 1 LeapMotion, 2 Hands, 0.2m x 0.2m space.

Performance: 6 Infrared Cameras, 90 children, 18m x 12m space

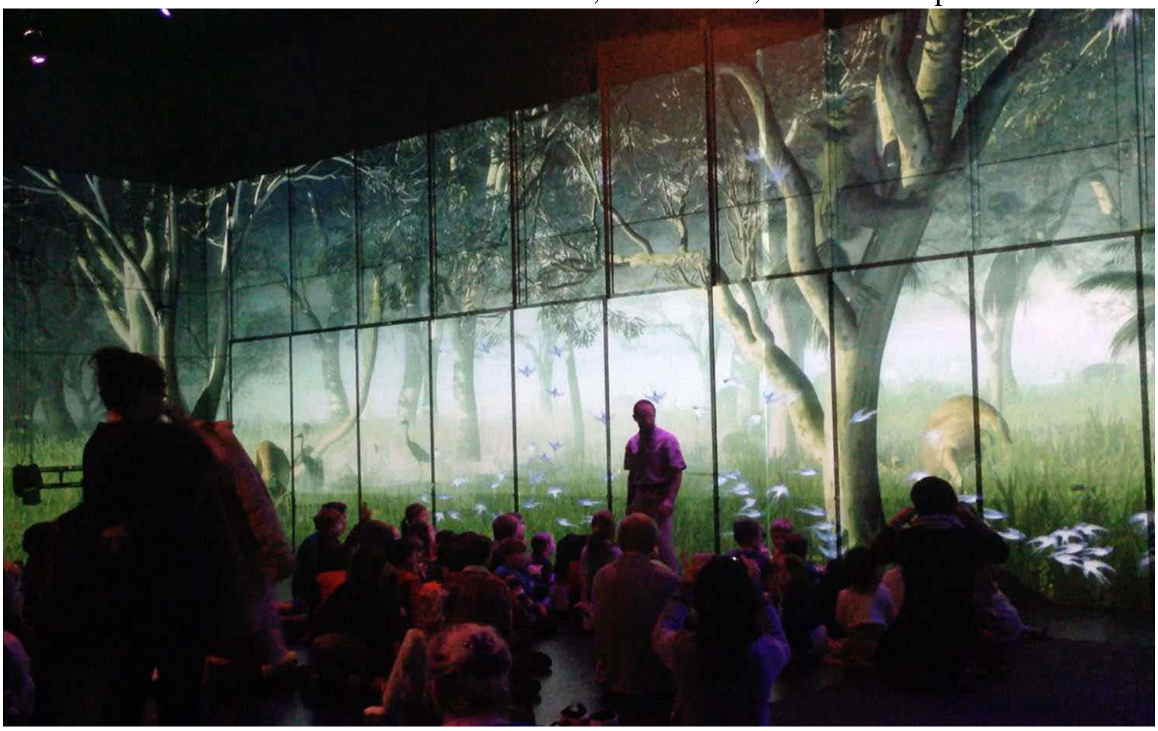


Figure 5.7: *Creature: Interactions*: The scale of motion capture in initial development vs performance at Queensland Performing Art Centre

Photos: Andrew Bluff

come from the way that the environment itself reacts to a participant's own presence. When a rock is thrown at a wall in the real world it will bounce off and fall to the ground whereas if a rock is thrown into a pool of water it will splash and ripple in response. These simple real-world reactions have been tacitly learnt since birth and are woven into the very nature of a human's understanding of the natural world. To heighten the sense of presence within a mixed-reality environment, the same actions and reactions that are common place in the real world should also be respected. Physics simulations can be used to mimic these real-world reactions within a virtual environment and many computer simulations have been optimized to run in real-time, making them suitable for live mixed-reality performances. The ParticleStorm software suite promotes the use of real world physical simulations to govern the movement of virtual objects in reaction to the human motion that is captured via the technology detailed in Section 5.4.

Although many immersive works place an emphasis on portraying realistic graphics and sound, in many ways the ubiquitous use of physics based on real-world phenomena has been key to the success of the artworks presented in this dissertation. It is the physics engine which allows the motion capture systems to be perceived as both precise and forgiving, it is the physics engine which drives and ultimately unifies the sound and vision to the human gesture and it is the physics engine which allows the artworks to be simultaneously simple and complex through the multiplicity of particles and emergent behavior. As an immersive technique, it is important to use physics that are reminiscent of real-world reactions and yet as an artistic technique, the system must be malleable enough to transform these reactions into the fantastical.

While an important step towards the mimicry of reality, the physics engine can function beyond the purposes of pure immersion. When coupled with a simple particle system, it allows the system to be complex. The system will respond in a way that is inherently understandable and plausible but the exact response of thousands of particles acting as individual agents is difficult to predict. Johnston (2009) argues that the complexity of response from a physics simulation can evoke a 'conversational' interaction between musicians and new musical instruments, where both the participant and the system react and respond to one another. Interactions with the fluid system during development of *Encoded* have been described by one of the performers as a form of 'contact improvisation' which indicates that this 'conversational' interaction can also be evoked within the physical forms of dance and theatre (Johnston, 2015).

The transformation of motion capture data into audio-visual output is solely mediated by physical simulations and a particle system. While direct and gestural mappings could give the performers a more predictable control over the system (see Section 2.3.2), ParticleStorm has been designed to harness the immersive, complex and fantastical potentials of interaction mediated through physical simulations. The real world movement of the performer(s) is detected by the motion capture system described in Section 5.4 and appropriate forces are injected into the virtual physical simulation. This movement also spawns virtual particles which exist inside the virtual physics simulation and obey the physical properties of the virtual environment. As these virtual environments loosely mimic the physical properties of the real world, the movement of the virtual particles (visualized through projected digital imagery described in Section 5.6) react to the performer's movements in an easily understandable manner. When the performer moves quickly, more force is injected into the virtual world and the virtual particles will move rapidly in response. Similarly, a slower movement by the performer will result in a more subtle movement in the virtual particles. Unlike direct or gestural mappings, the system's reactions are easily understandable. The performers don't require formal training to interact with the system as they can understand its behavior and artistic potential through sessions of improvised play and experimentation.

The modular nature of the ParticleStorm system has allowed the trial of different physics engines and transformations, including rigid body collision physics, fluid mechanics and flocking algorithms. While every system has its own benefits and drawbacks, these systems are not mutually exclusive and multiple physics engines can often be combined to increase complexity and facilitate a more engaging ‘conversation’.

### 5.5.1 Rigid body physics

Figure 5.8: The rotation and movement of tiles through rigid body collisions in *Airstorm* rehearsals

Photo: Andrew Bluff

Rigid body collision physics has been added to the system using the open-source Bullet[7] library. This rigid body collision algorithm is deeply rooted in Newton’s three laws of physics and mimics the real-world behavior of simple objects colliding with one another. It is called rigid body collision because it is a simplification which ignores the crumpling and crushing of materials on collision. As each of the particles within the system collide with each other, they bounce and roll off one another in a seemingly realistic fashion. Gravity can be added to the world to provide more realism and can be angled to simulate winds and other universal forces. While it does not perfectly simulate the complexities of real

[7]http://bulletphysics.org/wordpress/

world collisions, it is a reasonable approximation that has been used in training simulations designed for astronauts embarking on outer-space expeditions (Hummel et al., 2012).

When the objects collide at an angle with one another, some of their kinetic energy is transferred into a rotational momentum and objects can spin through the virtual three-dimensional space (see Figure 5.8). This rotational information can add extra complexity to a particle system, beyond the possibilities of a simple 2D engine. When enough particles are present, the objects will cause a chain reaction of collisions as they become hurtled through space in response to the movement of the human participants. In this way the rigid body physics can create complex interactions within the virtual world, as each particle can react to both the forces injected into the system by human motion, and simultaneously collide with every other particle present in the virtual world.

### 5.5.2 Fluid dynamics

The real-time fluid simulator ofxMSAFluid [8], was used extensively in the original *Encoded* physical theatre show to produce an organic and complex virtual accompaniment to the human performers (see Figure 5.9). The physical movements of the performer are translated into virtual forces which act upon, or 'stir', a simulation of fluid causing ripples and waves in the virtual fluid. Particles are placed into the system which effectively float on top of the virtual fluid and move in response to these ripples and waves. A number of parameters in the simple fluid simulation, such as viscosity, can be changed during a performance to make the system appear to be either more 'floaty' or 'sticky' as desired.

[8] ofxMSAFluid is an OpenFrameworks addon developed by Memo Akten. http://www.memo.tv/ofxmsafluid/

Figure 5.9: The dancer causes a 'wave' of particles in the virtual fluid simulation of *Encoded*

Photo: Matthew Syres

The ofxMSAFluid is a very simplified two-dimensional simulation of fluid that is highly optimized to run in real time on relatively modest computers. It does not compute rotational values for each particle, nor does it take into account any interactions between particles in the virtual fluid. Every particle is completely oblivious to the existence of other particles in the system, responding only to the forces contained within the virtual fluid. These simplifications make the fluid system capable of handling roughly 100 times more particles in real-time than the Bullet rigid body simulation on a single CPU. While each particle, or agent, within the fluid system is very simplistic compared to the 3D positional and rotational information respected within the rigid body collision system, the sheer number of particles computable by the 2D fluid system provides a greater potential for complexity and emergence than the information-rich 3D particles.

### 5.5.3 Particle attraction

Every particle in the system is computed individually and can be attracted to (or repelled from) a various number of locations. Combining these forces of attraction with the output

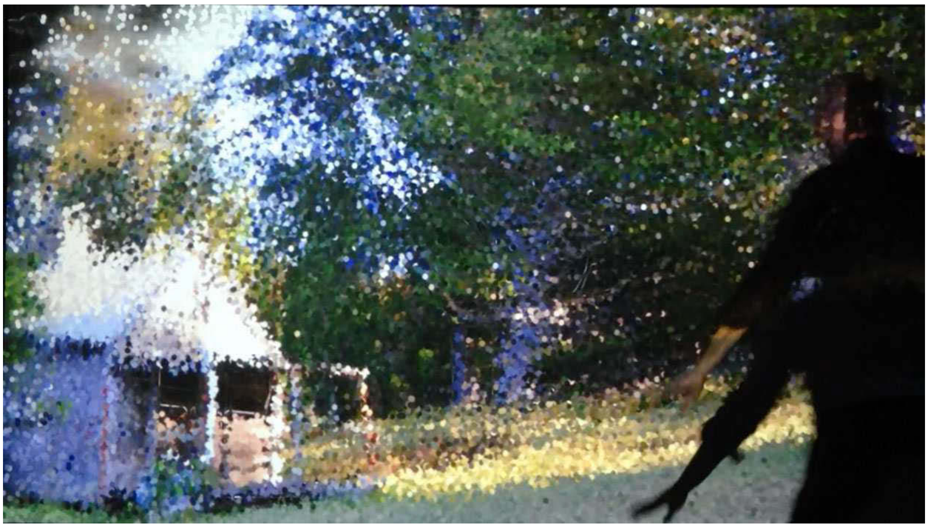


Figure 5.10: 2D Image attraction of an outback cabin creates an interactive 'impressionistic' painting during *Creature* development
Photo: Andrew Bluff

of the physics simulation engines can induce certain emergent behaviors. At its simplest, particles can be made to attract or repel from a central point on the stage. Repelling particles from a central point can make the particles fly outwards and appear as though the virtual universe is expanding. A central attraction causes the particles to contract and constricts the often expansive pixel canvas into a more intimate and ever-shrinking size. The expansion has been used to exemplify larger and more spectacular movements such as aerial somersaults, while the contraction can been used to highlight more intimate movements and when fully contracted makes a convenient transition into a different graphical scene.

Simple images and 3D models can be imported into the system as a more detailed source of attraction for the particles. Somewhat analogous to arranging bread crumbs into simple shapes and watching the patterns created by a nest of ants as they flock to the food source, the particles can be attracted to form more representational shapes and images. Attracting the particles to a 2D photo or image creates a low resolution, almost impressionistic, depiction of the image as seen in Figure 5.10. The attraction to simple 3D models was used to create the virtual 'totems' (see Figure 5.11) that were prominently featured in

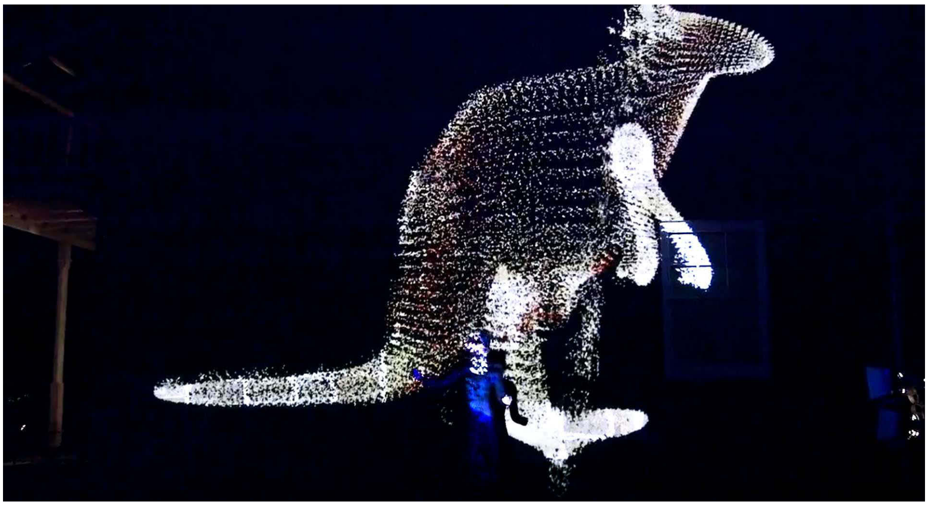


Figure 5.11: The attraction to a simple 3D model makes a kangaroo 'totem' emerge from the interactive fluid particle system in *Creature: Siteworks*
Video Still: Sam James

the *Creature* theatre show and installations. When a strong attraction is present, the object appears like a solid shape that bends and morphs organically in response to the motion capture and underlying physical simulations. When the particles are only mildly attracted to the object, then the system behaves normally until there is a lack of action in the motion capture and the image begins to emerge from the stillness. The strength of this attraction can be modified during a live performance to create an interesting dynamic between the abstract beauty of the *fluid* or *collision* particles and a more representational mode of graphics with a definite shape and form.

Attractions can be used to simulate simple biological systems where animals are naturally attracted to a food source or mate and are repelled by the presence of a predator. The ParticleStorm system allows the particles to be attracted to or repelled by the nearest source of motion detected. This attraction, when coupled with the rigid body collision simulations, closely resembles the boidal flocking algorithm created in 1986 by Craig Reynolds to mimic 'flocks' of birds, fish and sheep. (Reynolds, 1987) Each agent (or particle) in the system operates autonomously and is governed by the three basic steering rules of **separation**, **alignment** and **cohesion**. (Tanner et al., 2003) **Separation** between each agent in the system is created by using a slightly oversized bounding box in the collision engine which ensures that objects can not occupy the same physical location. **Cohesion** occurs where all agents that are near each other are attracted to the same source of motion capture, i.e. the attractor. **Alignment** occurs where nearby agents will head towards the same attractor whilst simultaneously rubbing against one another in the collision engine. In the *Creature: Dot and the Kangaroo* theatre show, motion-based attraction was coupled with attraction to a simple 3D model of a lake. This combination of attraction and rigid body physics allowed the particle engine to mimic flocks of pigeons that are attracted to a central feeding ground but are repelled by the physical movement of predators. The 'bronze-winged pigeon' scene eventually became the director's favorite and is further discussed in Section 6.5.2.

### 5.5.4 Combining multiple physics transformations

Just as particle attractions can be combined with the output of physical simulations to add extra behaviors to the system, so too can different physical simulations be combined for a more refined interactive experience. That physical simulations can be combined should be no surprise, as each physical simulation is indeed a very reduced simplification of how objects interact in the real world. If we take, for example, objects in the real world that are floating on top of a body of water, the objects will move about as the waves and currents in the fluid dictate, but they will also collide with one another obeying Newton's three laws of motion. This describes the combination of fluid simulation and rigid body collision and as it can be commonly found in nature, the response from virtual particles obeying both of these systems is quite natural and can be considered immersive. While the rigid body system adds an appealing richness to the interaction, the fluid system adds a quality of hysteresis to the interaction where forces remain in the system for some time, naturally emanating outwards from the source of the movement. If the motion capture system and visual feedback are not 100% accurate or perfectly aligned, this natural hysteresis of motion capture can help to make the system feel more responsive, somewhat masking its inherent inaccuracies. A combination of these two systems was used in the *Creature: Interactions* workshop, where the virtual moons collide and rotate naturally with rigid body collision while the fluid simulation made the interaction more forgiving.

The combination of physical simulations and attraction mechanisms implemented in the ParticleStorm system add a level of complexity to the interactions whilst reacting ways similar to that found in the real world. The complexity and naturalness of these immersive techniques create a conversational mode of interactivity that promotes experimentation and play between the performers and the virtual system, blurring the boundary between the physical and the virtual.

## 5.6 Display

The physics simulations combine with the quality of the motion capture to define the interaction aesthetic, but it is the display technology which largely defines the audio-visual aesthetics of the work. Once again, the distributed nature of ParticleStorm's architecture allows great flexibility in the way that the virtualized system is displayed to the real world. Multiple displays can be connected to the network, allowing various perspectives and real world modalities to be represented simultaneously. During development of the work many different modalities were explored, including the control of third-party wind, heat, smell and snow machines in the Data Arena, and the development of a haptic glove prototype. While each of these displays showed a great potential for increasing the level of immersion within the performances, unfortunately, their current implementations were distractingly noisy, clunky and lo-fidelity. They were ultimately deemed to be detrimental to the overall experience of the works and were therefore omitted from any public showings.

Visuals were explored as the primary display throughout these works, closely followed by audio which was used within the *Blue Space*, *Creature: Interactions* and *Creature: 3D* projects. All other performances contained sound and music, but these elements were presented without direct input from the ParticleStorm particle engine and are therefore regarded as artistic elements of the performance, rather than technical examples of a ParticleStorm auditory display.

### 5.6.1 RenderStorm

RenderStorm is the visual display component of the ParticleStorm system. In its essence it is a networked OpenGL 3D renderer written in C++ and OpenFrameworks. It renders the particles created and transformed by the physics engine(s) and can composite multiple layers of these particles with real-time visual effects, pre-rendered video and live camera feeds. It can render the particles in a variety of shapes including dots, lines, tiles, boxes, spheres and simple 3D models that can be textured with custom images, video files, live camera feeds or simple colours. The combination of these parameters can create quite different visual aesthetics (as seen in Figure 5.12) and can be tailored to address whatever thematic, dramaturgic or narrative requirements the performance might have.

#### Render fx

Each layer within RenderStorm, whether a particle layer or video layer, can have advanced post-processing effects applied in realtime. These effects are rendered with the ofxPost-Processing addon, using GLSL shaders to perform pixel-based effects. The effects currently available in the system are bloom, edge detect, pixelate, invert, contrast/brightness, soft shadows, kaleidoscope, depth of field blur and a custom-built trails effect (see Figure 5.13b). These effects can work in combination and are very useful for changing the visual aesthetic during a performance. A range of visual effects were dynamically linked to the

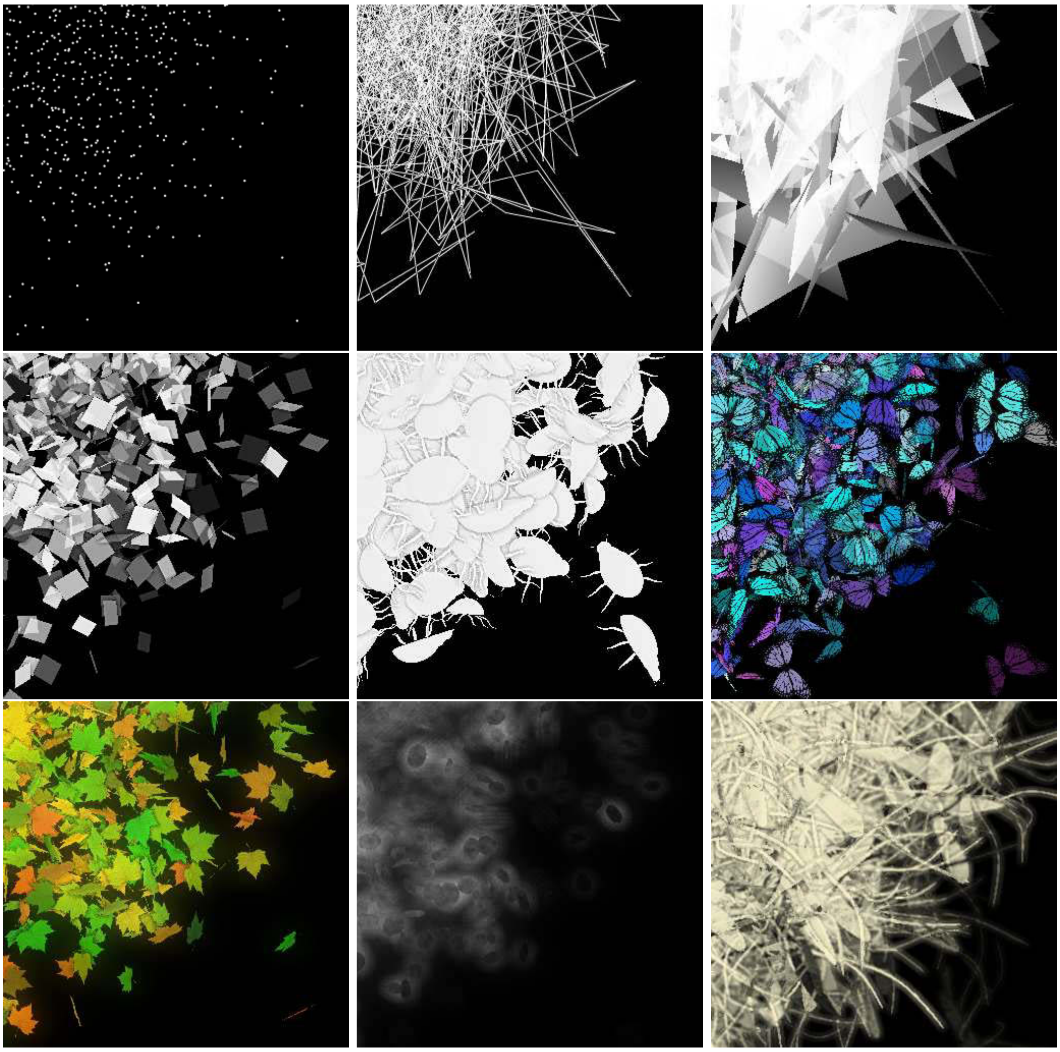
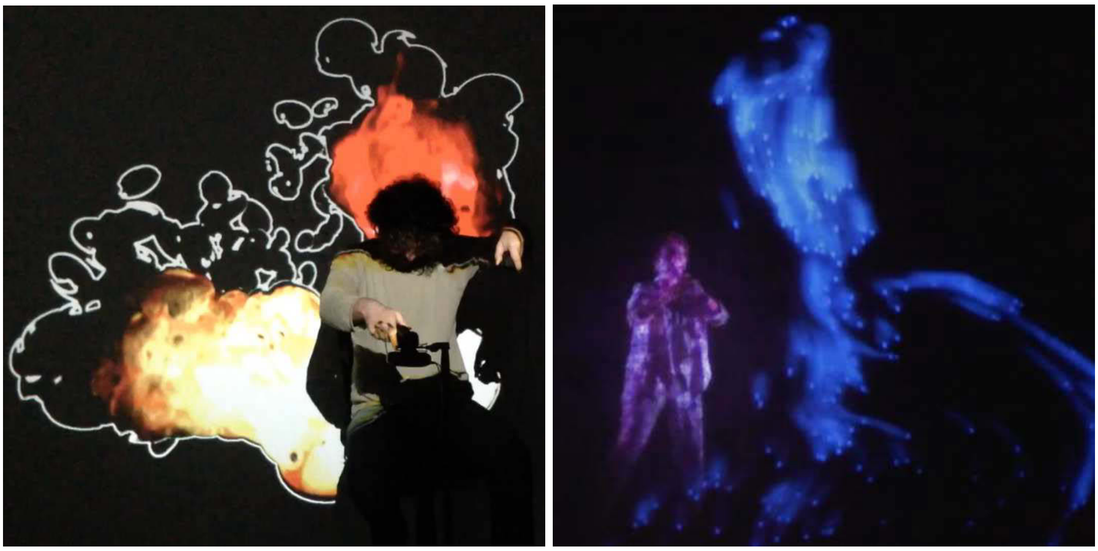


Figure 5.12: Identical particles rendered with different textures and shapes



(a) *Airstorm* (b) *Blue Space*

Figure 5.13: Real-time effects alter the visual aesthetic in response to the performer's gesture

performer's gestures in the *Airstorm* project, which added an extra dimension to the synaesthesic conjoining of gesture, sound and vision. Figure 5.13a shows a depth blur changing a mass of red and yellow particles into a smokey fire effect, while an edge detect responds to the performer's rhythmical timing, displaying the greater extent of particles with a flashing white outline. The soft shadow and depth blur shaders use the OpenGL depth buffer to alter their effect in response to the z-distance of a rendered particle. This attention to depth increases the immersive potential of these effects as they try to mimic the way 3D objects respond to light and as they drift in and out of visual focus in the real world.

### 5.6.2 Compositing video layers

The system used in *Encoded* was a combination of interactive fluid-based particle graphics and pre-rendered video. The particle graphics were rendered on one computer and output via an HDMI video feed into a Blackmagic video capture device[9] in the second computer. The second computer would mix the output of the particle computer with the pre-rendered video in Resolume[10], a live video mixing application. The Blackmagic/Resolume video mixing technique was reinstated to combine a fluid-based particle system and a rigid body particle system for *Sticks with Viz* and *Creature: Siteworks*. While this approach was relatively simple, the *Creature* projects subsequently evolved in terms of complexity (number of particle systems), breadth (number of simultaneous displays) and visual integration (blending between layers) pushing the scope beyond the practical limits of the Blackmagic and Resolume setup.

To extend the aesthetic capabilities of the visual display, a video playback engine was added to RenderStorm alongside a video compositing system which could adjust the colour balance, scale and position of each layer. The layers could be combined with a custom-made luma-key pixel shader, allowing any layer in the system to be used as an alpha mask. A real-time warp effect was added that can shift each pixel of an image individually based on the RGB pixel values of any other layer, creating a blending effect that is reminiscent of the cloaking device used in the motion picture *Predator*[11]. These compositing techniques allowed the complex particle graphics to be used as a visual effect on top of pre-rendered video and vice-versa. All of these effects could be altered dynamically during a performance and smoothly transition between these states, as dictated by the user interface.

The blending between layers was heavily used during the ‘berries of understanding’ scene in *Creature: Dot and the Kangaroo*. This scene is where the protagonist, Dot, consumes the berries given to her by a friendly kangaroo and the Australian bush suddenly comes to life with the coherent chatter of native Australian animals. This moment is a key narrative plot point and dramaturgically a big leap for Dot’s character progression. Three separate fluid systems were combined with pre-rendered video to create the transformative

[9] https://www.blackmagicdesign.com/products/intensity
[10] https://resolume.com
[11] http://www.imdb.com/title/tt0093773/

Figure 5.14: Particles reveal the bush in *Creature: Dot and the Kangaroo*
Video Stills: Jaina Kalifa

effect showing her magical transformation into the colourful world of understanding the Australian bush. One of the layers uses a 2D image particle attraction as seen in Figure 5.10, one layer has the trails effect and one layer contains a smokey-blur and is used as a mask to reveal the pre-redendered 3D bush scape. This approach proved to be successful, as the 'berries of understanding' scene was found to be one of the peak moments of the theatre show, as discussed in Section 6.5.1. The integrated composition engine provided the ability to blend between the interactive particle effects and reveal the pre-rendered video. The real-time blending effect strengthened the magic nature of this peak moment and tightly integrated the movement of the performers with the emerging bush landscape.

### 5.6.3 Stereoscopic rendering

The combination of realistic physics engines, full-bodied motion tracking, 3D OpenGL rendering, dynamic soft shadow effects and depth of field blurs can create uniquely immersive experiences, especially when projected on all surrounding walls, as was the case with *Creature: Interactions.* Despite how realistic these effects can become, there is still an obvious divide between the physical performers or participants moving around in three-dimensional space and the virtualized graphics which are confined to a flat 2D projection surface. To break through this divide in visual depth, stereoscopic rendering was added to the ParticleStorm system. Stereoscopy is an immersive technique commonly found in '3D' cinema and virtual reality where the audience will have a slightly different view of the virtual world through their left and right eyeballs to reflect the real-world phenomenon of parallax. If we assume that the eyes of the audience are focussed on the surface of the projection screen, objects can be made to appear either in front or behind the screen by rendering the object with different horizontal spacings for each eye.

When rendering a virtual 3D scene within OpenFrameworks *(*or any OpenGL applications*)* the position, geometry and scale of every object in the virtual world is passed to

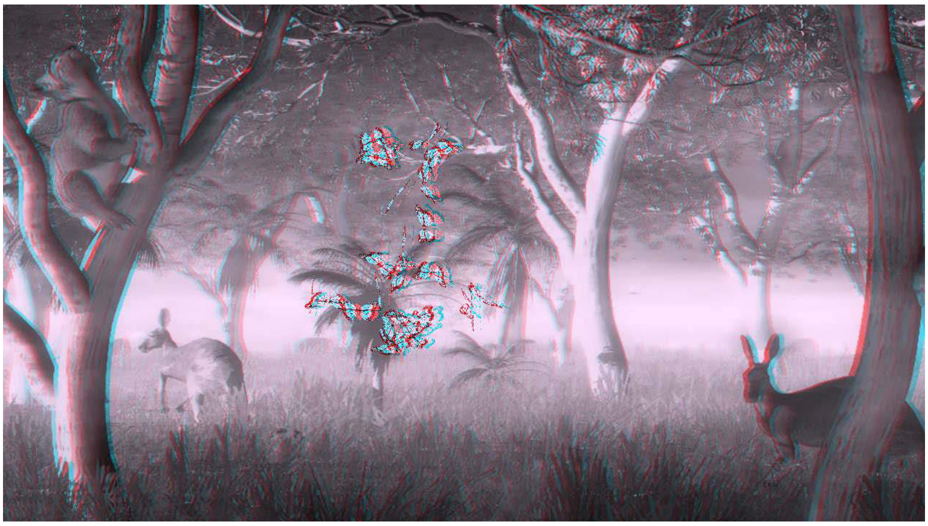


Figure 5.15: Stereoscopic red-blue anaglyph rendering of *Creature: 3D*

the graphical rendering system. In addition to the virtual world geometry, a virtual camera position is necessary to render the scene. When using virtual stereoscopy, the system will render the 3D scene from two different virtual cameras that are roughly 60mm apart in the virtual world to mimic the inter-pupillary distance between the left and right eyes of an average adult human. The images rendered through the virtual left and right cameras need to be exclusively visible to the corresponding left or right eyes of the viewer(s) for the stereoscopic depth effect to work effectively. The ParticleStorm system is capable of overlaying these separate images with special colour filters to produce a single anaglyph (cyan-magenta) stereoscopic image, as shown in Figure 5.15. It can also display images in the side-by-side (see Figure 5.16) and top-and-bottom formats commonly used for active-shutter projectors such as those found in the UTS Data Arena.

Pre-rendered stereoscopic video and images can be input to the system in either top-and-bottom or side-by-side formats and will be translated to the selected output format automatically. A stereoscopic warp was added to RenderStorm which allows simple 2D images or videos to be converted into stereoscopic 3D with the addition of a depth map.

Figure 5.16: Stereoscopic left and right cameras of *Creature: 3D*

This technique was used to create the startup screen for the *Creature: 3D* installation, displaying logos and simple text at different stereoscopic depths, without the need to recreate the graphics in a 3D modeling program.

### 5.6.4 Real-time depth compositing

Luma-key compositing was found to be a convenient and powerful method of combining pre-rendered and interactive visuals layers for the *Creature: Interactions* project. When visual elements were displayed in this manner, a simple depth hierarchy was developed. The pre-rendered visuals of the bush were the background layer, fluid-based particle dots were on top of that, rigid body particles with geometry (birds, moons and butterflies) were placed on top of that and finally pre-rendered environmental effects such as fire and rain were placed on top of everything. This layering creates a visual sandwich that is more stylized than what would naturally occur in the real world. While not a very realistic way to combine visual elements, this sandwiching of visual layers allowed the interactive elements to be highlighted as they floated over the top of non-interactive elements.

When the layers are displayed stereoscopically, this simplistic compositional method provides an inconsistent representation of depth that can disturb the eyes and quickly lead to a headache. Objects which are to be displayed behind the screen can accidentally appear over the top of pre-rendered 'background' elements which may be quite close to the viewer. Our eyes have become accustomed to seeing the closer opaque objects visually obscure a more distant object in the real world, and portraying anything to the contrary in a virtual stereoscopic display was found to be quite unsettling.

In order to keep the visual occlusions consistent with the stereoscopic representation of depth in each layer, a depth-aware compositing mode was added. Each layer stores with it a depth-map (grey-scale representation of z-depth) which is used to determine on a pixel-by-pixel basis which object gets painted in front of the other; the brighter the pixel in the depth map, the more priority it is given in the compositing process. The particle layers can generate their own depth-map during OpenGL rendering process, and, in a somewhat unconventional format, pre-rendered stereoscopic video files can have depth maps rendered in greyscale at the bottom of the image. Respecting the depth of the image on a pixel-by-pixel basis for each separate visual layer ensures that the closer objects are placed over the top of more distant objects and allows the immersive stereoscopic image to remain consistent through all visual layers. When combining layers in this depth-aware manner, there is no longer the notion of a background or foreground layer, as all layers are integrated into the same three-dimensional world on a pixel-by-pixel basis.

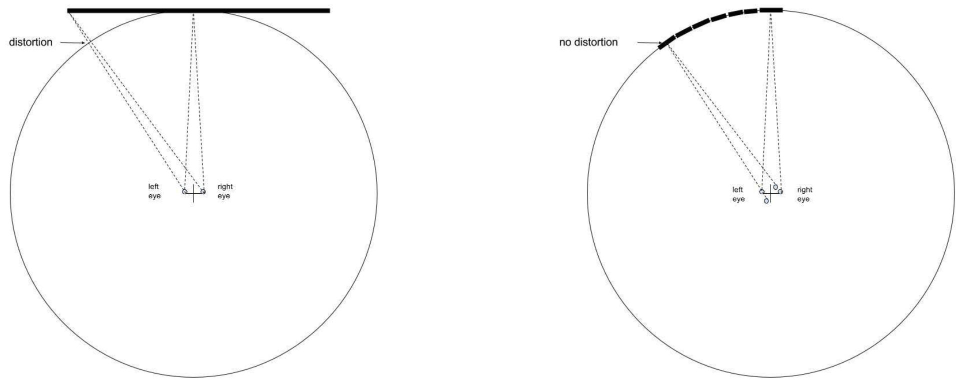
### 5.6.5 Omnistereo shader

CAVE environments, such as the UTS Data Arena, surround the audience with visual displays (normally projection screens) that present a stereoscopic view of virtual environments to multiple viewers simultaneously. To maximize the sense of presence in such a space, each viewer would ideally have their own unique viewpoint depending on where they are positioned within the room and what direction they are facing. Unfortunately, the display system is only capable of presenting one unified perspective that is shared by all viewers in the space. Traditionally, CAVE technology will track the head position of a key performer, or guide, and calibrate the view to her perspective whilst leaving all other viewers with a distorted view of the virtual world. To promote an inclusive and democratic notion of interaction and quality of immersion, RenderStorm provides an alternative visual rendering technique called 'omnistereo'. The omnistereo perspective renders a scene through a progression of vertical slices where each slice is rendered as if the viewer is facing directly outwards from the centre of the room (see Figure 5.17). Rendering in this fashion was found to produce a "better quality stereo" and "wider field of view" when compared to standard fixed perspective methods (Simon et al., 2004). When it was integrated into the iCinema, an almost identical cylindrical viewing system to the Data Arena, the developers observed that "omnistereo images can be viewed comfortably from any position inside the theatre". (McGinity et al., 2007)

As proposed by Simon et al (2004), the omnistereo process can be created by two different rendering techniques; 'multiple view' and 'object warping'. The multiple view method approximates the cylindrical viewing space by rendering a number of flat viewpoints orientated around the surface of the screen, while the object-warping method manipulates each object individually to render it as though it is placed at the very centre of the virtual camera viewpoint. McGinity et al (2007), have described a noticeable degradation in rendering performance (achievable frame rates) and image distortion when using the multiple view method. Whilst conceding that the object warping was the better solution, their Virtools[12]-based system was unable to render third-party compositions with object warping correctly and they ultimately decided to use the inferior but more supportable multiple view method.

The RenderStorm software implements the object warping solution with a custom-written vertex shader that uses the GPU (graphical processor) to transform every vertex of a 3D object into an omnistereo version of camera-space. Manipulating objects on the vertex level is very efficient and the object-based warping removes the distortion commonly found with the multiple-view method. The problem faced by McGinity et al when implementing their own object warping vertex shader in Virtools, is that OpenGL shaders do not operate well in series and prevent the use of the built-in OpenGL lighting model. To

[12]www.virtools.com




(a) Standard rendering (b) Omnistereo rendering

Figure 5.17: Omnistereo creates vertical slices to remove stereoscopic distortion of curved screens

circumvent this problem, the omnistereo vertex shader has been combined with various custom lighting shaders, such as spotlights and point lights, to offer an all-in-one object warp and lighting shader solution. Although the visual effects and depth-aware compositing processes within RenderStorm also use shaders to render efficiently, they are deliberately performed in a series of separate render passes on a 2D render of the scene, rather than on the 3D objects themselves. The first pass renders the 3D scene and applies the omnistereo object warp and lighting effects. All subsequent passes render a simple 2D plane and manipulate the texture and depth maps from the previous passes to create a new texture with the applied shader effect (see Figure 5.16). This separated render pass architecture allows the omnistereo-lighting shader to work in isolation from the visual effect shaders and is therefore not impacted by the restrictions placed on combinations of OpenGL shaders.

The ability to render particle simulations in layers with varying geometries, textures and visual effects, blending seamlessly with depth-aware prerendered media, allows the ParticleStorm system to display a wide range of visual aesthetics that retain a complex but

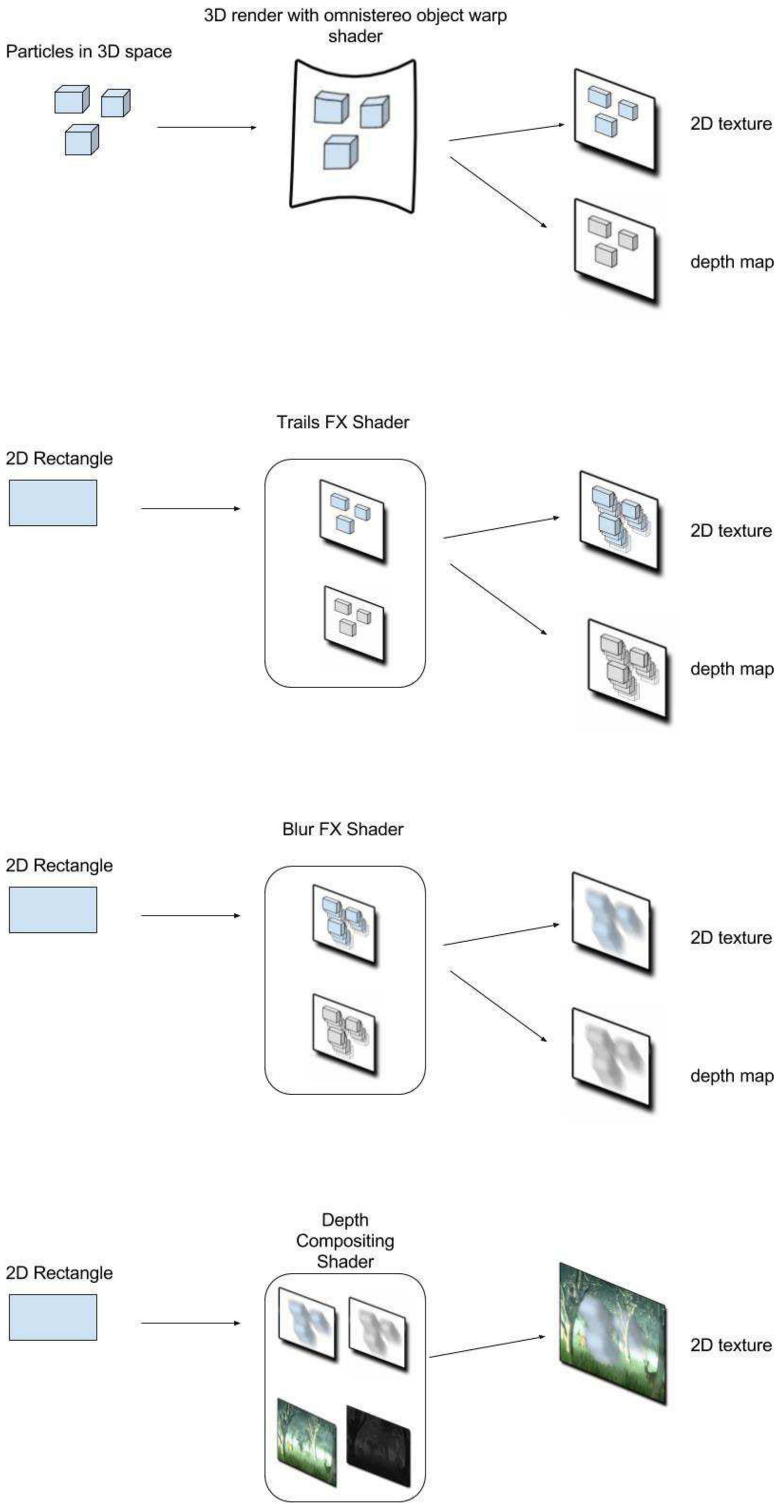



Figure 5.18: A typical four-pass process to render one particle layer with omnistereo object warp, blur fx, trail fx and depth composition.

innately understandable reaction to motion tracked movement. The ability to render in omnistereo allows an audience to view this visual display with a highly immersive stereoscopic representation of depth in a shared physical environment.

## 5.7 SoundStorm

In a similar fashion to the visual rendering of particles, the ParticleStorm architecture allows the particles to be sonically rendered with a variety of immersive and aesthetic techniques in real-time. Taking advantage of the distributed nature of the ParticleStorm system, an OpenFrameworks application, entitled SoundStorm, was developed which allows the sonic display to be computed on a separate machine from the physics, motion capture or visual display components of the system.

### 5.7.1 Sound grains

The particles in the system are sonically represented by small samples of digital audio that can be played back and manipulated in response to the particle's current position, rotation and velocity. These samples can vary greatly in time span, anywhere from a 10,000th of a second up to a minute in length, depending on the current playback settings of the SoundStorm system. Despite the ability to extend beyond the minuscule scale of granular synthesis, the samples of audio are referred to as 'sound grains' as it provides a nice visual metaphor, linking the sonic samples to the virtual particles and their visual representation. These grains can be played back on certain events such as particle collisions, and can also be looped indefinitely to mimic continuous sounds such as a bird flapping its wings in a flocking scenario. The sound grains were taken from prerecorded sound files in *Creature: 3D* to create sounds of birds flapping and moons swooshing past, while the grains used real-time sampling to create an immersive audio-visual experience in response to the *oboist* during the live performance of *Blue Space.*

### 5.7.2 Distance-based amplitude panning (DBAP)

To create an immersive soundscape that represents the particles output from the rigid body and fluid physics simulations, it is important to create a strong link between the position and movement of these particles to real world space. Just as the different perspectives in left and right eyeballs is synthesized into a cognitive depiction of 3D space, sound is interpreted by both ears to create a positional sound field in three dimensions. There are many audible traits that our brains compare between the ears to identify locations of a unique sound source. These traits include minuscule delays between a sound hitting either ear, frequency shifts caused by sounds passing through and around the head, and the different timings of sound waves reflected from walls, floors and other hard surfaces. Perhaps the most common method to represent positional sound is by panning the amplitude of separate audio sources between two speakers in a standard stereo sound system to mimic the natural decay in audible volume that occurs with increased distances between the listener and the sound source. Distance-based amplitude panning is a simple expansion of this phenomena and allows any number of speakers to represent the source position in two or three-dimensional space. While ambisonic and vector-based amplitude panning (VBAP) have been found to provide a slightly better representation of position when observed at the sweet spot in the center of the room, distance-based amplitude panning (DBAP) was implemented in SoundStorm to exploit its superior flexibility of speaker configuration and listener position (Kostadinov et al., 2010; Lossius et al., 2009).

The SoundStorm DBAP system allows you to map any number of real-world speakers, by creating a virtual counterpart which is positioned in virtual 3D space corresponding to its real-world location. Sounds emitted by virtual particles are output from the real-world speakers with a loudness determined by their proximity to their virtual counterparts. The size of these speakers and volume can be adjusted independently for each separate speaker and can be seen overlaid on a simple top-down interpretation of the 3D world to help with placement and troubleshooting. The distance from each of the speakers to a sound source is computed using simple 3D vector arithmetic, and the system scales the volume independently for each speaker to mimic the natural falloff of sound intensity through air in the real world. This system is highly efficient, being able to mix and output hundreds of uniquely localized particle sound sources simultaneously on standard computer hardware. While used in a simple two speaker setup in the musical performance *Blue Space*, it was successfully scaled up to 16 speakers placed equidistantly around the cylindrical screen of the Data Arena to add an immersive location-based sound display for *Creature: 3D*.

In addition to particle-based sound grains, the SoundStorm application can use DBAP to distribute pre-rendered audio files around the performance space. *Creature: 3D* used the system to introduce an immersive depth into the atmospheric soundscape when depicting the Australian bush during fire and rain cycles.

### 5.7.3 Particle-based effects

The distance-based amplitude panning can sonically place an object in three-dimensional space, but acoustics in the real world is a complicated phenomenon and, as with the visual elements, the sound display can benefit from a number of immersive techniques combining to mimic the real world as realistically as possible. The Synthesis Toolkit[13] was integrated to allow the sound grains to be played back with various combinations of *EQ,* pitch shifting, gain, distortion and reverb effects. These effects are applied to the sound grains and can be individually linked to the real-time position and velocity of the grain's associated particle. This allows the system to mimic real world phenomenon such as the doppler effect where the frequency of sound is altered by the velocity of the sound source. *Creature: 3D* increases the reverb effect on 'moon' particles as they fly off into distant locations to mimic

[13] An open-source C++ audio processing library written by Perry R. Cook & Gary P. Scavone. https://ccrma.stanford.edu/software/stk/

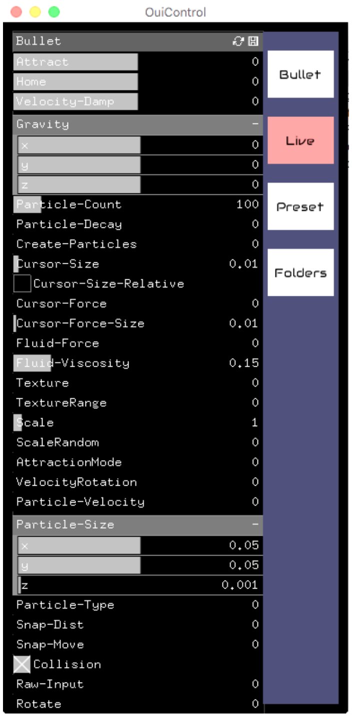



Figure 5.19: The OpenUserInterface (OUI) application

the extra reflections present in wide open spaces and promote the feeling of a wide expansive space. In the *Blue Space* underwater scene, the sound grains were progressively pitch shifted to lower octaves to depict a descent through the ocean where listening becomes muffled as water restricts any high frequency movement in the human eardrum.

The combination of sound grains, DBAP surround sound processing and velocity controlled audio effects can mimic real-world phenomena, providing SoundStorm with the ability to sonically display the virtual particles with both artistic and immersive aesthetics in order to complement the visual display.

## 5.8 User interface

The distributed nature of the ParticleStorm architecture has provided a great deal of scalability to the system, allowing it to be installed in many different situations from a single laptop to the complex multi-computer environment of the UTS Data Arena. Unfortunately, this flexibility can create a more complex system and manipulating all of these various software applications running on different computers can be difficult to manage in a live situation. To combat this difficulty, a dedicated application called OpenUserInterface (OUI) was designed to control all of the distributed nodes with one unified user interface (see Figure 5.19). The OUI application can run on *Windows, Linux, OSX* and has also been created for use on iPad and iPhone devices.

The OUI application is called an 'open' user interface because it has no knowledge of the underlying system built into it. All of the applications in the ParticleStorm suite have been built with the OUI library which automatically maps internal parameters into simple toggle button and sliders. These elements are placed onto user interface panels which can be viewed locally and automatically connect to any OUI application that exists in the system. The sliders and buttons are automatically arranged in simple panels on the OUI application and can then be saved as presets to be loaded back later. User interface panels that have identical names are treated as the same interface that will be synchronized and distributed to multiple applications automatically. This is useful in more complex situations, such as the Data Arena, where multiple render applications are employed to create a sense of immersion. Any change that is made to one render node via the user interface will instantly be made to all of the render nodes identically. Multiple instances of the OUI application can also be run on the same network and will automatically synchronize with one another, allowing two simultaneous operators or controls located on multiple machines if desired.

The open nature of the user interface application means that it can be run on any type of ParticleStorm installation without any modification. It has been used to control a simple one laptop instance of RenderStorm during *Airstorm* performances and the same application has been used in the Data Arena to control rigid body physics, SoundStorm, a DMX lighting controller, a haptic feedback glove and six RenderStorm applications simultaneously.

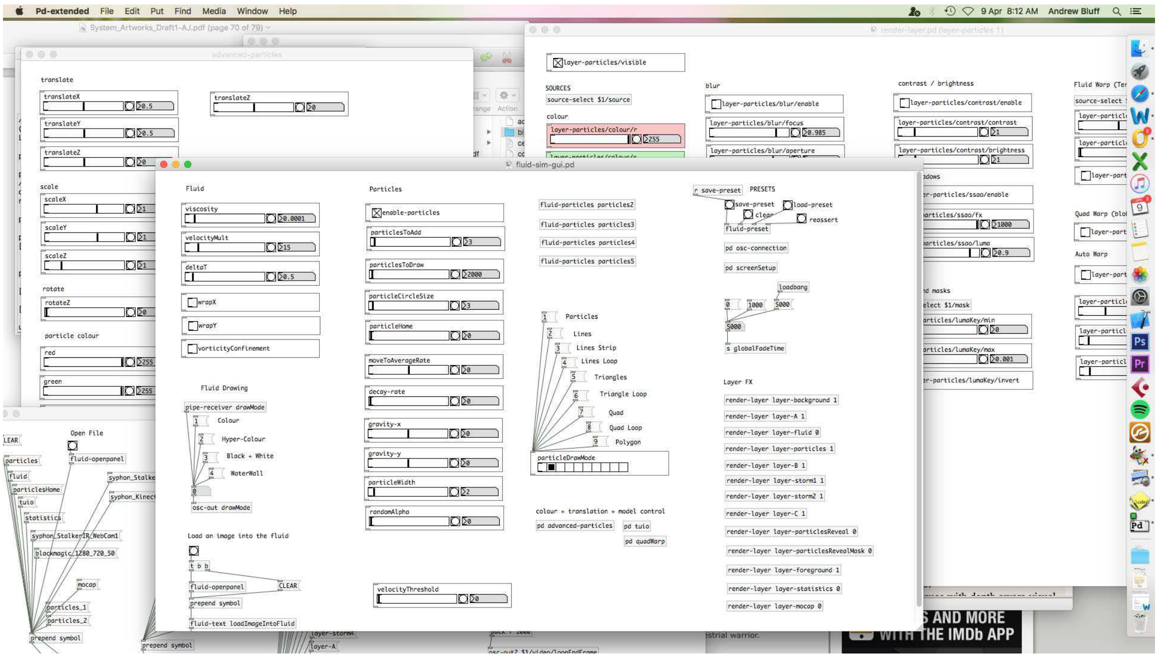


Figure 5.20: A small section of the PureData user interface

The OUI application connects with OUI enabled interfaces through simple OpenSound-Control (OSC) messages transmitted over UDP. This makes the system flexible and allows OUI to control applications found outside of the normal ParticleStorm software suite. The use of OSC also allows the ParticleStorm software suite to be controlled by other applications, such as PureData or Max/MSP, when an extra level of automation is required by the system. This reliance on OSC messages over UDP makes the system very flexible but has been found to be unreliable when connecting wirelessly from iPhone and iPad devices. A more robust messaging system is an area which will need to be addressed in future developments of the system.

OUI was initially a very important component in ParticleStorm, but the complexity of the system has somewhat outgrown the simplicity of the OUI interface as it stands. More recent works have enlisted a PureData patch (see Figure 5.20) to control the options available to the particle systems, visual effects and compositing layers which total well over 1000 individual parameters across the entire system. Custom slider and preset saving modules were created for the PureData to mimic some of the OUI features. While the PureData patch is quite usable in its current state, there are features that are sorely missed from the OUI user interface, such as preset editing and the dynamic network and parameter configurations. Upgrading the OUI application to cater for the growing complexity of the system is a significant area to be considered for future development.

## 5.9 Conclusion

An extensive system capable of real-time audio visual interactivity was developed in association with the artworks examined during this research. The system was built in C++ and OpenFrameworks to ensure that creative techniques could be quickly developed while still maintaining an efficient, robust and extensible system. A distributed architecture based on standardized messaging protocols was adopted to allow the system to be as flexible and scalable as possible.

A number of motion capture techniques were integrated into the system including camera-based optical flow and blob tracking, Optitrack marker tracking, Kinect skeletal tracking and LeapMotion hand tracking, allowing the system to be used in a number of different performance and development scenarios. The system begins the virtual part of the interaction loop by transforming the motion capture data into particles and forces in a virtual world. The virtual world is governed by a combination of rigid body collisions, particle attractors and fluid simulations that mimic certain behaviors found in the real world. Messages containing the positional, rotational and velocity information of these particles is then passed on to one or more rendering applications that strive to display the virtual world using a combination of immersive techniques.

Visual display applications have been developed to render these virtual particles in a variety of different looks, combining 3D rendering techniques with depth-aware visual effects to display in a range of configurations from single screens up to the highly immersive

360 degree omnistereo displays. An audio display application has been developed to complement the visual display and is capable of outputting particle data located in 3D space using distance-based amplitude panning and real-time audio effects that can mimic behaviors found in the real-world. The real-time audio and visual data can be mixed with pre-recorded media in a live scenario to enable a richer body of narrative-driven aesthetics to be realized than would be possible with the particle-based system alone.

The number of audio-visual techniques and physical simulations integrated is testament to the flexibility and scalability of the system. The ability to combine these complementary techniques in real-time provides a greater sense of immersion and aesthetic malleability than any one effect could provide in isolation.

In the next chapter we will examine the *Creature: Dot and the Kangaroo* theatre show to see how the system was used as a storytelling device in a live theatrical context.

# Chapter 6

# Creature: Dot and the Kangaroo

## 6.1 Introduction

This chapter examines the way embodied interactive visuals were used as a storytelling device in the physical theatre production of *Creature: Dot and the Kangaroo*. The 2016 production is a 45 minute physical theatre show that uses a mix of spoken word, music, song, physical movement and interactive visuals to retell Ethel C. Pedley's classic Australian children's novel *Dot and the Kangaroo* (Pedley, 2014). The story follows the little girl *Dot's* adventure as she befriends a motherly kangaroo and begins to understand humankind's negative impact on the natural environment. The visuals are a combination of animated backgrounds, interactive particle systems and real-time visual effects that respond to the movement of the physical performers. This movement is detected by a camera-based tracking system and mediated through virtual fluid and rigid body simulations as described in Chapter 5. Whilst somewhat experienced with interactive projection technology through *Encoded (*see Section *4.2)* and *Pixel Mountain* (see Section A.1), the *Dot and the Kangaroo* theatre show was the first time that Stalker Theatre had incorporated a literal and spoken narrative into their work. This chapter documents how the technology was used and its impact on the physical theatre show.

Highlights of *Creature: Dot and the Kangaroo* can be viewed online at https://vimeo.com/199996091.

## 6.2 Totems

> "...a totem is something inherently personal and meaningful and so we managed via the interactivity to make those totems alive and responsive in a personal way." - Director (*Creature: Dot and the Kangaroo)*

Inspired by the success of the *Creature: Siteworks* performance (see Section 4.5.1), the *Dot and the Kangaroo* theatre utilized an interactive attraction system that allowed simple 3D models of Australian native animals to emerge from the fluid-based particle display. These graphical creatures were called 'totems' by the crew and represented the spirit of the animal characters on stage, including a kookaburra, platypus, snake, bittern, dingo, kangaroo, willy wagtail and brolgas. The 'totem' creatures would morph, shift and warp in response to the actors' movement on stage.

> "...when someone would go past a projection it would respond like any other performer on stage so everybody was responsive to each other's contributions if you know what I mean...they were alive and responsive like everybody else on stage was." - Co-Director (*Creature: Dot and the Kangaroo)*

The sense of 'aliveness' that the interactivity provided these totemistic creatures was seen to manifest a presence on stage, somewhat reminiscent of a human actor.

> "As a director what I perceive when we have the interactive technology, [...] is a type of presence being manifested on stage and that presence is almost like another actor, but not quite." - Director (*Creature: Dot and the Kangaroo)*

Figure 6.1: The interactive hare totem
Photo: Darren Thomas

The attribution of aliveness and presence to the interactive system is an intriguing observation that appears to be linked to the complex reactions of the physical simulations. In his book, *Animation, Embodiment and Digital Media*, Kenny Chow describes 'technological liveness' as 'a quality in animated phenomena that makes us think of life or living things' and goes on to present complex emergent systems (or physical simulations) and digital morphing as a type of liveness which is 'integral to the illusion of real life' (Chow, 2013). Using a detailed analysis of Stalker Theatre's previous interactive dance work, *Encoded,* Abbie Trott determined that the human performers interact with the fluid-mediated visuals as 'embodied' entities that were capable of creating a sense of 'co-presence' (Trott, 2016). A form of liveness was similarly found in the interactive mass-spring system of *Double Skin/Double Mind,* where the dancer described the physical simulation as being 'alive' and going so far as to call her own performance with the system a 'duet' (Fdili Alaoui et al., 2014). The interactive physical simulations in ParticleStorm have provided the animal totems in *Dot and the Kangaroo* with a complex morphing behavior that managed to elicit a sense of aliveness and a manifestation of presence.

These physical simulations were then combined with the literal 3D animal shapes to form the virtual animal totems (see Figure 6.1) that allowed these manifestations of presence to actually portray a character within the story.

> "...it's actually, you know it's another character in a way telling the story."
> - Co-Director (*Creature: Dot and the Kangaroo)*

Although the interactive movement of these totems has been described as 'minimal' by the director, he sees the creatures as crucial to the show and suggests that the 'aliveness' gives the projections a certain soul.

> "...these motifs, I think, are crucial to the work. And again, [...] we play with the thresholds a lot, but basically we keep it fairly minimal and it's just to give that sense of aliveness, I think, in as much as the human is alive. We sense

> the human's aliveness. We also then can create an aliveness with these totems. Which I think, you know, with good x-ray paintings or dot paintings, any good work of art is alive. Has its own soul." - Director (*Creature: Dot and the Kangaroo)*

The totems depicted the animals from the novel in a responsive and personal way. The interactivity brought a sense of aliveness that manifested a presence in the projected imagery, making them characters in their own right.

## 6.3 Landscapes

During the development of *Creature: Interactions,* visual artist Boris Bagattini generated a three-dimensional model of the Australian bush landscape in the software packages *Maya* and *TouchDesigner* (see Figure 6.2). The landscape was generated as a literal representation of the bush setting from the original novel and was later reused to portray the locations of various scenes in the show. These animated visuals colourfully depicted a creek for the platypus scene*,* a river for the brolgas and a sunny field for the willy wagtail. The show also featured an animated descent down a rocky hilltop as the kangaroo travels to a distant gully with the little girl in her pouch.

These background landscapes were positively received and the colourful visuals presented the biggest aesthetic shift from the initial demonstration performance, *Creature: Siteworks*.

> "I thought that the main breakthrough that was more obvious this time was all the 3D environment that was made as a background that before wasn't there."
> - Rigging Technician (*Creature: Dot and the Kangaroo)*

Considerable effort was made to ensure that the very disparate 3D landscapes worked aesthetically with the interactive animal totems. Despite being considerably more colourful,

Figure 6.2: A section of scenic bush landscape

the non-reactive nature of the landscape graphics made them appear as a backdrop to the more interactive totem characters.

> "...we've managed an aesthetic continuity between the interactivity and the projection....So it's an aesthetic, and there's less agency with the actors. It does become a backdrop. It becomes an animated backdrop." - Director (*Creature: Dot and the Kangaroo)*

The digital projections, and in particular the 3D landscapes, took on the role of theatrical backdrop in the *Creature* theatre show, providing a suitable location for the interactive totem animals.

## 6.4 Spoken word

**The challenge**

The Stalker Theatre team had worked with interactive visuals prior to the *Creature* development (in *Encoded* and *Pixel Mountain)* and felt a certain familiarity with the technology. These prior works, however, were quite abstract dance-orientated performances that possessed a very loose narrative structure. *Creature: Dot and the Kangaroo* is the adaptation of a children's novel and contains a definite narrative structure, large amounts of spoken word and sung musical elements. These narrative elements were new to the Stalker team and the challenge became finding ways to marry the physical and visual elements with the script and spoken word.

> "Well, looking at it theatrically, probably the biggest challenge was the integration of a narrative structure and that's particularly to do with the type of work that I've made and Stalker theatre has made traditionally. It's usually been non-narrative-based and somewhere between abstract and semi-abstract, so I think that was the biggest challenge." - Director (*Creature: Dot and the Kangaroo)*

To address the inexperience of the Stalker team with narrative structure, a professional and well-regarded playwright, narrator and co-director were added to the team. However, just as spoken word was new to many of the Stalker team, the use of physical theatre and interactive technology was new to those more experienced in the use of text. A large part of the development process was therefore concerned with how to actually combine the interactive physical performance with the spoken word.

> "...bringing in text and acting in that way was something really new. It was a new element to work on,... two different languages having to come together. Or to communicate together" - Performer 3 (*Creature: Dot and the Kangaroo)*

### Density of script

The theatre show is an adaptation of a classic children's novel and the co-director recounts how much of the playwright's process was one of reduction. Firstly, the amount of text needed to be reduced from the full length novel into something suitable for a 45 minute theatre show.

> "How is the story going to be told? Like, how are we going to reduce it without kind of taking away anything at the same time?" - Co-Director (*Creature: Dot and the Kangaroo)*

The script also needed further abridgment to meet the young target audience of three to eight year old children, many of whom had not previously been introduced to the original novel.

> "...how can we most economically tell this for this audience? Because this audience are not going to want to hear adjective after adjective." - Co-Director (*Creature: Dot and the Kangaroo)*

Finally, what became evident throughout the early portions of the four week development period was that the script needed to be further reduced from the descriptive novel format to one that allowed the physical choreography and visuals room to 'speak'.

> "It's really dense. So how can it be porous enough to accommodate all those other languages that are going to be telling the story?" - Co-Director (*Creature: Dot and the Kangaroo)*

### The strategy

As the script was by far the most developed portion of the show prior to entering the rehearsal space, the process of building the show was in many ways guided by the text and finding ways to represent the essence of the script through the physical and visual languages. The text represented the story that needed to be told. When other ways were found to tell a portion of the story, then it was removed from the script and added to the choreography or visual elements. One performer sums up the development process by stating

> "this is the script... can you do something with that and then we can take that out" - Performer *(Creature: Dot and the Kangaroo)*

The script was used as a 'blueprint' during the planning stages. As the entire show was already fixed in terms of narrative structure, each day a scene was selected for the entire team to work on. At the end of each day the script could be reassessed in light of the new choreography, visuals and music that had been developed.

**Influence of graphics on the script**

The modeled landscapes of the Australian bush portrayed the locations from the script. As these locations were visually represented, the script no longer needed to include lengthy descriptions to set the scene for the physical action. The co-director recalls a process of elimination when finding these now redundant descriptions in the script.

> "...the visuals, like in a novel that would describe and paint a beautiful detailed picture. Your projections could do that. So I just remember putting my pen through lots going "Oh the visuals can do that. The visuals can do that.""
> - Co-Director (*Creature: Dot and the Kangaroo)*

The totems represented the *spirit* of the characters on stage and can be considered to play a similar but complementary role to that of the animated digital set. Where the modeled landscape of the Australian bush provided a location for the setting of the action, the totems provided a simple descriptive context and spirit to the animal characters of the story. The co-director thought that the context provided by the living totems, along with the landscapes, allowed other elements of the show to take on a less descriptive role.

> "...those projections also supported that sparcity of text so that the movement... had more space to be because the pressure of the performers to describe everything was alleviated... the visuals were speaking about location, about spirit of bush, about magic." - Co-Director (*Creature: Dot and the Kangaroo)*

**Balance**

The deletions and constant reworking considerably reduced the density of the script and reliance on spoken word as a storytelling device. Despite being wary of text's potential to dominate, the co-director thought the process resulted in a balanced production.

> "...we needed to constantly be conscious of not letting the text dominate the piece, that there are other languages that can tell the story really viscerally and they did. ...I think we achieved a really good balance" - Co-Director *(Creature: Dot and the Kangaroo)*

Whilst obviously proud of the theatre show, some of the cast felt that a better balance between script and physical performance could have been achieved with a longer development period.

> "I just think that our creative development period would have seen the text... not to be spoken verbatim but to be used as a resource." "...rather than becoming a performance resource, it seemed just due to the ferocity of the lack of time that it became automatically a script to be spoken" - Musical Composer *(Creature: Dot and the Kangaroo)*

**Summary**

The marriage of strong narrative arc with spoken word, interactive visuals and physical performance was new for all of the crew involved in the production, and was the greatest challenge of the project. The process started with a fully developed script which was slowly whittled down to facilitate storytelling through other performance elements. The landscape and totem graphics were found to describe the location and spirit of the animals within this world and facilitated a reduction from the spoken text. This approach produced a high quality show that all of the crew were proud of, although some thought that given a longer development time, they would like to further reduce the dependency on spoken word.

## 6.5 The peak experience

> "We had the ability to make the stage come alive in a very particular way. I think those moments... they are a peak experience and in a theatre show you look at having a few of those." - Director (*Creature: Dot and the Kangaroo*)

During the interviews with the production's performers, artists, technicians and directors, a few select scenes from the show were consistently mentioned. Of the 26 scenes that are in the entire show, four scenes were referenced more than any other. This includes the 'berries of understanding' scene which was mentioned 17 times, the 'bronze-winged pigeon' and 'brolga dance' scenes which were both referenced 18 times and the 'dingo attack' scene which was mentioned 10 times. All other scenes were mentioned six or less times, and many of the scenes were not discussed at all in the course of the interviews. These frequently mentioned scenes were all described fondly and can be thought of as the "peak experiences" that the director seeks to craft in a theatre show. The interactive system's role in making the "stage come alive" can be examined during these scenes to understand how the technology was used during these peak moments.

Figure 6.3: The berries of understanding
Photo: Darren Thomas

### 6.5.1 Berries of understanding

The story of *Dot and the Kangaroo* is based around a little girl named Dot befriending a Kangaroo (Mrs K.) and going on a journey through the Australian bush. Throughout this journey she becomes increasingly aware of humans' negative impact on the natural environment. Somewhat reminiscent of Alice passing through the rabbit-hole, the narrative device used to enable this journey are the 'berries of understanding'. Mrs K. gives Dot the berries and she becomes increasingly aware of her natural environment as she eats them until finally she understands and can talk to the animals. This was a pivotal moment of transformation in the novel and is represented by the interactive particle system in the theatre show.

As Mrs K. starts to talk to Dot and offers the berries, the two performers start a simple unified dance of tumbling and rolling about the stage. Simple white particles are emitted and flow about the stage in response to their movements. As more berries are taken, they move up to the slings and swing about the space where coloured particles are generated from their movements which slowly start to settle down and reveal for the first time a full-colour 3D rendering of the Australian bush.

The visual effects used for the berries were seen as an important storytelling device. The shift to colour and a more realistic 3D animation style visibly portray her transformation by showing the Australian bush somewhat 'coming to life'.

> "The story centered around the transformation of the little girl, who kind of had her perception altered, so I think the visuals really helped us paint that transformation of perception on stage beautifully." - Co-Director (*Creature: Dot and the Kangaroo)*

Having Dot and Mrs K. physically bring the bush to life in response to their movement is key to demonstrating that it is their own actions that are having an impact on the transformation and provides a strong link between the actions of the physical performers and what otherwise could be considered a simple two-dimensional backdrop of the Australian bush.

> "There was a degree of magic and shifting reality and I think that's what the visuals did so well. When those beautiful particles, the particles of reality, kind of 'oooh', and then all of a sudden she got to see the bush in a way that she had never got to see before. I mean it was so magic it was like 'aahhh' and because it was interactive it wasn't just this sort of two-dimensional screen. It was when the actors swirled around on those slings that they were interacting with it." - Co-Director (*Creature: Dot and the Kangaroo)*

> "It was quintessential to transformation and the idea that humans can transform. It's almost like an epiphany moment, you know, the berries of understanding. It's a luminal moment. And how better to show that than the space coming alive." - Director (*Creature: Dot and the Kangaroo)*

The interactive effect was also mentioned for its refined method of mixing the more abstract particle graphics with a more literal depiction of the Australian bush. In this case the abstract graphics were used to reveal and transform the blank space into a more literal representation of the bush.

> "For a moment that transition was abstraction and literalism" and "the ability for us to merge more classic animation styles with interactive is kind of the meat in the sandwich of collaboration in some ways... I thought there's a way of marrying these two worlds. And there is, and we're gradually refining it and getting it more and more sophisticated" - Co-Director (*Creature: Dot and the Kangaroo)*

### 6.5.2 Bronze-winged pigeons

Shortly after Dot is transformed into a state of understanding by eating the berries, she is transported to a watering hole by Mrs K. the Kangaroo where she comes in contact with the bronze-winged pigeons. The pigeons are flying around the trees as they are afraid of the human Dot and refuse to come down to the watering hole. After seeing Mrs K. the Kangaroo enter the water hole, the pigeons gain courage and come down for a drink. This scene marks the first time that Dot realizes that animals and birds are afraid of humans. It is the first step in her journey towards understanding humanity's destructive impact on nature. In the beginning of the scene, all of the performers are nestled high in the slings pretending to be birds, while the narrator breaks character to interact with digitally projected birds that are flying over the entire projection screen. The system uses rigid body collision combined

Figure 6.4: The bronze-winged pigeons
Photo: Darren Thomas

with attraction forces (see Section 5.5.3) to simulate the flocking behavior of the birds in reaction to the narrator's movements. At first they are attracted to the trees and strongly repelled by the movement of the narrator, but as they gain confidence they are attracted to the waterhole at the bottom of the screen and are only slightly disturbed by the human presence of the narrator. Finally, the attraction to the waterhole is removed and the digital birds all fly away to transition into the next scene.

The scene was well received with the Director stating that it is one of his favorite scenes.

> "Parts of the show that are your favorite change and what changed for me .... was actually the end of the 'bronze-winged pigeons' and the whole 'bronze-winged pigeon' scene. Because of the bush noise, maybe because of the interactivity and then the silence as they walk forwards and just the bush... it was just visually beautiful." - Director (*Creature: Dot and the Kangaroo)*

As well as being aesthetically appealing, he also considered this scene a good example of the technical capabilities of the system being improved to meet the narrative needs of the show.

> "'Bronze-winged pigeons', one of our little moments... we have, three or four modes of particle behaviour here. We were driven to it by the narrative, but in that way it increased what was technically possible. They needed to come down to the water hole." - Director (*Creature: Dot and the Kangaroo)*

The immersive system was also applauded for its ability to convey the environmental message of the narrative.

> "I think the birds were fantastic" ... "when the performer did something to the birds, well the birds flew away so I think a lot it was talking to children about looking after, being conscious of the footprints we are creating in the bush, so I think the interactive technology is doing that in a way too". - Co-Director (*Creature: Dot and the Kangaroo)*

### 6.5.3 Brolga dance

On her journey to find her way home, Dot comes across a flock of brolgas (a native Australian crane) and joins them for a distinctive brolga dance. The inclusion of Dot in the brolga's dance is evidence of her transformation into a more sympathetic human being as she becomes at one with nature. The scene contains little or no spoken word, focussing on the dance performed by three physical performers swinging around the room in a beautifully choreographed routine. The dancers are accompanied by prerecorded melodic music with a live vocal harmony. The immersive system displays a pre-rendered waterhole animation with three large brolga totems displayed in wireframe on top of the background. The background imagery and the totems both shimmer and sway in response to the swinging movements of the live dancers. This background shimmer is technically achieved by feeding the motion capture data into a fluid simulation and warping the pre-rendered animation in response to the fluid. The totems are influenced by the same fluid system but consist of a series of particles floating on the virtual fluid that are attracted to the vertices of a simple 3D model of a brolga. The background and foreground elements react to the rippling fluid simulation, creating a sensation of viewing the reflection of a pool of water.

The interaction was only subtly different from that used in many other scenes such as the kookaburra, platypus and willy wagtail characters, but the tight rippling motion in the foreground and background elements was especially appreciated by both directors.

> "... the [brolgas] were beautiful, that had a whole different kind of feeling about them." - Co-Director (*Creature: Dot and the Kangaroo)*
>
> "I'm thinking brolgas. It wasn't just... the totems were present but it was different from the totems somehow, it was that sense of movement that you could either notice or not. I don't think everyone would consciously register what was going on but there was a sense of aliveness from the technology."
> - Director (*Creature: Dot and the Kangaroo)*

Figure 6.5: The brolga dance
Photo: Darren Thomas

The subtle interactivity of the fluid simulation was appreciated by the directors, but performers may enjoy certain scenes for other reasons such as being allowed to play with and learn new equipment.

> "... my big 'whooh' moment of every show was getting in the brolga's sling... I just wanted to have a go on the slings. That's why I was pushing it. I wanted a sling moment." - Performer (*Creature: Dot and the Kangaroo)*

Another performer particularly enjoyed the moment because she was not involved and could relax and actually watch the scene during rehearsals.

> "Brolga's always been my absolute favourite, but I think because I could sit down and watch it. I remember I brought my daughter in one day and she watched bits of it, a basic run, and she kind of stopped and went away, but when the brolga moment came up she sat down next to me and she said 'That's so beautiful"' - Narrator (*Creature: Dot and the Kangaroo)*

### 6.5.4 Dingo attack

After performing the dance of the brolgas, Dot rejoins Mrs K. the Kangaroo and they watch the moon rise and darkness fall upon the stage. In perhaps the scariest scene of the entire show, dingos start to surround the two heroes and Mrs K. sends Dot to safety before attempting to fight off the alpha dingo herself. A large totem figure of a dingo's head and torso emerge towards the top right of the projection screen and the performer playing Mrs K. performs a martial arts warm up before launching into a massive flying kick using the sling as a giant swing. As Mrs K. makes contact with the dingo, its form starts to dissolve under the force and a series of red particles are emitted from the impact to represent the blood oozing from the point of impact.

The build up of tension and integration of multiple elements in this scene was of particular interest to the musical composer.

Figure 6.6: The dingo attack
Photo: Darren Thomas

> "I'm thinking of like the 'dingo attack' scene, and how that built. That was a lot more cinematic use of sound and music where it was underscoring the dialogue and the dialogue was there with movement, ... the borders between the forms of spoken text, physical movement and music song started to blur. And overarching behind all of this is all the visual work that you guys have done." - Music Composer (*Creature: Dot and the Kangaroo)*

The narrator loved the interactive nature of the scene and its aliveness.

> "I keep coming back to the dingo moment and the bronzed-winged pigeons ... those are the two really wonderful moments where you are interactive with this other character and it becomes alive" - Narrator (*Creature: Dot and the Kangaroo)*

Another performer simply enjoyed the overtly gruesome nature of the scene.

> "[Mrs K.] would kick it and the dingo dissolved or you can see that she's you know. I could see, couldn't everyone see it. You know. But I love the blood. It's like 'Oooh there's some blood' it's good to watch that one, that was really enjoyable. Gruesome." - Performer (*Creature: Dot and the Kangaroo)*

While the Director liked using the interactive system to "generate theatrical tension" and enjoys the idea of "combining abstraction with literalism" to depict horror, he thought that the scene could have been improved.

> "Not quite there, but heading in the right direction. Again, it's one of those things where you go, more time? Maybe we would have ended up there. I think the horror of it, I think what we were trying to get was there was something horrible about the distortion of the dingo, which represented the horror of the guts being ripped out... Watching it you see the idea, but maybe you don't really feel it."

### 6.5.5 Peak analysis

The elements of the peak scenes have been analysed by watching video footage of the performances and placed into Table 6.1 for comparison. The individual cells within this table are displayed with a colour value that ranges from pure white to dark blue and indicate the relative strength, dominance or density of the elements within a particular scene. The 'berries of understanding' and 'bronze-winged pigeon' scenes have each been split into two sub-scenes as the elements considerably changed mid way through each of these scenes. The elements were categorized in the following manner:

- **Scene** - name of the scene
- **Time** - start and end time of the scene within the show
- **Interactive System** - the type of interaction used (ie particles, flocking, totems)
- **Reactive Amount** - how rapidly the graphics react to the physical movement of the performers
- **Freedom of Particles** - how much are these particles attracted to a preset shape like an animal totem
- **Visual Effect** - what type of visual effects are used in the scene (eg blur, trails, masking)
- **Graphical Movement** - to what extent do the visuals move in the scene (as a percentage of the entire screen)
- **Foreground Projection** - the colour palette of the foreground interactive visuals
- **Background Projection** - the colour palette of the background visuals
- **Physical Performers** - how many physical performers were actively moving in the scene

| Scene | Taking Berries | Transforming Berries | | Pidgeon Chase | Pigeons Waterhole | | Brolga Dance | | Dingo |
|---|---|---|---|---|---|---|---|---|---|
| Time | 9:30-10:50 | 10:50 - 11:50 | | 16:00-16:30 | 16:00 - 18:27 | | 26:40 - 30:30 | | 30:50 - 32:50 |
| Interaction System | free flowing particles | particles reveal the bush | | rigid body flocking | rigid body flocking | | 3 totems + fluid warp | | totem + particles |
| Reactive Amount | very reactive | very reactive | | reactive | reactive | | very reactive | | reactive |
| Freedom of Particles | free flowing | loose | | attracted to trees + water | attracted to trees + water | | quite tight | | medium - loose |
| Visual Effects | | masking, blur, trails | | | | | fluid warp background | | trails |
| Graphical Movement | 3/4 screen | full screen | | fullscreen | fullscreen | | full screen | | 1/2->3/4 |
| Foreground Projection | white | colour | | whiteish | white / brown birds | | white | | white + red |
| Background Projection | black | black | | colour | colour | | colour (fades out) | | black + colour |
| Physical Performers | 2 -> 4 | 2->4 | | 1 | 5 | | 4 | | 1 |
| Physical Location | floor | in slings | | Floor | slings to floor | | medium height slings | | sling |
| Physical Action | dance, swing, rolling | swinging | | running | dropping and hopping on floor | | lots of swinging choreography | | swinging kicks |
| Digital Acknowledgement | | Noticing | | deliberate interaction | | | | | deliberate |
| Sound Design | | mild birds | | bird flapping | bird flapping | | | | dingo howl |
| Music Style | music (gentle) | music (heavy) | | | | | music + vocals | | music building |
| Song | | | | | | | | | |
| Spoken Word | medium | mild | | single yell | heavy | | | | heavy |
| Mood | happy | very happy, laughter | | | serious | | poetic reflection | | action |

Table 6.1: *Creature: Dot and the Kangaroo* scene analysis (peak scenes)

- **Physical Location** - where the majority of movement was occuring from the performers (ie on the floor or up high hanging from the rope-like slings)
- **Digital Acknowledgement** - how do the actors acknowledge or interact with the projected visuals (if at all)
- **Sound Design** - what types of sound effects are used in this scene
- **Music Style** - how prominent is the music in the scene
- **Song** - does the scene include any singing elements
- **Spoken Word** - how much spoken word is used throughout this scene
- **Mood** - what mood would best describe the overall scene

From Table 6.1 we can see that the peak scenes differ significantly in many of these categories. They all use a different interactive systems with the 'berries of understanding' using a particle effect, 'bronze-winged pigeons' using a rigid body flocking, 'dingo attack' using a totem with particles for blood and the 'brolga dance' using 3 totems and a fluid warp. The colour palettes of the foreground and background elements are quite diverse and a number of different graphical effects were also used in these scenes. While each of these scenes utilized different interactive systems, colour palettes and effects, they were all quite reactive with the graphics moving over the large majority of the projection screen.

The performance saw the actors taking on multiple roles throughout the performance; switching from narration and musicianship to physical performance and vice-versa. The number of actors giving a physical performance varies tremendously within the peak scenes, as does the location of their actions. The performance also contains a considerable amount of spoken word, song and music and once again, we see more variance than consistency in these aural elements.

Considering all of the elements of the performance, the main theme that exists across the peak scenes of *Creature: Dot and the Kangaroo* is one of variation. The only real factors that are consistent across these scenes are the high level of reactivity within the interactive graphics and the resulting scale of graphical movement across the entire projection canvas.

## 6.6 Show analysis

> "...you've got to give it breath and space. It's like in a jazz improvisation, you can never have all of the instruments playing all the time." - Director (*Creature: Dot and the Kangaroo)*

Examining the more successful scenes of *Dot and the Kangaroo* has revealed a high level of reactivity and wide-reaching movement in the projections and a large variance in all other performance elements. By extending the scope of the analysis to look at the entire show, we can examine the difference between the peak and non-peak scenes and see larger patterns emerging throughout the piece to find what techniques the director has used create a sense of 'breath and space' across the multiple elements of the work. Tables 6.2-6.4 show an overview of the entire performance split into the same categories as described in Section 6.5.5. The peak scenes have their names highlighted in red.

### 6.6.1 Aristotelian three stage composition

Looking at the overall structure of Tables 6.2-6.4, we can reveal a diverse distribution of focus across the piece with many elements ebbing and flowing nicely from scene to scene. The piece is quite dense across many elements, especially in the middle portion of the show from the hill travel scene (14:30) until the end of the leap of faith at (34:20). Aside from the introductory scene, the first ten minutes of the production do not contain any coloured

| Scene | Introduction | Rabbit | Dot | Kangaroo | Waterfall | Lost Joey | The Meeting | Taking Berries | Transforming Berries |
|---|---|---|---|---|---|---|---|---|---|
| Time | 0:00 - 1:30 | 1:30 - 4:50 | 4:50 - 6:00 | 6:00 - 6:52 | 6:52 -7:27 | 7:27 - 8:26 | 8:26 - 9:26 | 9:30-10:50 | 10:50 - 11:50 |
| Interactive System | | totem follows performer | totem | totem | totem + waterfall of particles with gravity | totem | 2 totems | free-flowing particles | particles reveal the bush |
| Reactive Amount | | medium | mild | mild | medium | minimal | mild | very reactive | very reactive |
| Freedom of Particles | | medium | tight | tight | water fall is loose | tight | tight | free flowing | Loose |
| Visual Effects | | | | | trails + blur | | | | masking, blur, trails |
| Graphical Movement | low | lower half | left 1/3 | centre 1/3 | centre 1/3 | centre 1/3 | 2/3 of screen | 3/4 screen | full screen |
| Foreground Projection | white | white | white | white | white | white | white | white | colour |
| Background Projection | black + colour | black | black | black | black | black | black | black | black |
| Physical Performers | 5 | 2 | 1 | 1 | 1 | 1 | 4 | 2 -> 4 | 2->4 |
| Physical Location | floor | floor | high | floor | floor (back of stage) | floor | mostly floor + high | floor | in slings |
| Physical Action | minimal, tumbling | chasing, tumbling | climbing, miming | running around stage | standing still in waterfall | standing (crying) | minimal, climb and swing | dance, swing, rolling | swinging |
| Digital Acknowledgement | | | | | | | | | noticing |
| Sound Design | | | | | | | | | mild birds |
| Music Style | | music (live bass) | - | song | song | song (ending) | | music (gentle) | music (heavy) |
| Song | | | | song | song | song (ending) | | | |
| Spoken Word | heavy | mild | heavy | mild | | medium | heavy | medium | mild |
| Mood | fun | fun | dramatic fun | action (chase) | action (hiding) | sad | nuetral - fun | happy | very happy, laughter |
| Peak Scene | | | | | | | | peak | peak |

Table 6.2: *Creature: Dot and the Kangaroo* scene analysis (beginning)

| Scene | Mrs K. and Dot Talk | Walking to Water | Hill Travel | Pidgeon Chase | Pigeons Waterhole | Kookaburra | Berries #2 | Platypus Talk | Platypus Song | Brolga Dance | Moon rise | Moths | Dingo | Leap of Faith |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | 11:50-13:00 | 13:00-14:30 | 14:32 - 16:00 | 16:00-16:30 | 16:00 - 18:27 | 18:30-20:40 | 20:40-21:40 | 21:40-23:10 | 23:10 - 26:40 | 26:40 - 30:20 | 30:20-30:40 | 30:40 - 31:50 | 31:50 - 32:50 | 32:50 - 34:20 |
| Interactive System | | | fake movement | rigid body flocking | rigid body flocking | totems + movement of snake | particles reveal the bush | totem | totem | 3 totems + fluid warp | video animation | rigid -body flocking | totem + particles | |
| Reactive Amount | | | | reactive | reactive | mild | very reactive | reactive | reactive | very reactive | | reactive | reactive | |
| Freedom of Particles | | | | attracted to trees + water | attracted to trees + water | tight | loose | medium | medium | quite tight | | loose | medium - loose | |
| Visual Effects | | | | | | | masking, blur, trails | | | fluid warp background | | trails | trails | |
| Graphical Movement | grass at bottom | grass at bottom | full screen | full screen | full screen | 1/2 screen | 1/2 screen | centre 1/3 | centre 1/3 | full screen | left 1/3 (v) | full screen | 1/2->3/4 | |
| Foreground Projection | | | | whiteish | white / brown birds | white | colour | white | white | white | | black | white + red | |
| Background Projection | colour | colour | colour | colour | colour | black | black | colour | black | colour (fades out) | black + colour | black + colour | black + colour | black + colour |
| Physical Performers | 4 | 2 | 2 | 1 | 5 | 2 | 2 -> 4 | 3 | 2 | 4 | 4 | 4 | 1 | 2 -> 4 |
| Physical Location | floor | floor | medium (in pouch) | floor | slings to floor | mostly on floor | floor + sling | floor + floor sling | medium height slings | medium height slings | floor | floor (crouched) | sling | high |
| Physical Action | standing | falling, tumbling, swinging | swinging in pouch | Running | dropping and hopping on floor | acrobatics | dance, swing, rolling | standing, talking | swinging a lot with each other | lots of swinging choreography | still | still | swinging kicks | giant swing |
| Digital Acknowledgement | | | | deliberate interaction | | | | | | | noticing | | deliberate | |
| Sound Design | mild birds | mild birds | mild birds | bird flapping | bird flapping | kookaburra laugh | | mild water birds | mild water birds + splash | | sfx | crickets + dingoes | dingo howl | |
| Music Style | | | song | | | live bass | music (gentle) | mild | song | music + vocals | | light synth | music building | music then silence |
| Song | | | song | | | | | | song | | | | | |
| Spoken Word | heavy | mild | | single yell | heavy | mild | mild | heavy | mild | | | heavy | heavy | mild |
| Mood | fun, slight serious | comedic | happy | | serious | danger + fun | happy | learning | joyful | poetic reflection | silence | spooky | action | danger action |
| Peak Scene | | | | peak | peak | | peak repeat | | | peak | | | peak | |

Table 6.3: *Creature: Dot and the Kangaroo* scene analysis (middle)

| Scene | Bittern | Willy Wagtail | End Speech | End Animation |
|---|---|---|---|---|
| Time | 34:20 - 37:00 | 37:00-39:30 | 39:30 - 40:45 | 40:45 - 42:00 |
| Interactive system | totem | totem | | |
| Reactive amount | mild | reactive | | |
| Freedom of Particles | tight | tight | | |
| Visual Effects | | | | |
| Graphical Movement | centre 1/3 | centre + bottom 1/3 | | 3/4 screen |
| Foreground Projection | white | white | | colour |
| Background Projection | black | colour | black + colour | white |
| Physical performers | 1 | 5 | 2 | 5 |
| Physical location | floor | floor | floor | slings |
| Physical action | minimal walking | acrobatic | sitting | sleeping |
| Digital Acknowledgement | | | | |
| Sound Design | | dawn birds | night chirps | day bush sounds |
| Music style | light intro | light music | | music |
| Song | | | | |
| Spoken Word | heavy | medium | heavy | |
| Mood | comedic | fun | serious | resolution |
| Peak Scene | | | | |

Table 6.4: *Creature: Dot and the Kangaroo* scene analysis (end)

projections or background images. The beginning of the show relies on the simple black and white 'totem' graphics to give a feeling of 'aliveness' and description of animal spirit.

The restricted use of colour and backdrop in the first portion of the show serves as a deliberate narrative device, visually depicting Dot's journey and transformation into an altered state of understanding and living as one with the many creatures that reside in the Australian bush.

> "I really liked the decision that we all made about really holding back and restraining on using any, much projection at all until the 'berries of understanding', so that was a complete portal into another world." - Co-Director (*Creature: Dot and the Kangaroo)*

The use of coloured background in this manner mirrors the three-act dramatic arc used to craft the theatrical performance. This three-act structure resembles Aristotle's notion that every play has a **beginning**, **middle** and **end** *(Janko et al., 1997).* Here the **beginning** is defined by Dot and Mrs K. losing their loved ones and eventually befriending each other. The **middle** showcases Dot's ability to talk with animals which is portrayed through the extensive use of coloured backgrounds during this section. The pair meet a number of different creatures and the bond between Dot and the kangaroo increases, climaxing with the 'dingo attack' and 'leap of faith' scenes where Mrs K. puts her own life in danger to protect the human child. The **end** sees Dot learning how to live in unison with the natural inhabitants and shows the two protagonists finally finding their loved ones.

Looking at the overall structure of the piece, we can see that the visual palette was not the only element used sparingly in the beginning section of the play. There were relatively few physical performers used at any time in the beginning of the show, and the characters were fairly obviously delineated, with one performer playing Dot, one playing Mrs K. the Kangaroo, and another playing the hare. As the story progresses into the middle of the show, we commonly see four or five physical performers at one time as the roles of Dot and

Mrs K. are performed by both narrators and performers simultaneously, interacting with a number various animal characters throughout the journey. Similarly the physical action stays relatively low to the ground in the beginning scenes with the notable exception being Dot who has climbed high up in a tree to find her parents. While Dot is hiding high up in a tree very early in the show, she does very little swinging and keeps her physical movements fairly contained in contrast to the large swinging actions that feature prominently in the middle section of the performance. The location of physical movement and number of performers share a similar structure to the arc of visual projection, although each element does contain its own unique ebb and flow to depict the particular storytelling needs of each scene.

The intensity of physical action within each scene seemed somewhat unrelated to this overall structure and instead cycled in and out during the entire piece with floor-based acrobatics, tumbling and running being used in tandem with the sling-based swinging choreography. This shorter cycling ensures the consistent presence of physical performance within the show whilst not overplaying its involvement. It also serves the very practical use of allowing the small ensemble cast some time to regain their breath and energy between the physically demanding scenes.

### 6.6.2 Totems

The parameters of 'interactive system', 'reactive amount' and 'freedom of particles' appear to be tightly linked together in the scene analysis. This linkage is essential to the production of the large reactive animal characters, or 'totem*s',* which feature prominently throughout the production. The particles of the system are attracted to various points of simple 3D animal models and are rendered with two-dimensional dots or connecting lines. These totems are by far the most used graphics in the interactive system and are present for roughly 25 minutes in total, accounting for more than half of the 42 minute show. Although varying slightly between scenes to suit the type and intensity of physical movement, the freedom of particles are kept relatively tight to keep the literal animal shapes whilst still being physically reactive to maintain the 'liveness' of the digital character.

Despite being heavily used throughout the show, it is interesting to note that the 'totem' graphics were only used in two of the four peak scenes where they were combined with other interactive effects such as free-flowing particles and fluid warps. The style of reaction was even slightly different in the two peak totem scenes compared to its use in the rest of the show. In an attempt to depict the rippled reflection of a pool of water, the 'brolga dance' scene features a *vorticity confinement* setting in the fluid simulation. This setting creates ripples and eddies in the virtual water, and made the totems very reactive to the movements of the physical performers. The totem of the dingo, also features a unique style of reaction where the tightness of shape is slowly relaxed throughout the scene, allowing the dingo to disintegrate into abstraction as it is defeated by Mrs K. the Kangaroo.

The totem graphics, although being appreciated by the crew, were equally present and absent from the peak moments, suggesting that they were indeed a worthy contribution but did not make any scene peak in their own right.

### 6.6.3 Song

The spoken word is densely used throughout the piece, but if we examine the analysis in Tables 6.2-6.4 closely, we can see some distinct gaps where it has been paired back to allow other modes of storytelling. The most obvious gaps in spoken word exist where a song takes over the narrative role. The three songs included in the show were an effective way to progress the narrative journey, whilst breaking up the rhythm of spoken word. These songs were able to pare back the more descriptive language of the narration and allowed the physical language to share the focus of storytelling.

> "... a song would condense a whole pile of description with [the composer's] lyrics into a small simple song that would tell a really large story in the book."
> - Co-Director *(Creature: Dot and the Kangaroo)*

The two narrators of the piece changed roles to provide live vocals and double bass throughout the three musical song numbers. The repurposing of the narrators/performers into musical roles enforced a sparser use of physical performers during the lyrical song sections. While there were less performers during these songs, they were no less active as they swung wildly in a joyful dance in the platypus scene and bounced along in the pouch of a hopping kangaroo during the hill travel scene.

Interestingly, in a theatre show that has a sufficient amount of live music and song to be described as musical-theatre, none of the peak moments identified actually contain songs. The 'brolga dance' scene does contain vocals, but with the absence of any lyrics, they are used more as a live instrument and therefore this section is considered live music rather than a song per se. The absence of song in peak moments should not in any way be associated with a lack of quality, as the songs were well crafted, very catchy and performed with presence and skill by the vocalist and live musician. With a high standard of song craft and the reduction of text that allowed a more balanced physical performance, perhaps it is the more conventional wedging of songs between spoken narration that prevented them from being viewed as particularly peak scenes.

> "Whilst I'm happy with the work that I've done, ... I still feel that it's quite a conventional almost musical theatre type of form that we've got with these songs. We would hit certain moments and now we are going to go into a song movement sequence. Most of the songs were quite discrete song movement moments." - Musical Composer *(Creature: Dot and the Kangaroo)*

### 6.6.4 Non-peak scenes

The scene analysis has so far revealed a traditional Aristotelian dramatic structure, with a reliance on spoken word and song to tell the story, while the reactive totem graphics and 3D landscapes act as a living backdrop to depict the location of action and spirit of character. The peak scenes were found to be quite diverse in their use of physical simulation, movement style, visual effects, sound composition and colour composition. We can, instead, examine the non-peak scenes to find which elements may have been found lacking in these moments. Once again we see a diversity of movement styles, colour composition, sound and music. We can see that totems were used in half of these non-peak scenes as discussed in Section 6.6.2 and that the system was generally less reactive and therefore produced a smaller graphical movement than peak scenes as found in Section 6.5.5. Whilst many of the elements feature prominently in both peak and non-peak scenes throughout the entire performance, there are two distinct elements which are noticeably absent from the less successful scenes. These elements are visual effects and digital acknowledgement and it is perhaps these least used elements which can reveal the most about the success of the peak moments.

#### Digital acknowledgement

Throughout the majority of the show, the actors interact with one another both physically and verbally whilst either looking at each other or in the general direction of the audience. As the visual graphics are projected onto a flat surface at the back of the stage, this means that the actors almost never face the projection screen directly. While the interactive graphics react to the movement of the performers, the actors rarely even acknowledge the existence of this large-scale visual world.

There are four brief but distinct moments where the actors themselves are given the permission to witness or interact with the visual world surrounding them. The most obvious of these moments is during the 'bronze-winged pigeon' scene where the narrator breaks character to run and shoo the interactive pigeons away treating the virtual birds as live characters. Another obvious moment of physical interaction is during the 'dingo attack' scene where Mrs K. the Kangaroo issues two deliberate swinging kicks at the giant dingo totem which crumples and disintegrates in response to the actions of the brave kangaroo. Whilst the actions of the performers aren't specifically directed at the screen during the 'berries of understanding' moment, the actors allow themselves to look at the screen and notice their influence on the surroundings as they swing in circles on the slings. This acknowledgement of their actions strengthens the causality between their own actions and the reactive bush landscape and is a pivotal moment in Dot's journey towards enlightenment. The final moment of acknowledgement is where the actors and narrators pause and watch the animated moonrise high above the stage before continuing the narration. While three of the four peak scenes contained moments of acknowledgement, only one of the 21 non-peak scenes included any form of acknowledgement which suggests a probable link between the two. The 'moonrise' scene was not popular enough to be named a peak scene, but was noted as a highlight by the director, strengthening the link between digital acknowledgement and the perceived success of a scene.

### Visual effects

The real-time visual effect capabilities of the immersive system were also used relatively sparsely, featuring in only five of the 26 scenes identified in the show. These effects included trails, blurs, masks and warps and featured in the 'waterfall', 'berries of understanding', 'brolga dance', 'moths' and 'dingo attack' scenes. The trail effect creates a comet-like tail on moving particles as it bleeds the information from one video frame onto the next, revealing a smooth trail of motion. It was used in the 'waterfall' scene to depict the froth and intense falling movement of the waterfall in which Mrs K. hid from the dingos early in the piece. The trails were also used in the 'moths' scene to give the swarm of bogong moths a more foreboding presence as their black motion trails effectively swallowed up the night sky and left the scared Dot in complete darkness. The 'dingo attack' scene used the blended motion blur of the trails effect to turn red particles into a flowing blood effect which spurted from the dingo totem and stained the projection surface as it dripped downwards from the injured beast.

The masking effect allows the interactive particles to effectively reveal another layer of visuals. This effect was used to progressively reveal pre-rendered landscapes during the 'berries of understanding' scene. The visuals of this scene consisted of multiple interactive particle layers with varying degrees of blur and trails effect to smooth out the particles over time. As masking was progressively applied to each layer, the Australian bushscape appeared to magically come to life in response to the performer's actions.

The 'brolga dance' scene features a warping visual effect in combination with a highly reactive fluid simulation to make the graphics have a particular shimmer representing the reflection of a rippling pool of water. The warping effect works by shifting pixels of a pre-rendered video layer based on the brightness of an interactive particle layer. In the case of the 'brolga dance' scene, the interactive layer was a visual representation of the fluid-simulation and the pre-rendered video was the animated landscape background. Warping the background with the same fluid-simulation that moved the brolga's totem tied the two visual elements together, unifying their reaction to the movement of the performers.

Although these visual effects were used sparingly throughout the production, they do feature in the 'dingo attack', 'brolga dance' and 'berries of understanding' scenes, constituting three of the four peak moments during the show. As the effects were also featured in two scenes labelled as non-peak, the mere presence of visual effects were not enough to make a certain scene successful, but the high incidence of visual effects within peak scenes indicate that they may have been another key ingredient.

### 6.6.5 Integrated storytelling

With the development period heavily focussed on finding ways of expressing the scripted narration through non-spoken language, the peak scenes may represent the moments where this approach was more successful. When compared to all other scenes, the peak scenes contain a multitude of high-density physical, visual and aural elements (shown in Tables 6.2-6.4 as dark blue), suggesting that an efficiency of language in any one medium was not crucial, but storytelling that occurred across many different elements produced more fruitful results.

In the peak scenes identified, the system was utilized to actually convey key narrative points through interactive visual effects. The free-flowing particles in the 'berries of understanding' scene gradually reveal the fully animated bush landscape, telling the story of Dot's transformation into an altered state of understanding. The interactive flocking of birds in the 'bronze-winged pigeon' scene demonstrate nature's fear of humans and confirm the notion that Dot's actions have serious repercussions for the animals. The combination of landscape and totems moving in poetic unison to the brolga dance inform the audience that Dot is becoming one with the natural world around her. The progressive disintegration of the dingo totem and splurging forth of bloody particles describe the gruesome nature of the kangaroo's triumphant victory to the audience. Rather than simply describing the location and spirit of each scene, the interactive system portrays key elements of the narration during these peak scenes which elevates its role from one of a digital set to that of a true storytelling device.

The system was also used as a storytelling device in the 'moths' scene where a flock of bogong moths slowly obscure the light from the moon, casting Dot into the dangerous world of complete darkness. The device was relatively effective but the scene was choreographed with the actors all sitting crouched on the floor, hiding in fear from the impending danger. The almost still performance was the best way to physically portray

Dot's fear and the physical actors were located at a considerable distance from the interactive moths. As a result, there was almost no physical movement for the moths to react to. The visual projections were linked to the movement of the performers, but the staging and subtle choreography prevented any observable interaction between the two. This lack of interaction may explain why the scene is not noted as a peak experience.

The same disparity occurred with Mrs K. the Kangaroo hiding behind the interactive waterfall in the opening scenes. Rather than a physical dislocation causing separation of actor from interactive graphics, here it was actually the opposite that caused problems. The performer was choreographed to moved extremely close to the projection screen to best portray her sense of hiding behind the giant waterfall. Although positioned directly in front of the waterfall, her position at the back of stage was actually behind the infrared stage lights and she was therefore invisible to the motion tracking system, preventing any observable reactivity. Once again there is a lack of noticeable interactivity between the waterfall graphics and live performer in this non-peak scene.

When compared to the rest of the production, the peak scenes were found to contain heavy physical, visual and aural elements that combined to tell key moments of the show's narrative.

## 6.7 Conclusion

The *Dot and the Kangaroo* theatre show ambitiously combined physical performance with spoken word, live music and interactive graphics to retell Ethel C. Pedley's classic Australian children's novel. The **physical simulations** used in the interactive animal totems added a sense of **aliveness** to the projections and manifested a sense of presence, causing the cast to describe them as **characters.** The colourful 3D animated landscapes portrayed the **location** of the scenes, and were largely viewed as a **digital backdrop** or **set.** The combination of script with physical performance and visuals was one of the biggest challenges when developing this production. The totems and the digital landscapes were seen to describe the **location** and **spirit** from the novel, successfully removing some of the denser descriptions from the text.

The interview process identified four scenes as being **peak experiences** and although quite varied, these scenes all possessed very **reactive visuals** and a strong sense of physical movement that combined to create a **large spectacle**, animating the visuals over the entire projection canvas.

There was a general trend for the density of each medium to slowly build up in the early parts of the show and keep a strong presence during the middle portion of the show. This trend is largely explained by the decision to hold back with certain elements until the berries transformed Dot into a state of understanding and fits the Aristotelian arc common in many contemporary theatre productions.

The peak scenes contained the rare instances of actors **acknowledging** or actively interacting with the large projection screen. This deliberate interaction between human and digital suggests that the story is being told by both mediums in combination and permits the audience to focus attention on the connection between performer and digital environment. The 'berries of understanding', 'brolga dance' and 'dingo attack' scenes also link the performers movements to the visuals through **interactive visual effects**. The peak scenes were identified as the rare scenes where the interactive system combined the physical and visual elements as a unified **storytelling** device.

The theatre show *Creature: Dot and the Kangaroo* was examined to explore the effects of interactive visuals on narrative-based physical theatre. In the next chapter, *Creature: Interactions* will be investigated to understand how immersive environments and live performance can affect an interactive artwork.

# Chapter 7

# Creature: Interactions

## 7.1 Introduction

The original *Creature: Siteworks* performance at Bundanon consisted of two main components, an improvised dance performance with reactive graphics and an interactive playspace where the audience was invited to physically play with the technology. The dance performance evolved to become *Creature: Dot and the Kangaroo,* a full theatre production with physical performers, narrators and live musicians, and the playspace became an immersive interactive experience entitled *Creature: Interactions*.

The theatre show and play space events used the same interactive technology and shared many digital assets such as landscapes, totem graphics, bird and butterfly models. Both events were roughly 45 minutes in duration, mixed live actors with virtual digital projections and were based around the natural Australian bush portrayed in the novel *Dot and the Kangaroo.* The two works premiered at the same children's festival held at Queensland's Performing Arts Centre (QPAC) in July 2016 and were seen to complement one another.

Whilst sharing themes and technology, the two events had a completely different emphasis and grew to become two very different experiences. As detailed in Section 6.4, the development of *Dot and the Kangaroo* started with a fully fleshed out narrative and script which was realized through a mixture of physical performance, interactive visuals, song and spoken word in a traditional proscenium arch theatrical setting. In contrast, *Creature: Interactions* was heavily focused on letting the audience actually interact (see Figure 7.1) with the immersive 360 degree projected visuals. The installation was themed around the locations and creatures of the novel, rather than attempting to tell the story itself. The experience was originally designed to work as a short, 15 minute, self-guided installation but after seeing a greater potential in an early demonstration, it was considerably expanded to have live actors (or facilitators), a dramatical arc, loose script and an extended 45 minute show duration for a participatory audience of up to 90 children.

This chapter details the development of the work and the effect of using an immersive environment for the interactive art piece. The introduction of live actors is then discussed as a means to promote educational content, encourage social interactions and improve the richness of physical movement.

## 7.2 The immersive artwork

The original *Creature: Siteworks,* performed in 2014, was an interactive installation exploring the themes of biodiversity through giant creature totems and interactive plant particle systems. A performative component was added to the work and acted as an introduction to the interactivity of the piece. The performance and participatory components complemented each other nicely, with the performance demonstrating how a professional dancer might interact with the artwork and the participatory nature of the artwork confirming that the system was actually responding in real-time to the movements of the performer. Both the performance and the installation was particularly appreciated by the children in the audience, some of whom played in the installation for almost an hour after the initial performance. When the opportunity arose to expand the piece into a fully developed theatre show based around the well known Australian children's book *Dot and the Kangaroo,* the

Figure 7.1: Interactively bringing the bush landscape to life
Photo: Darren Thomas

addition of a participatory interactive experience to supplement the show was an obvious choice.

### 7.2.1 Developing the artwork

Work began on the interactive installation several weeks before the major development period of *Creature: Dot and the Kangaroo*. The idea was to reuse the successful particle system and interactive wireframe animals from the *Creature: Siteworks* project and combine them with a more vibrant and visually literal representation of the Australian bush. Inspired by the locations depicted in the *Dot and the Kangaroo* novel, visual artist Boris Bagattini created three-dimensional tree, landscape and animal models in Maya and imported them into TouchDesigner to be arranged into a large digital bush landscape. Considerable effort was made to craft locations that were from the book and could also suit the various interactive visuals being developed. This included grassy tree sections for the wireframe animals, the night sky to house star-like particle graphics and a swampy waterhole scene to house fish and interactive vines.

The original setup used TouchDesigner as the real-time rendering environment. The optical flow camera tracking data was fed into the TouchDesigner environment to drive interactive grass, birds, fish, leaves and vines. The interactive fluid display was rendered on a separate laptop and passed into the TouchDesigner environment via a live video feed which was displayed inside the bush environment. This setup was initially very exciting as it allowed a consistency of lighting and visual effects between the interactive elements and the 3D landscape and allowed the landscape itself become interactive.

Unfortunately, the TouchDesigner environment could not handle the camera tracking information from multiple cameras and became very sluggish and unstable when scaling up to the multiple-wall setup. In light of this instability, the system was completely redesigned. Instead of displaying the interactive elements inside the TouchDesigner computer, the landscapes were rendered out as videos and placed into the interactive systems. The camera tracking system was beefed up to handle multiple cameras and this data was passed to a rigid body collision system to create flocking birds, butterflies and interactive 'moon' balls for the night sky. The fluid system was updated with a compositing engine so that the fluid-based particle system, rigid body flocking system and pre-rendered landscape videos could be simultaneously layered on top of each other on the one screen. The compositing engine also allowed the fluid, rigid body particles and landscapes to each have their own unique visual effects. Masking and warping effects were also created to blend the layers together in creative ways.

The landscape video from TouchDesigner was split into a separate segment for each projector in the room and all of the displays were synchronized through network messages and carefully aligned to create a near-seamless interactive canvas. The change to playing pre-rendered video with interactive visuals inside the bespoke interactive software produced a considerably more robust system that successfully scaled up to create an immersive 360 degree environment at the Queensland Performing Arts Centre.

### 7.2.2 Immersive visuals

> "I think the immersive was, you know f#$%*^g amazing" - Artistic Director (*Creature: Dot and the Kangaroo)*

The projection onto all four walls to create a continuous 360 degree display around the large 18m by 12m rectangular room was seen as a major attraction of the artwork. Six high definition projectors were used to create the five metre high wrap-around screen which would unravel to 60 metres of continuous display if projected onto a single flat surface (see Figure 7.2). The animated bush was rendered as one giant landscape and then sliced

Figure 7.2: Immersed in the 360 degree bushscape
Photo: Darren Thomas

into six separate pieces, one for each projector. Six infrared cameras were used to capture the movement of the audience and the interactive particle graphics were spread across the networked computers along with the bush landscapes to create a large and continuous high definition interactive display that completely surrounded the audience. The immersive nature of the large scale wrap around screen was unanimously preferred over the single wall display used in development.

> "One of the greatest things I thought about it was how striking and kind of aesthetically interesting it was to literally stand in an immersive – meaning it was around us – environment." - Director (*Creature: Interactions)*

> "...the whole 360 immersion of it was quite, quite overwhelming actually. It was really... Well it was impressive certainly just because you are completely surrounded by it." - Actor (*Creature: Interactions)*

The continuous projection onto all four walls certainly impressed by physically surrounding the audience, but it also created a sense of being immersed within the interactive digital environment. Not only of being surround by, but of being *inside* the virtual environment.

> "I think there's something to be said about it being 360. I think it's just kind of striking on the body and the brain. You know, when it's just one wall I guess you are just not inside it. And I don't know what that is, I guess it's the word immersive. But when you're in a space like that it just seems like kind of better art. It seems to suit the thing better, you are inside a digital environment, you are inside an animated environment. It kind of feels like you are inside a TV, you're in a computer or inside a digital environment. People talk about it a lot, but I feel that really did it. When you're inside it, you're really inside it, you know." - Director (*Creature: Interactions)*

The shift to surrounding the audience with projections had more than merely aesthetic or immersive implications for the interactivity of the piece. As the entire room was transformed into a giant interactive canvas, there was physically nowhere to be but inside the piece. The audience could not shy away from the interaction that was happening all around them, it was present wherever they looked or moved.

> "It is storytelling, the journey, the fantasy, but in a way that is so immersive that you can't escape from it. With interactive stuff it's a lot harder just to be a witness of it. You become part of it because it's all around you, so that's great."
> - Rigging Manager (*Creature: Dot and the Kangaroo)*

> "I did love the idea of going to a four-wall place. I thought that was exciting... It was more of an environment you were in as opposed to a staged thing you approach. You were just in it which was great. So the focus was all about the installation whereas if you just got one wall you could turn back to there. It

> just felt like you were in an environment more." - Creative Director (*Creature: Dot and the Kangaroo)*

The immersive nature of the experience coupled with the emphasis on interaction required a significant shift from the audience to stage relationship common in many modern theatre works, including the more conventional *Creature: Dot and the Kangaroo*. The audience inhabited the exact same virtual world and physical space that the actors and facilitators inhabited themselves. This more inclusive use of space forced the actors to reassess their usual habits of stage-based theatrical performance and removed much of the hierarchy traditionally instilled between audience and performer. It permitted the audience to become participants who forged their journey alongside the performers, rather than merely being voyeurs as the action unfolded. The move to a four-wall projection ironically destroyed the notion of the metaphorical 'fourth-wall' that stands between the audience and the stage in traditional proscenium arch theatre.

> "One wall is fine but I think what it does for me is it actually immediately gives me connotations of this being film that in some way I am interacting with. Whereas the four wall sets it up as being a far more immersive gallery experience. It feels different... I feel like I'm being hemmed in by a proscenium, you know the proscenium arch of the theatre as soon as it's only on one wall. That in itself triggers behaviors from performers about where they stand, what they do, the performativity stuff starts kicking in immediately as soon as we go one wall. And I think that would impact greatly on what we do." - Teaching Artist (*Creature: Interactions)*

Perhaps most importantly of all, the large scale of the immersive projections invited a sense of wonder and desire to explore in the children.

> "...the scale of it was incredibly impressive so that when it first came up and that it was all the way around them. You could just see the kids going 'Wow. I want to play with this. I want to explore it' " - Actor (*Creature: Interactions)*

### 7.2.3 Simultaneous interactions

The large scale and surrounding nature of the digital work provided space for up to 90 children to be comfortably immersed in the environment at any one time. While this shared environment is seen as a major benefit to the work, the number of children engaged with the artwork simultaneously creates certain technical challenges with respect to motion tracking. Marker or skeleton-based systems will often struggle to work with large numbers of people, so the optical flow camera-based system was again the tracking system of choice. This system detects any type of movement, and can work with any number of audience members, as long as the camera can actually see the movement of each individual participant.

In the more exploratory and interactive sections of the workshop, it was necessary to have a clear reaction from the system to promote sustained engagement with the work. If the system did not detect the movement of the participant or did not obviously respond to this movement in a visible manner, the participants could easily become frustrated. In light of this, the system was designed to be forgiving in the face of undetected movement. Unlike some gestural recognition or direct mapping systems which need exact motion capture data to respond correctly, the combination of optical flow tracking and fluid simulation provided reasonable reactions even where the movement was partially obscured from the cameras. The interaction zones started at a distance of about four metres from every wall and covered the entire area up to and including the wall itself. This allowed a large-sized play area for each projection surface, while the centre of the room was setup as a 4m x 8m rest area where participants could relax (see Figure 7.3).

The setup created a large play space at a comfortable distance from the walls and the children naturally moved into the unmarked interaction zones without being prompted. The interactive system itself was never explained to the children, parents or teachers that entered the workshop and the technology was largely hidden high up in the ceiling of the large play space. The absence of technology in the room added a sense of magic to the interactions and allowed the audience to become fully immersed in the surrounding digital bush landscape. Despite the lack of instruction as to the technical system, the camera-based fluid simulation was relatively intuitive and most children enjoyed exploring their relationship with the digital particles.

While the system was able to interact with many participants in the large immersive space simultaneously, the camera tracking was not infallible and some children unfortunately struggled to understand the relationship between their movement and the digital projections.

> "I think that some children struggled to understand that they could affect the animations on the screen with their movement." - Facilitator 1 *(Creature: Interactions)*

On observation of the workshop, it was revealed that helpful parents were somewhat to blame for the diminished interactions that some children experienced. A natural place for the parents to stand in the workshop was directly behind their children so that they could watch the child interacting and give suggestions or encouragement without interfering with the child's view of the projections. Many of the parents were waving arms and interacting with the system themselves, partially to demonstrate how the system worked to the child, and partially because the adults were themselves enjoying the experience of interacting with the artwork (see Figure 7.4). Parents were encouraged to stay out of the interaction zones, but upon reflection, the technical reasons behind this were perhaps not stated clearly enough. Unknown to the well-meaning parents and teachers that stood behind their children

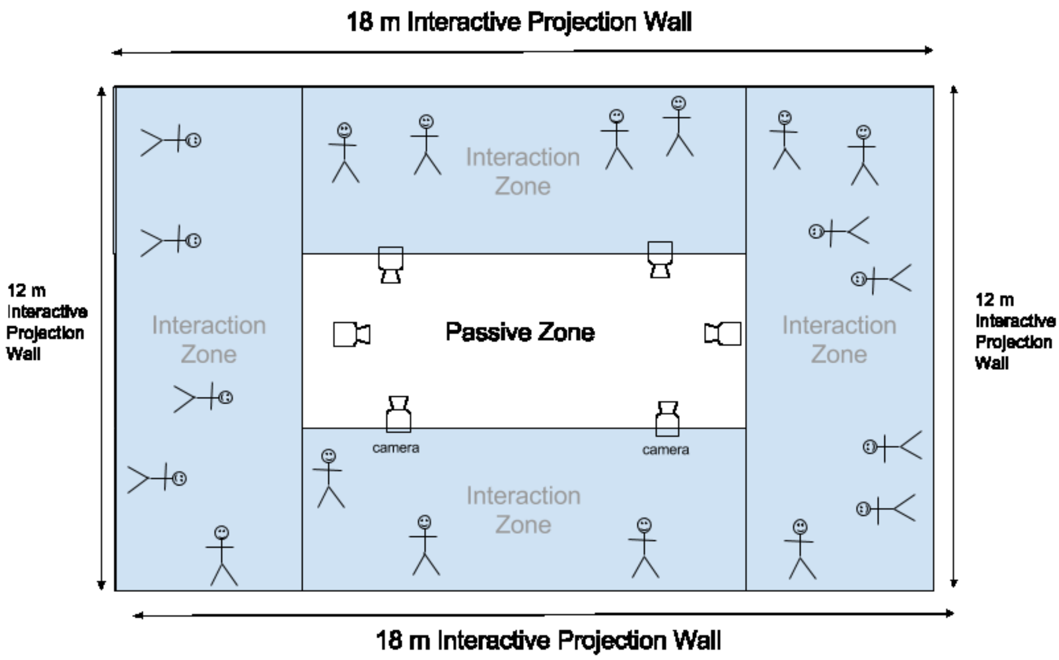



Figure 7.3: A top-down view of the *Creature: Interactions* interaction zones

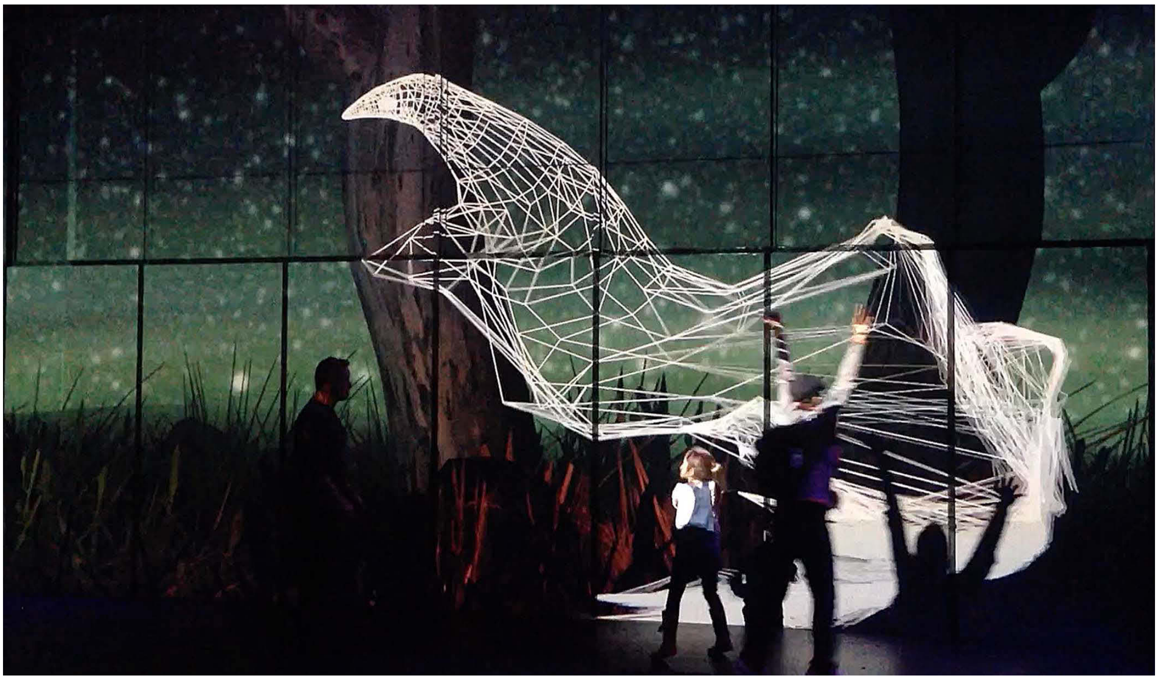


Figure 7.4: Parents also played with the artwork
Photo: Andrew Bluff

in an effort to help, they were actually diminishing the experience by blocking the infrared cameras that were installed in the centre of the ceiling and directed towards the walls.

A clear reaction from the system is vital to understand the effect that movements are having on the artwork. The combination of fluid system, particles and optical flow camera tracking made the artwork both responsive and forgiving for many people simultaneously, although some children were completely obscured from the camera system by the taller adults and struggled to meaningfully interact with the system. While the problem obscuring the camera by standing behind a small child was easily circumvented by standing beside the child, parents were not formally taught this during the workshop. The good intentions of the parents were left to negatively impact the experience of their children. This behavior will need to be addressed in future presentations of the work, either altering the camera setup or by better educating the parents how to help their child explore the space.

### 7.2.4 Summary

The large-scale 360 degree projections onto all four walls was seen as a major feature of the work, making it ‘immersive’, ‘striking’ and ‘exciting’. The surrounding nature of the visuals made the interactions inescapable and removed any preconceived notions of what the artwork was. The interactive system was able to scale up to the immersive environment through the use of pre-rendered video and a real-time compositing engine networked across multiple computers. The optical flow tracking system successfully catered for very large crowds inside the immersive space, although a small number of children were being blocked by well-meaning parents.

## 7.3 Live facilitators

Part way through development, the *Creature* installation was demonstrated on a large single wall to test how it would be received. The mixture of adults and children attending the event enjoyed the interactive 10-15 minute self-guided artwork, with some children playing in the space for extended periods of time despite seeing it out of context from the theatre show. Witnessing the potential of the work, Stalker Theatre and Queensland Performing Arts Centre decided that there was still scope to expand the piece. The artwork was given its own name, *Creature: Interactions*, it was expanded to a full 40 minute event and, although premiering simultaneously, it was ticketed independently from the theatre show.

A Queensland based team including a dedicated director, teaching artist, lead actor and volunteer facilitators were brought onto the project to help expand the interactive artwork into its new 40 minute format. As the interactive designers were now busy developing the content for the *Dot and the Kangaroo* theatre show, they had little time to develop new digital content and the Queensland team had to craft an experience from the work with only minimal changes to the system. These changes included the ability to control scenes from an iPad, the addition of a bushfire scene and a particle effect inspired by the theatre show's 'berries of understanding' scene.

Despite having limited access to the interactive system and not being able to substantially change the digital content, the team created a rough script and dramaturgy that would excite the imagination of the children and teach them to move like native animals found in the Australian bush. The lead actor dressed in a park ranger costume and assumed the role of Bushman Dan to guide the children through the experience. The facilitators didn't have a formal script but helped the smaller children interact on a more personal level throughout the entire piece.

### 7.3.1 Early performances

The immersive and interactive system certainly facilitated a physical interaction from the children, but the energy in the first few performances quickly became chaotic and unfocused with up to 90 children simultaneously engaged in free play. There was no doubt that many of the children were enjoying the experience, but certain children would tend to dominate the space.

The structure of these early workshops had the children entering the space and learning some simple 'animal' dances. Once the immersive visuals were introduced, the children were largely left to explore the interactive space as they saw fit, with the facilitators offering some advice where they deemed it necessary. As the interactive play continued unfettered, the boisterous children would feed off each other's energy until they were running around the room at full speed, bashing into walls and scaring the meeker children.

There was a five foot wooden barricade that sectioned off a small area in the corner of the room containing computer equipment from the rest of the play area. During these first workshops, the more active children would run at full speed and violently slam their bodies up against the barricade. The scholar in residence found that the unbridled and chaotic energy of these early shows overshadowed the entire experience.

> "I just saw this kind of mayhem really, and I thought well no-one's going to get anything out of this" - Scholar in Residence (*QPAC*)

While some of the children were enjoying themselves by interacting with the technology and each other in the giant play space, the experience was advertised on the festival website as a 'hands-on workshop' that offered 'an opportunity to learn about Australia's best loved wildlife'[1]. The mayhem of this play overtook the entire performance and any chance for learning was severely hampered as a result.

> "...early on it had a kind of crazy energy, like kids were just running around and going absolutely nuts... you don't want that the whole way through the workshop otherwise there's not enough kind of pedagogical engagement, there's not enough learning, there's not enough structured play." - Director (*Creature: Interactions)*

### 7.3.2 Facilitated interaction framework

> "...you have to quieten people for them to be able to actually surrender and connect to the immersion." - Scholar in Residence (*QPAC*)

Once the detrimental effect of the chaotic energy was identified, the job at hand was to determine how to actually shape the energy flow within the workshop to find a better balance between play and learning. The sculpting of energy flow is commonly examined when developing live performances, shifting the number of actors on stage, intensity of music and the type of physical movement to create a satisfying energy journey for the audience.

[1]https://www.outoftheboxfestival.com.au/event/ootb_creature_interactions_16.aspx

> "...what energy journey are you taking the audience on?... I always look at shows in that way." - Director (*Creature: Interactions)*

To create this energy journey, the team started to craft the dramaturgy of the workshop, to find the peak moments of the experience and frame them as you would do in a traditional theatre setting.

> "We kind of picked up on [...] key moments inside the workshop, ... the pivotal moments in the drama. We dug into them a bit more, understood them a bit more and used them a bit more. [That] gave the workshop a better dramaturgical structure." - Director (*Creature: Interactions)*

The dramatical arc of the interactive visuals were kept largely unchanged, but the installation was split into seven separate scenes featuring different bush locations and interaction styles. These scenes were the 'bush reveal', 'totems', 'fire and rain', 'climbing the trees', 'night sky' and the upbeat 'party mode'. After an initial welcoming stage for the installation, each scene would be introduced and demonstrated by the bush leader. The children would then interact with the system, and following this was a question and answer session about what they had learned in the recent scene.

These facilitation stages closely resemble Loke and Khut's Facilitated Interaction Framework (Loke and Khut, 2014) in which they detail stages of 'welcoming', 'fitting and induction', 'the ride', and 'debriefing and documentation'. This framework was designed for facilitation of intimate body-focused artworks, but can be adapted to facilitate the shared physical interactions in *Creature: Interactions.* While heavily based on this framework, no 'fitting' or 'documentation' was actually used in this work and 'the ride', which deals with the core aesthetic experience, could more aptly be described as 'interactions' for this artwork. In an attempt to clarify further discussion, these stages will be referred to as **welcoming**, **induction, interaction** and **debriefing** to more clearly reflect their usage within *Creature: Interactions*.

These four stages of facilitation can best be demonstrated by describing the opening moments of the installation.

### Welcoming

The welcoming for *Creature: Interactions* actually began outside of the immersive environment where the lead guide, Bushman Dan, and his team of facilitators would collect the children from a designated point in the venue's foyer. They would introduce themselves and prepare the children for 'an exciting adventure in the bush' before bringing them excitedly into a large empty room. This fake introduction to the work was developed as a joke and started the installation with a fun atmosphere, whilst keeping the children in a mode of anticipation. Unlike a shared gallery setting, the work was ticketed in advance and was performed in a closed 360 space, so there was no need to attract visitors to the work beyond the initial marketing campaign which was setup by the venue.

After the initial welcoming session, the lead facilitator began the induction, interaction and debriefing sessions for the *'bush reveal'* scene as follows:-

### Induction

Upon entering the space, the children were gathered and Bushman Dan took the children through a series of simple dances and animal movements. As the children mimicked his actions they were learning very simple facts about Australian animals such as willy wagtails and brolgas, but more importantly they were learning movement styles which could be used with the system.

The children were then seated on the floor in the interaction dead-zone in the middle of the room. They were told about the "magic of theatre" and the "power of imagination". They were instructed to close their eyes and imagine the sounds of the Australian bush, at which stage the soundtrack based on recordings of birds and insects was slowly introduced.

As the sounds emerged, the lights were dimmed and the children were allowed to open their eyes once more. In the darkened space, Bushman Dan would talk about the “power of movement” before once again demonstrating the animal actions learned earlier. This time, however, the interactive system was turned on and particles were emitted by his gestures, inducting the children to the interaction aesthetic of the system and promoting the use of full-bodied, animal-based movement.

#### Interaction

After viewing the lead guide’s demonstration, the children were instructed to spread out around the room and play with the system, using their newly acquired animal actions. As the audience moved through the space, digital particles were created which then floated around the walls of the installation in response to their movements. The particles slowly grew in size and eventually revealed the 360 degree animated bush landscape. The movement of the children “magically” created the bush landscape through a session of unstructured physical play.

#### Debriefing

Once the bush was fully revealed, Bushman Dan would call a loud ‘cooee’ which is a traditional Australian bush call that can be heard across large distances. The cooee signaled the end of the ‘interaction’ phase, and instructed the children to gather and seat themselves in the center of the room once more. The leader would then ask the children a series of questions about their experience like “What happened when you were moving around the space?” or “What animals did you find in the Australian bush?”. The children would raise their hands and would excitedly relay their recent experiences with the technology.

The remaining scenes followed roughly the same induction, interaction and debriefing structure, where Bushman Dan would talk for a minute or two about the scene and then demonstrate it working in response to full-bodied movement. Following this the children were instructed to participate with the system in free-play for three or four minutes, after which a cooee was called and the children were gathered for another minute or two of questions and answers.

The induction, interaction and debriefing approach allowed the children to reflect upon what they had achieved or discovered within each scene of the immersive workshop. The shared debriefing would cement any learning that had occurred and also allowed the children to hear the interactions and interpretations that the other children were using to explore the digital environment. The induction into the next scene provided the children with a framework with which to explore the next style of interaction. The movements introduced by the bush leader would immediately stretch the interaction aesthetic beyond the overly simplistic “hand-waving”.

The act of bringing the children to a seated position in the centre of the room for these sessions had a significant impact on the energy of the piece. This simple act instilled the quietness that the workshop so desperately needed. The interactive freeplay of the workshop was broken into three or four minute segments separated by the moments of seated reflection. The shortness of this free play prevented the energy from escalating beyond control. The barricade, which had been consistently rammed during the initial workshops, was left relatively untouched by the children in the final performances of the work. The framing of key moments through introduction and reflection had successfully tamed the wild energy of the early sessions.

#### Criticisms

The model of facilitation successfully tailored the energy of the room, but setup strongly resembled a classroom setting. The children were assembled into seated position in the

Figure 7.5: Raising hands like a classroom setting
Video Still: Jaina Kalifa

middle of the room and the bush leader stood in front of the group explaining the technology. Questions were asked of the group with the children raising hands one by one to answer them. In a quest to grab the attention of the entire group, the bush leader's teaching background would often leak through the performance (see Figure 7.5).

> "The workshops I loved most, the kids set the tone... the worst ones Dan went teacher on them and would be coming down on them and trying to get them to 'shoosh' and move like this and do like this.... This is not a classroom and we do not want to make it feel like a classroom." - Teaching Artist (*Creature: Interactions)*

While the structure successfully tamed the energy of the workshop, the balance between induction, interaction and debriefing was questioned by some of the facilitators. The participants spent as much time learning how to use the system and talking about how they used the system as they did actually experiencing the artwork. It is possible that slightly less induction between each scene would have made the work less prescriptive and allowed the children a greater agency to explore on their own terms.

> "I would be interested in giving the agency of discovering and exploring the boundaries of the technology over to the children more. Less modelling by the adults. Perhaps this could lead to us discovering new capabilities about the technology." - Facilitator 2 (*Creature: Interactions)*

The facilitation approach may have erred slightly on the side of discipline and prescription over free play, but framing the key moments with reflection and introduction nonetheless tailored the energy levels within the workshop, transforming it from a chaotic adventure into a more successful experience.

> "The first day I saw it, no, it was chaos,... when I saw it at the end it was much more than a seed, it was a beautiful piece of work." - Scholar in Residence (*QPAC*)

### 7.3.3 Summary

The live facilitators were added after witnessing the potential of the interactive artwork and had to create an experience from the available digital content. The interactive and immersive system successfully promoted physical interactivity in the children but the first few shows suffered from an overabundance of unfocused energy. The facilitators tamed this energy by framing the participatory moments of the piece with dedicated induction and debriefing sessions. While this approach may have been slightly heavy-handed and prescriptive, it successfully transformed the artwork into a meaningful and enjoyable experience for all of the children.

## 7.4 Facilitating a richer interaction

> "I think it's definitely an artwork in itself and visually, it's viscerally astounding. So I would place it in the world of art, but I would call it an art experience. I don't feel that it's an artwork that exists without people." - Teaching Artist (*Creature: Interactions)*

The large-scale immersive visuals were certainly appreciated by the audience of the workshop, but as with any interactive or participatory artforms, the audience need to actually participate to gain the most from the experience. *Creature: Interactions* is an interactive work that is based around free-form full-bodied movement, and requires a certain commitment from the participants to be fully appreciated. Using the Facilitated Interaction Framework stages of 'induction', 'interaction' and 'debriefing', the live facilitators promoted a richer style of movement from the human participants and tamed the chaotic energy of the earlier sessions in a safe and fun environment.

We shall now examine in detail some of the methods the facilitators used to encourage the children towards a richer movement dynamic, promote social interactions and improve the immersive nature of the work.

### 7.4.1 Task-based actions

In a bid to tame the unbridled energy flow of the early workshops, the live performance team started to give the children tasks during certain portions of the experience. Not only did these tasks successfully sculpt the energy flow throughout the experience, but they also encouraged the children to explore a richer palette of movements when interacting with the digital environment.

The installation showcases different locations within the animated bush setting and the immersive video smoothly pans between each of these locations. In a subtle tie-in with

Figure 7.6: Climbing through the trees as the moon rises
Photo: Darren Thomas

the theatre show where Dot climbs a tree in the opening scene, Bushman Dan suggests that the audience could perhaps "climb to the top of the trees to get a better vantage point of the entire landscape" (see Figure 7.6). The lead actor then invites the children of the audience to stand up and copy him as he mimes a tree climbing action with his arms and legs. As the children start to mimic the bush leader, the transition is actioned and the camera pans vertically, slowly emerging from the grassy bush floor to the tops of the trees. The children's willingness to believe is engaged by the task and they can imagine that the surrounding visuals are moving in response to their own tree climbing actions.

> "[During the season] we highlighted them a bit more for the kids, so 'Let's climb to the top of the tree so we can see the stars'. And then we all started climbing and then it went. So I guess that's a direct result of the beauty of the moment [that] was created through the visuals. It was like, how can we now dig into that moment and make it more immersive. More interesting, more specific." - Director (*Creature: Interactions)*

The 'bushfire and rain' sequence was another instance where task-based directions made the children feel engaged with the immersive visuals. The fire was created using prerecorded video layered on top of the animated bush landscape and would grow in stages gradually consuming the entire bush in flames. An interactive smoke was added to the flames which became progressively thicker and turned from black to an ominous dark red as the fire enveloped the entire space. Once the fire had consumed the space, a full screen video of rain would replace the fire and the bush environment would gradually come back to life. The fire and rain visuals were accompanied by multi-layered and multi-channel recordings of fire and rain to create a more immersive atmosphere.

Within the interactive workshop, the children were split into smaller groups and tasked with finding ways to extinguish the fire. Despite the scene containing only a small amount of digital interactivity and the dubious educational value of allowing children to put out

Figure 7.7: Extinguishing the virtual bushfire
Video Still: Jaina Kalifa

a bush fire, the scene became a key moment of teamwork (see Figure 7.7). The children were given a deliberate task to achieve which opened up a chance for learning, promoted collaboration and shaped the energy of the room. Once the rains came, the children were invited to lie on the ground or stand against the walls, imagining that the rainstorm was real. Although containing very minimal digital interactions, both of these scenes were identified as highlights – the task-based instruction had combined with the immersive graphics to ignite the children's imaginations.

The facilitators were asked to describe the "most interesting child interactions observed during the workshop".

> "Watching a group of children work as a team to put out a fire. Hearing them come up with their own creative solutions like 'let's use a helicopter to drop water on it'... I also loved watching the children enjoy being in the world

> created within the bush such as when the rain came." - Facilitator 1 (*Creature: Interactions)*

Another facilitator responded with similar sentiments.

> "The children's acceptance of the complicite of the bush fire and their collaborative and creative ideas/efforts to put it out. Similarly, their reactions and observations about the rain were fascinating and such poignant examples of their story-creation instincts and abilities" - Facilitator 3 (*Creature: Interactions)*

The combination of having smaller groups, dramaturgy, immersive visuals and a distinct task provided some of the best social interactions and creative thinking within the workshop.

### 7.4.2 Animals

> "The instruction was [to] use the animal movements that they explored from the two dances, the frog, crocodile, [and the] mosquito clap. They had the framework for the bush to come to life so that it wasn't just an open-ended willy-nilly let's just run about or wave our arms to make the particles move." - Dan the Bushman (*Creature: Interactions)*

Nature can be an endless supply of inspiration for innovation and in a workshop themed around the Australian bush, mimicking native animals proved to be a fruitful way of expanding the participant's palette of movement beyond simple hand waving. Each workshop started with Dan the Bushman standing in a large empty space without any digital projections and provoking the children to imagine their own bush landscape. During this mental exercise, bush animals were verbally introduced by the leader who would start performing physical actions relating to these animals. Jumping like a frog, flapping like a bronze-winged pigeon, waving posteriors like a willy-wagtail, dancing like a brolga or clapping hands to squish imaginary mosquitos, the actions either mimicked the animals or invoked the spirit of the animals. The children were encouraged to perform these movements alongside the instructor and to continue the mimicry when interacting with the digital artwork (see Figure 7.8).

While many of the small children struggled to remember the choreography of the simple dance demonstrated by Dan the Bushman*,* all were able to copy his animal movements and many developed their own actions based on the interactive creature totems that emerged from the digital landscape. These crouching, jumping, slithering and flapping motions were indeed more diverse and full-bodied than those observed in trials with the self-guided installation. Children inevitably explored the same waving, jumping and twisting movements prevalent in the self-guided installation, but the invocation of Australian bush animals gave them an expanded repertoire with which to interact. While the technological system was not deliberately detecting any animal gestures, the movement qualities of full bodied animal mimicry was sufficiently different to that of simple hand waving. The system would have noticeably different reactions to the hopping, slithering and flapping motions made by the children.

> "... that was important in that they could operate then on a variety of levels. One level would be 'let's just move and see what happens' whereas if they were 'let's move like an animal we've explored and then see what happens', there's just another level of complexity there" - Dan the Bushman (*Creature: Interactions)*

The animal movements were inspired by and themed to the bush locations and story of *Dot and the Kangaroo.* Enticing the children to interact as if they were animals may have facilitated the sense of immersion within the surrounding digital bush landscape. Animals

Figure 7.8: Moving like animals
Photo: Darren Thomas

belong in the natural world and placing animal movements within the surrounding bush landscape fit the pedagogy, dramaturgy and aesthetics of the work. Invoking the spirit of an animal within a digital bush environment provides a logical bridge with which to accept the co-location of the real and virtual worlds and facilitates the suspension of disbelief. While the immersive effect of the animal mimicry was never fully investigated, the Director of the experience thought that the animal mimicry "activated the kids to copy" and allowed them to "stay in that drama world in order to manipulate the walls" while Dan the Bushman felt that the animal movements helped the children by "immersing themselves in the environment that they had created."

### 7.4.3 Group dynamics

> "So yes, that's one movement you can do but what happens if you jump really high, what happens if eight of you get together and you jump really high. It does different things and you get a different aesthetic experience when you do it." - Director (*Creature: Interactions)*

We have seen that the interactive aesthetic changes with a dense or sparse number of participants, and that aesthetic is altered once again when engaged by a collective group of participants. Just as the individual agents of the complex particle system can portray emergent behaviour when viewed collectively, the movement of multiple human participants can combine to interact with the system as one emergent entity. When working towards a common goal, a group of participants had a larger amount of movement energy, or inertia, to inject into the system. This increased inertia, in turn, had a greater impact on the visuals controlled by the virtual fluid simulation (see Figure 7.9).

When the children were interacting with the totem creatures towards the beginning of the workshop, the facilitators would suggest a certain interaction (such as a frog jump) to

Figure 7.9: Working together to reveal a King Parrot
Photo: Darren Thomas

any children in their immediate vicinity. This would create a small ad-hoc group of children that worked together with the facilitator on a certain interaction. A group of children jumping upwards at the same time to mimic the movements of a frog managed to move the totem creatures more than any child could do on their own.

Seeing the groups of children interacting with the totem animals was noted as a highlight by the Teaching Artist and the facilitators alike.

> "I loved the moments where they were helping each other to achieve something... the moments where they were working with the animals and were jumping at once to make something happen... that collective power was so beautiful to watch." - Teaching Artist (*Creature: Interactions)*

The ability to interact collectively in the same physical space has social benefits beyond merely altering the interaction aesthetic. The groups were made completely on the fly and there was no prior knowledge as to whether children knew each other or not. Children were teaming up with other children that they did not know prior to the workshop and working towards a common goal. They were learning how to socially interact with one another in a largely physical playspace mediated by the reactions of the immersive system.

The social aspect of embodied child's play was described as a highlight by one of the facilitators.

> "The most interesting interaction were actually amongst kids that didn't know each other working together to move and create shapes with the animals. This showed a form of unity and ensemble which is lovely to see the kids start to grapple with." - Facilitator 2 (*Creature: Interactions)*

In addition to learning how to socialize with one another in an embodied play and working towards a common goal, the children would actually teach each other how to use the system. They would try certain actions and if they found something particularly interesting they would inform their friends. The children were not only forming groups to interact in unison, but were also attempting their interactions in turn, alternating between demonstration and observation. If one child successfully moved the particles with a jumping motion, the next might try to embellish on the jump with a cartwheel or a jumping kick. This process of building upon ideas as a collective group is an important method to generate and refine social knowledge. The process facilitates a richer interaction aesthetic for the individuals and demonstrates the power of collective knowledge.

> "...they were teaching each other too, they were saying things like 'Check out what I just did. This happened. Do you want to try it with me.' That's something really powerful and I think that conglomeration of knowledge is very interesting... the collective is a better experience, a richer experience." - Teaching Artist (*Creature: Interactions)*

The collective experience is an important way in which to change the interaction aesthetic, either acting in unison to create a larger force of inertia or building upon each individual's ideas to push the envelope of individual movement expression. The large number of participants that are able to use the system simultaneously facilitates a more social interaction than offered by virtual reality headsets and personal device interactivity. The groups facilitated different interactions than the individual, both with the system and between each child participant. The social dynamic of working in unison added an extra dimension to the interaction aesthetic of the artwork.

### 7.4.4 Summary

The lead actor and facilitators were able to expand the palette of movements explored by the participants through certain task-based activities and the mimicry of animals. They promoted group work and facilitated social interactions between all of the children within the experience. The tasks and animal movements were themed with the Australian bush and helped to create a tighter link between the human participants and the immersive digital landscape.

## 7.5 Conclusion

The *Creature: Interactions* interactive artwork was developed to be a small self-guided adjunct to the theatre show. After witnessing the potential of the work to engage young audiences, the piece was significantly expanded to become an independently ticketed 40 minute experience. The work was presented in a large-scale 360 degree environment which was described by the entire crew as **immersive**, **striking, amazing, impressive** and **overwhelming**. The format placed the audience **inside** the virtual landscape where there was **no escaping** from the interactive work. This format removed any existing **preconceptions** about the work and its sheer scale **promoted interactivity.** The combination of pre-rendered video with rigid body and fluid-based particle systems was able to scale up to the task, and the networked camera tracking system successfully handled **large numbers** of participants **simultaneously**.

The biggest expansion to the piece was the addition of facilitators and a lead actor, who managed to **focus** the wayward energy of the first few shows through a repeated structure of **induction, interaction** and **debriefing** resembling the Facilitated Interaction Framework**.** The facilitators also promoted **group work** and **social interactions** amongst the children. The introduction of animal movements and set tasks increased the **richness of movement** while the question and answer sessions confirmed the **educational** aspect of the experience.

The previous chapter explored the addition of interaction to the theatre show *Creature: Dot and the Kangaroo* and this chapter has explored the addition of immersive and live performance to *Creature: Interactions*. The next chapter shall look at these works combined to examine how the interactive and immersive system is viewed by the participating performance artists and will identify some strategies with which to develop new performance works.

# Chapter 8

# Performance Implications

## 8.1 Introduction

The previous two chapters have examined the use of interactive projections in the live theatre production *Creature: Dot and the Kangaroo* and the use of immersive visuals and live facilitation in the interactive artwork *Creature: Interactions*. In this chapter the discussion is broadened to the entire body of work to examine how the artists actually perceive the interactive technology and how this technology can impact their own particular performance role. Strategies for developing new interactive and immersive performance works are then discussed, based on the observations and feedback of both *Creature* works.

## 8.2 Artist's perception

Live theatre is a well established art form, and although some fluidity exists between different productions, the roles of both cast and crew are generally well understood. These include roles such as actors, singers, dancers, choreographers, playwrights, set designers, costume designers, lighting designers, music composers, production managers and directors. When determining how best to integrate a new component into such a well established tradition, it is worthwhile to determine what role the new component will undertake and how it will be approached by the various artists involved in creating a performance work.

### 8.2.1 Role of the virtual

The artists and performers from the theatre show *Creature: Dot and the Kangaroo* were never directly asked what role they thought the interactive projections assumed. Nonetheless, it became apparent throughout the interviews that they were discussing the system as though it filled a number of different theatrical roles. The particular role was not consistent within any one interview, as each artist altered their descriptions of the digital projections throughout the duration of the interview to fit the context of the current discussion. Some artists even described the visuals through multiple roles in one single response.

The artistic directors and performers described the system as a character on numerous occasions throughout the interviews. This was no doubt influenced by the presence that was found to manifest the projections described in Section 6.2.

> "... it's almost like another character I guess on stage. So you can't not interact." - Narrator (*Creature: Dot and the Kangaroo)*

The reactive projections were displayed on a giant screen behind all of the actors on stage. The landscape projections described in Section 6.3 were found to describe the location of the action, and were seen by many of the crew as a virtual or digital set.

> "I mean this in the nicest possible way: it was like a digital set." - Sound Designer (*Creature: Dot and the Kangaroo)*

When selecting fabrics for a costume, the designer has to deal with the way that the theatrical lighting reflects from these materials. As the projection of light onto the costumes was an important concern for her work, she saw the digital projections as a form of lighting.

> "... unquestionably light was the set in that work. In all its different, or the three major categories of it...[landscape] animations, and the interactive work and then the lighting. And it's a classic thing that lighting designers sculpt with light, so in the work we have three light sculptures happening which all have very different geometries" - Costume Designer (*Creature: Dot and the Kangaroo)*

The artistic director relates to the technology through the concept of a mask which has been traditionally used in theatre practice to anonymize and/or influence the movement and presence of an actor. He firstly describes the masking effect as a way to explain the aliveness and presence of the set.

> "We're probably not fully understanding what's really happening, cognitively... Again, I come back to the thing of masking. Of the idea of, we are creating a living, a kind of living, breathing set, and that is the difference." - Artistic Director (*Creature: Dot and the Kangaroo)*

The framing of a mask also allows him to see the technology as being some kind of actor/set hybrid, as it has its own presence that is both influencing and being influenced by the actors at the same time.

> "...Actors work a lot with presence. And it comes down to this question again of mask...masking. It's almost like if you put on a mask, there is a different type of presence that you use as an actor. As a director what I perceive when we have the interactive technology, alive, is again there is a type of presence being manifested on stage and that presence is almost like another actor but not quite. It's caused by the other actors... is it a mask? Is it like, in a mask sense you are possessed by the mask. But it's a diffuse mask that is affecting all of the space." - Artistic Director (*Creature: Dot and the Kangaroo)*

The cast and crew of *Creature: Dot and the Kangaroo* have described the technology as manifesting a number of different roles including a character, digital set, lighting system and theatrical mask. These roles are all found in traditional theatre productions and viewing the technology through these established roles may help the artists understand how to utilize or interact with these virtual projections.

### 8.2.2 Effect of performance genre

In 2012, Johnston found that the cast and crew of Stalker's *Encoded* also viewed the interactive system in a number of different ways including a 'contact improvisation dance partner', a 'movement amplifier' and an 'interactive theatrical mask' (Johnston, 2015). While the system is seen in a number of roles in both productions, the nature of these roles has shifted in the newer theatre piece. The visuals used in the 2012 physical dance piece are described as a way to change the movement of the dancers either through contact improvisation, movement amplification or masking. The *Dot and the Kangaroo* projections are described through traditional theatrical storytelling elements of a character, lighting or digital set. Even when viewing the technology as a mask in both productions, the Director mentions the 'movement of the body' when describing this effect in *Encoded* and 'actors', 'presence' and 'sets' when describing it for the theatre piece.

The artists' conceptions of the technology shifted from being movement or dance-based to being one of storytelling. Whether this shift of focus has resulted from the way the technology has been used, or if the perceptions have themselves been 'masked' by the nature of the production they were used in, is still unclear.

## 8.3 Influence of the virtual

The artists involved in the *Dot and the Kangaroo* theatre show perceived the interactive system through certain theatrical roles. The research around the dance production *Encoded* revealed a similar effect, although the types of roles changed with the style of performance it was used in. The performance genre has influenced the way the technology is received. By expanding the observations to cover the entire body of work, we can examine the effect that the interactive system has on the traditional roles of artists and performers across a wide range of genres.

### 8.3.1 Costume

> "In terms of creating costumes for that kind of work, working with the two layers, with the interactive technology and the video projection, and lighting it adds a series of conversations and complexities" - Costume Designer (*Creature: Dot and the Kangaroo)*

The Stalker Theatre show *Encoded*, featured a type of 'virtual costume' (see Figure 8.1) where the performers wore harnesses that projected video onto their faces, arms and torso to create a dynamically changeable costume with a futuristic aesthetic. While this technology was visually stunning and a good example of immersive technology taking the role of costume, the harnesses severely restricted the physical abilities of the performers. The virtual costumes were so restrictive that they were only used on the introduction and ending scenes, allowing the performers to move freely for the rest of the show. In *Dot and the Kangaroo*, the 'virtual costumes' were not used and the projections did not explicitly take on the role of costume, but they still impacted the costume design nonetheless.

The visual aesthetic of the costumes needed to balance with and complement the video projections.

Figure 8.1: *Encoded:* The Virtual Costume
Photo: Matthew Syres

> “....finding a way that could work without, um seeking to upstage any other element, but be part of the synthesis of work... would it all be lost in the beauty of all that digital stuff and what was important to put in so it doesn’t want to be half-baked, it doesn’t want to be desperate.” - Costume Designer (*Creature: Dot and the Kangaroo)*

In addition to the aesthetic design decisions, once entering the performance space there was a practical need to dye the costumes a slightly duller colour in response to the theatrical lighting and brighter projection environment.

> “The classic example of what changed there is that creamy white wool of their swimsuits, that the performers on slings wore, had to be coffee dipped because they were bouncing lights around. It was maddening for the lighting designer, but they also weren’t strong enough inside that field of the digital projections. The interactive projections. Not so important with the video animation because that was generally so bright.” - Costume Designer (*Creature: Dot and the Kangaroo)*

The costumes can also be greatly restricted by the needs of the underlying motion capture system. Systems which track small ping-pong ball like markers attached to the body can produce accurate results but pose great restrictions on how a costume designer can clothe a performer. The optical flow system used in *Creature* is marker-less, and therefore does not have this restriction, but instead relies on infra-red light and camera-based tracking algorithms. During rehearsal there was an issue where one performer was wearing an outfit that wasn’t showing up in the infrared camera and therefore wasn’t being tracked by motion tracking system. The way her clothes reflected or absorbed infra-red light during rehearsals was considerably different to all of the other performers. After this discovery the costumes were all tested under infra-red light. The seemingly identical denim jeans worn by the crew conducting the test all behaved radically differently, but luckily the actual costumes all responded consistently well to the infra-red motion tracking system. Despite being lucky this time, the reflective response of fabrics to infrared light will have to be considered for productions using the infrared motion tracking in the future.

### 8.3.2 Lighting

Projectors can be considered large screen displays, but they are in essence just a high-definition light source that can impact on a more traditional theatrical lighting design. They have been used as a replacement or adjunct to traditional theatre lighting in many live performances. In the outdoor theatre show *Frameshift* (see Figure A.7), projection mapping techniques were used to light up bespoke scaffolding structures with a mixture of abstract and representational graphics. When certain angles were difficult to reach with conventional lights, the digital projectors were also used to light up the performers with a dappling of light. In the absence of any theatrical lighting, the choreography at the beginning of *Airstorm* was specifically designed to dynamically reveal and hide the performer's body with the interactive projections, a job traditionally undertaken by a lighting designer (see Figure 4.3).

The projections were never deliberately used as a source of lighting in *Creature: Dot and the Kangaroo*, but the projections had a serious impact on the lighting design nonetheless. The lighting designer was very keen to hide the big white screen at the back of the stage and fought to have a black scrim placed in front of the screen. This was tested within the performance space and found to improve the dynamics and drama that the lighting designer was able to achieve. Unfortunately the scrim severely impacted the quality of the projected visuals and was subsequently discarded by the artistic director, much to the lament of the lighting designer.

The light cast by the projector also had an impact on the lighting. The lighting plot had to be performed in conjunction with the interactive projections to make sure that final lighting settings took into account the dynamic state of the projections on a scene by scene basis. In addition to considering the light cast by the projectors, the lighting designer needed to provide a stable source of infrared lighting for the infrared tracking system. The infrared lighting system used traditional theatre lights with a dark blue[1] gel to block the visible light, leaving only the invisible infrared light. While easy to source and quite convenient, these lights still create a small amount of visible blue light which needs to be balanced by the lighting designer.

The projections can be used *as* lighting in a theatre show, but a more traditional lighting design was used to improve the visibility of performers in *Creature: Dot and the Kangaroo*. Despite the addition of traditional lighting, the costume designer still identified the projections as a light source to understand its effect on the colour, sheen and visibility of her costumes. The lighting designer needed to consider the impact of lighting on both the visuals of the projection and the workings of the motion capture system.

### 8.3.3 Actors

The interactive projections were found to manifest a presence on the stage in both *Creature: Dot and the Kangaroo* and *Encoded*, as discussed in Section 6.2. This presence is yet another entity to be considered when crafting a show and the performers will need to provide this presence with its own sense of space and timing.

During the *Dot and the Kangaroo* development period, one performer noted that she had to act *with* the projections as she would with any other actor on stage, allowing them sufficient time to 'breathe'.

[1] lee 181 - congo blue

> "I can see that the projection, yeah we talk to you , [the digital artists], but your baby was the projection and that's who we were acting with. So then when the moon hits its peak I say my line... it allowed me to see the breath in the piece once I was shown these things." - Performer (*Creature: Dot and the Kangaroo)*

Once the digital projections were acknowledged as a character in their own right, the actors could use the visuals to help improve their own performances. The interactivity of the digital pigeons was appreciated by the narrator as both an acting prop and a source of childhood nostalgia.

> "I didn't have to pretend that there was pigeons there; they were there and watching them kind of go up. And I just, you know that thing of pretending that I'm a child on the beach shooing seagulls away and breaking out of the narration role and becoming [myself] in that moment." - Narrator (*Creature: Dot and the Kangaroo)*

The interactive projections are built to react to the performer's movements but the actors themselves need to be aware of the virtual presence on the stage. Once they are aware of its presence, they can provide the visuals with a physical and temporal space as they would for any other human actor.

### 8.3.4 Set design

> "We talked about maybe having a structure, but it was really clear the moment we were in the space, with even the barest modicum of the projections that it would become very crowded, visually very crowded with the objects in the space." - Costume Designer (*Creature: Dot and the Kangaroo)*

The presence of an animated digital backdrop in *Creature: Dot and the Kangaroo* not only replaced any painted backdrops that might have been used, but impacted the use of physical props in the set design as well. The costume designer for *Creature* was also tasked with the role of set designer, but decided the presence of digital projections replaced the need for traditional set elements.

The replacement of physical sets with digital projections is a common theme across all of the works presented in this dissertation. Physical sets have not been explicitly added to any of these theatre, dance or musical performances. Many of the musical performances, including *Sticks with Viz, Airflow* and *Blue Space* were performed behind a projection scrim which hid many of the amplifiers, microphones and instruments that you would traditionally find on a musical stage. Performances of *The Hour* saw the large drumkit covered in a white sheet to minimize its physical impact on the stage and provide an extra projection surface.

The large-scale immersive visuals have largely replaced the physical sets in these works, providing a more malleable and interactive style of set design.

### 8.3.5 Sound design

> "... the specifics of the visuals are part of the information that I really concentrate on. Especially when you get to sound design. Sound design is just an aural set for me, in that sense, so it has to." - Music Composer (*Creature: Dot and the Kangaroo)*

As the composer and sound designer of *Creature: Dot and the Kangaroo* has described, the sound design for a performance ties very closely with the visuals. In the case of *Creature: Dot and the Kangaroo* and *Creature: Interactions,* this means creating a suitable soundscape that matches the action in the scene and, like the projected landscape backdrops, provides a locational context for the storytelling. Within *Dot and the Kangaroo*, this required sound recordings of Bronze-winged pigeons for the pigeon scene, the sounds of Dingos to provide tension in the dingo fight scene and general dusk and dawn bush recordings scattered about the rest of the show. *Creature: Interactions* heavily used sound recordings of birds and crickets to immerse the audience within the location of the Australian bush, and multiple sound recordings were layered upon each other to give the bushfire and rain sequences the dramatic gravitas to depict such large environmental changes. In both of these situations, particular attention was paid to creating a multi-channel soundscape which surrounded the audience to create an immersive aural environment.

> "... we had the soundscape, the bush sounds, they were also in the front speakers but they were also exclusively in the surround. Various elements we put into the surrounds [...] just to create that sense of the audience being inside in the middle of the bush. I thought it was important to, whenever we can, I will always do as much of a surround sound system for that wherever we perform."
> - Music Composer (*Creature: Dot and the Kangaroo)*

The *Creature: Interactions* installation featured a quadraphonic electroacoustic soundtrack which was largely composed of environmental sounds. The main theme was constructed from field recordings of birds and insects taken in the Australian bush. These recordings were then layered to create a varied atmosphere and embellished with subtle electronic drones, synths and bells. The fire and rain visuals were matched with intense sound recordings to match the visuals and the night scenes were depicted with cricket sounds and a subtle sci-fi reverberant synth to give it a slightly outer-space feeling to match the stars and moon. The soundtrack was designed to make the participant feel immersed in the location of the installation, supporting the themes of Australian bush whilst not becoming obviously repetitive.

> "I thought the sound supported it well, you know when we had fire, we had fire sound. When we had environment we had the sound of those environments. It just kind of made sense in terms of the visuals." - Director (*Creature: Interactions)*

In both *Creature* productions, the interactive visuals strongly influenced the sound design and a spatialized sound system was used to make it more immersive.

### 8.3.6 Music

> “Particularly when we are in the white pixel clouds, there’s almost a weighted sensuality about how the visuals move. [...] It’s part of the visual information [that] leads me to put down particular choices compositionally” - Music Composer (*Creature: Dot and the Kangaroo)*

In the performance *Blue Space* the immersive system responded to the physical and sonic actions of the musician and her oboe, pushing particles around a virtual fluid simulation. In addition to the particles that were visually projected onto a large translucent scrim hanging in front of the performer, the sounds of the performer were also being recorded into these particles. As she stirred the particles they would play back their recordings with various effects depending on how fast they were moving around the space. This tight linkage between sound, image and physical movement gave the system a strong musical presence during the piece, constantly shifting roles between that of a musical instrument, musical effect and improvisational live musician.

During the development of *Creature: Dot and the Kangaroo*, there was an idea to use this technique for the *‘berries of understanding’* scene. A set of presets were generated in the system which would allow it to react to the sounds of the live singer/narrator by generating particles and forces in the fluid simulation. These particles would react to the physical movement of the performers and finally reveal the Australian bush backdrop. The time constraints of the development period prohibited sufficient exploration of this idea and it was ultimately dropped from the show. Despite its omission, the show’s musical composer enthusiastically embraced the idea of fusing the music, visual and physical performances with the interactive system.

> "Yeah, that really excites me. More from the point of view from that there was a live musician doing it of course. Different interpretations each night. [...] For me interactivity inspires improvisation." - Music Composer (*Creature: Dot and the Kangaroo)*

Even with the lack of live interaction between the music, performers and visuals, the graphics still inspired the composition of music to a certain degree.

> "It had to be magical. It had to be magical for small kids like that, storytelling. Lots of sparkle and gold dust throughout it and I thought that the visuals did that. So in a very practical sense, I'm just trying to work with the dynamic of the reveals of what you guys did. Some really lovely moments." - Music Composer (*Creature: Dot and the Kangaroo)*

Portions of the music were generated by the interactive system in the musical performance *Blue Space* and the visuals were found to inspire certain musical elements in *Dot and the Kangaroo*. In *Creature: Interactions,* the rhythmic music played a different role. Instead of inspiring the artists or musicians, the music managed to change the physical movements of participants.

The immersive work featured a soothing soundscape which was largely composed of bird sounds recorded in the Australian bush. The one exception to this soundtrack was a boisterous Mexican-inspired instrumental piece which added a sense of fun and energy to the final scene. In a desire to end the workshop with a climax of fun and energy, the last scene was dubbed a 'party-mode' where coloured interactive particles would shoot from the digital sky and the up-beat music added to the frivolity and energy of the scene (see Figure 8.2). The latin theme of the music paired with the coloured particles to create an atmosphere resembling a piñata-packed birthday party. The shift from natural bush to latin party aesthetic signaled that any real learning had concluded and it was just time to have a bit of fun with the technology. Perhaps more important than the styling of the music was

Figure 8.2: Colourful particles indicate ‘party-mode’
Photo: Darren Thomas

its distinct beat which promoted a rhythm of movement that was absent from the rest of the workshop.

> "Party-mode:- I think that was essential... to prompt the kinesthetic nature of movement with a beat and a bit of sound." - Dan the Bushman *(Creature: Interactions*)

The only difference between the penultimate scene of 'star and moon' exploration and the 'party' scene was the introduction of some colour to the particles and the rhythmic music. The particles reacted to movement in exactly the same manner to the stars of the previous scene, and yet the actions of the children was significantly different between the two scenes. In the 'stars and moons' scene the children initially faced the nearest wall and explored the particle interaction from a standing position. The music of the 'party scene' promoted a more energetic and vigorous physicality in the children who would run around the room, dancing and performing animal movements. They were still watching their effect on the surrounding digital particles, but increasing focus was given to their own actions as they energetically traversed the space, matching the pace and intensity of the music. The light hearted rhythmical music had successfully raised the energy of the workshop for a climax and shifted the interactive aesthetic from one of guarded self-exploration to a full blown physical exploration of the entire immersive room.

The ability to dictate mood, energy and movement was recognized by the Teaching Artist who was somewhat conflicted by her desire to curate it more in future developments of the piece.

> "I have an instinct to soundtrack it and to have music leading the journey, but then I wonder if the music leading the journey will actually lead their exploration and discovery in a way that we may not want. It might actually tell them how to move and I'm not sure that we wanted that." - Teaching Artist (*Creature: Interactions)*

This dilemma highlights the power of music to move and shape the dramatic journey of the experience. Through its many incantations in this body of work, we can see that music is closely entwined with the physical movement of the participants and can interactively influence the physical systems generating the visuals. The visual and interaction aesthetics can also inspire the music composition.

### 8.3.7 Summary

The immersive system was found to assume the roles of character, digital set, lighting and theatrical mask in the theatre show *Creature: Dot and the Kangaroo*. By expanding the breadth of the examination to include works from the entire body of work, we see that the system has influenced many other elements of live performance including the costume design, lighting, set design, acting, music and sound design.

## 8.4 The participant and the spectator

The two productions examined in Chapter 6 and Chapter 7 are companion pieces which were designed to be experienced together, but can also stand on their own as independent works. They share digital assets, interaction aesthetics, ecological themes and are both run from the same technological system. Despite the many similarities, the two works were developed from different perspectives; *Dot and the Kangaroo* was designed as a theatre show that incorporated interactive visuals while *Creature: Interactions* was designed as an immersive interactive art experience that added live actors, facilitators and a dramaturgy to enrich the experience. We can examine these works through existing mixed reality and interactive art frameworks to understand the similarities and differences in both works to the overall audience experience.

Reeves et al. (2005) created a taxonomy aimed at designing the spectator experience which can be applied to both performance and participatory interactions in a public space.

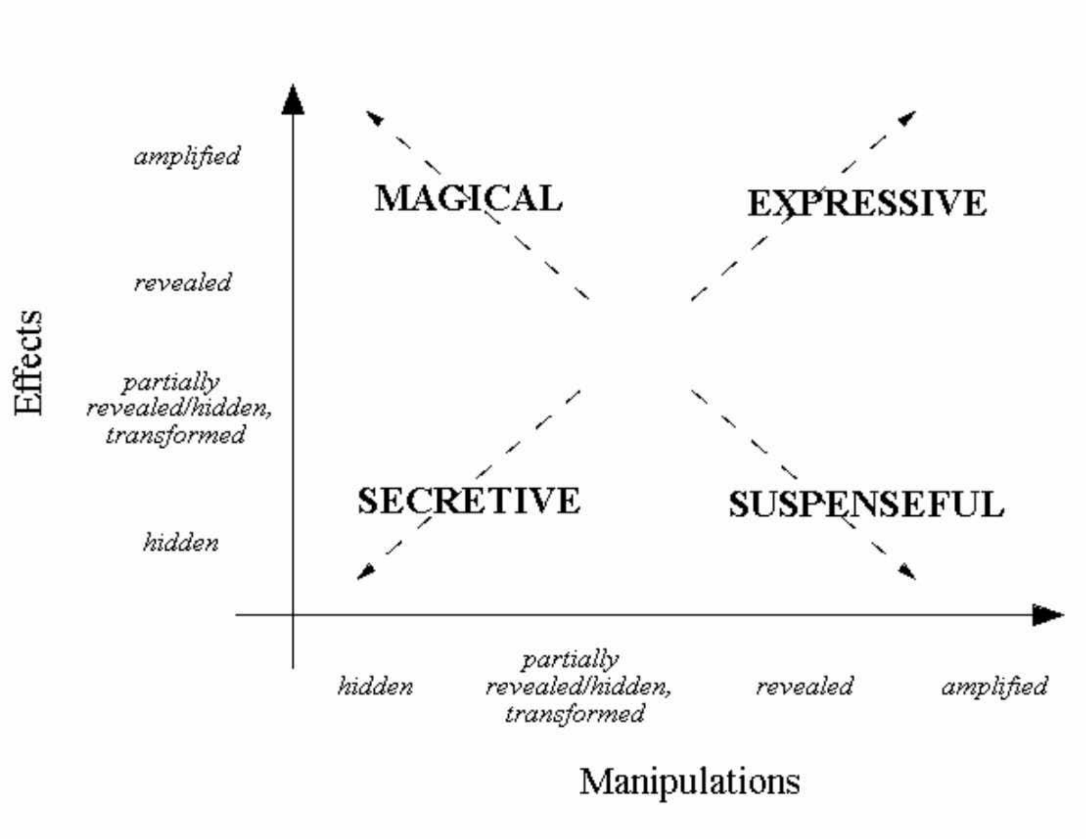



Figure 8.3: Manipulations vs effects (Reeves et al., 2005)

This taxonomy views the spectators of live performance and of interactive installations identically and treats any audience member participating in the interaction as a performer in their own right. While treating the participants and performers identically, they separate performance actions into two distinct categories; *manipulations* and *effects. Manipulations* are the actions carried out by the primary user of an interface and *effects* are the results of these manipulations and can be thought of as the output of the system. These two modes of action are then classified according to their desired visibility ranging from *hidden* and *partially hidden* through to *revealed* and finally *amplified.* This taxonomoy gives rise to four approaches to public interface design as depicted in Figure 8.3.

The majority of manipulations in the *Dot and the Kangaroo* theatre show consist of the performers swinging, dancing or somersaulting across the stage. The system responds to these manipulations with a combination of complex physical simulations, particle systems and visual effects. These interactions lie well within the *expressive* category as both the movement of the performers (manipulations) and the resulting movement of particles (effects) are *revealed* and often *amplified* on the stage for all of the audience to see. There is, however, an additional hidden interaction that is occurring in this production. A digital artist is operating the technology from the projection room throughout the show. The operator loads preset system states at specific cue points to progress the narrative or dramaturgy in accordance with the specific scene being performed. These presets change the background graphics, visual effects and interaction settings of the system. This interaction falls into the *magical* category because the interface, operators and manipulations are all hidden from the audience while the effect of these manipulations are glaringly revealed as large graphical changes across the 16x9 metre projections at the back of the stage. These two different interaction types make the digital projections of *Creature: Dot and the Kangaroo* both *magical* and *expressive.*

The *Creature: Interactions* installation shared the same interaction styles as its theatrical counterpart. The movement-based interaction, whether by the facilitators demonstrating the work or by the participants playing with the system, was *expressive.* Both the manipulations (physical movement) and the effects (particles response) of these expressive interactions were visible to the spectators. The interactive installation also featured *magical* interactions where a hidden systems operator would select scenes in response to certain phrases or gestures initiated by the lead facilitator as he loosely followed a predetermined script. The manipulations vs effects framework has highlighted the similar approaches used by both productions to interweave movement-based *expressive* interactions with the narrative-progressing *magical* interactions.

While these works use the same technology and share certain interaction and visual aesthetics, they undoubtedly present a different experience for the audience. This difference can be highlighted through Saltz's dissection of interactive art and live performance entitled *The Art of Interaction: Interactivity, Performativity, and Computers (1997).* He argues that, while it is closer in nature to the performing arts than to traditional visual arts, computer-based interactive art is still a unique art form unto itself. In making this claim, he distinguishes between *staged interactions* (those made by a performer for the benefit of an audience) and *participatory interactions* (those made by the audience themselves). This distinction differentiates between the staged interactions present in the theatre show and the participatory interactions which are the focus of *Creature: Interactions*.

Saltz further distinguishes between participatory and staged interactions by examining the *perspective* of the audience.

> "The difference between staged and participatory interactions is one of perspective: in the first case, the audience is looking at the interaction from outside the system, and in the second, from within the system." - David Z. Saltz (1997)

Categorizing interactions as either being observed from outside or from within the system provides a simple way to define these interactions and separate performance art from interactive art. Further examination of *Creature: Interactions,* however, shows that this divide in perspective is not as straight forward as presented by Saltz. The *Creature: Interactions* experience alternates fluidly between *staged interactions* (as initiated by the lead facilitator*)* and *participatory interactions (*involving the audience) throughout the duration of the work. To further blur the perspective, the children were found to play and interact with the system at the same time that they were demonstrating their interactions to their friends and fellow participants. The audience were simultaneously participating in their own interactions, staging interactions for others to see and observing the interactions of fellow participants around them. As discussed in Section 7.2.2, the immersive 360 degree interactive display facilitated the blurring and overlap of these interactions. They could participate in their own interactions and turn to observe or show their interaction to a friend without taking themselves out of the experience. Contrary to Saltz's definition, the immersive and shared nature of *Creature: Interactions* allowed both staged and participatory interactions to occur from the perspective of being *inside* the virtual environment*;* from *within* the system.

Exploring Saltz's and Reeve's notion that participatory interactions with a digital installation can become performative in their own right, Sarah Rubidge (2009) describes three categories of 'performative' or 'choreographic' art installations:-

1. choreographed performances that take place in an installation rather than a staged environment;

2. choreographed or improvised performances in an installation environment which incorporate a measure of interactivity between responsive technological systems and performers;

3. interactive engagements in an installation environment between 'audience' members and responsive technological systems that give rise to informal performance events.

Placing *Creature: Interactions* within these categories is impossible as it includes elements of all three; taking place inside an installation, including interactive choreography inside a reactive technological system and providing interactive engagements between 'audience' members that give rise to informal performance events. The production's inability to comfortably sit within either of these categories suggest that it lies outside of what is considered to be a 'performative' installation. The inclusion of both *staged* and *participatory* interactions once again highlights the hybridity of the work; mixing live performance art (theatre) with performative interactive art installations.

Comparing the *Dot and the Kangaroo* theatre show with *Creature: Interactions* through these frameworks show the similarities and differences between these two works. The *manipulations vs effects* framework reveals a similarity in the technology, interaction aesthetic and dramaturgy design of the two works. Examining the works from the perspective of the audience places the show within the practice of performance art (being viewed from *outside*) while the immersive presentation places the audience *within* the system and positions *Creature: Interactions* within the realm of interactive art. Framing the interactions of both works as being either *staged* or *participatory*, we once again see *Dot and the Kangaroo* as being performance art, while *Creature: Interactions* reveals its hybrid nature as it uses both *participatory* and *staged* interactions to bind the interactive experience in theatrical dramaturgy. Using these frameworks and taxonomies has highlighted the similar interaction aesthetics used in both works and demonstrated that while *Creature: Interactions* displays traits from both live performance and interactive art disciplines, the immersive aspect of the piece may have planted it more firmly in its interactive art background.

## 8.5 Improving interactive performance

The *Dot and the Kangaroo* and *Creature: Interactions* productions differed in terms of development focus. The theatre show focussed on the script and introduced interaction and visuals to aid the story telling. The workshop started life as an interactive installation and introduced a script and dramaturgy to aid the interaction. While each experience varied in developmental focus, the shows shared a lot in common. They were both themed around the Australian bush, featured live actors, used the same interactive technology and were both targeted at young children between the ages of three to eight years old. Both productions were successful in their own right with seasons at two of Australia's premiere theatre venues (Queensland's Performing Arts Centre and the Sydney Opera House) and extensive international touring slated for 2017 and 2018.

Although successfully received by theatre-goers and critics, the crew felt that both performances could be further improved given more development time. There was also a strong consensus that with the current state of the arts sector in Australia, it was actually very rare to get any extra development time. The resources spent developing the works were somewhat ‘typical’ for a production of their size. Given that the shows could have been further improved and that the quantity of development time would probably not increase in future projects, it is worthwhile to examine how the **quality** of development could be improved in future projects.

### 8.5.1 Integrated development

The interactive and immersive visuals used in the theatre show were found to take on the multiple roles of character, digital set, lighting system and mask. The system has also influenced many other elements of live performance, including the costume design, lighting, set design, acting, music and sound design. The interactive graphics have facilitated the reduction in density of script by “speaking about location, about spirit of bush, about magic” (as detailed in Section 6.4), and have been described as a “contact improvisation dance partner”, and a “movement amplifier” in Johnston’s research of the *Encoded* performance (Johnston, 2015). With so many elements being influenced by the system and vice versa, the development of these productions can be difficult to manage. We can examine the way both *Creature* productions were developed to understand the impact that an integrated development may have on the work.

#### Creature development: Dot and the Kangaroo

The *Dot and the Kangaroo* theatre show had a partially fractured development. Development started with a few days of brainstorming which served to familiarize the creatives with the locations, characters and themes of the original novel. Following this introduction, some interactive and choreographic ideas were investigated by the respective teams in their own time and the script was extensively refined. Many of the team wished for a more cohesive and extensive pre-development period, and the show's musical composer noted that during the development period, "we all operated in our own silos". He felt that a more tightly integrated period of development prior to entering the rehearsal space would have been greatly advantageous.

> "I do think that it would have been really beneficial if we had even a two or three week period to work together to establish what I call a performance style a little bit more. " - Musical Composer (*Creature: Dot and the Kangaroo)*

The desire for a more cohesive, or extended, pre-development period was shared by many of the creatives and was also noticed by the General Manager of the Stalker Theatre company. The scattered nature of this initial development period was viewed negatively by the General Manager, but was an unfortunate consequence of budgetary constraints and a difficulty in aligning the availabilities of the varied creatives working on the piece.

> "I think the hardest thing for us was how fragmented it was... it just sort of felt like there was no concentrated time to focus on the work." - General Manager (*Stalker Theatre)*

Despite the fractured nature of the pre-development period, the bulk of the work was generated in a four week intensive development and rehearsal period leading up to the opening season, with the creatives working together in the same large rehearsal space. The dedicated time spent working together was instrumental in creating a show that attempted to integrate so many different storytelling elements.

> "... to make a work where you are telling the story through multiple languages, it would be impossible unless we had the slings, the music, the projection and

> [the interactive team] on the spot. ...There's no way you could have come in at the end... it had to have all the story makers from their respective language in the space, making the story together" - Creative Director (*Creature: Dot and the Kangaroo)*

With so many elements that were inter-dependent with one another, developing the work together as an integrated team was vital to its success. The costumes were altered to match the aesthetics of the background projections and materials were selected that worked with the infra-red motion tracking system. The silhouettes on early designs of the costumes inspired the ending animation which in turn changed the choreography of the show's finale. The historical and cultural research that went into the costume design inspired instrumental changes in the music score which then inspired the choreography. As the choreography developed from day to day, the interactive graphics were refined to complement the new movements, and the choreography was simultaneously being altered to make better use of the interactive graphics. The script was being altered daily as the choreographic, visual and sound elements progressed and could lift some of the narrative burden from the text. The reduction of script freed up the narrators to play a more physical role which once again altered the choreography, interactive visuals and musical elements. The costumes were constantly evolving to meet the storytelling needs of the scripts and to ensure that they facilitated the physical demands of the choreography. Every single element of the show was simultaneously being inspired by, and inspiring every other element of the show.

In addition to artistic concerns, every element was also working within the practical limits and concerns of the other elements. Costume materials were selected that worked well with the infra-red motion tracking system, and facilitated free movement for the choreography. Choreography was altered to allow a smooth reaction from the system, ensuring that actors did not enter the interaction dead-spot at the very back of the stage. Algorithms were developed in the tracking system to allow the performance slings to be lowered in and out of the space without drawing attention through overzealous interactive graphics.

Two of the actors shifted roles between narrating, physical choreography, acting and performing live music. The script, choreography and music was in a state of constant asset management as the more important roles for these multi-skilled actors was negotiated scene by scene. Special lights were added to the lighting design to allow all of the action to be visible within the infrared spectrum while still theatrically highlighting the important storytelling moments of the piece. All of the creatives were in a constant battle to extend and refine their own work, all while working under the technical constraints added by the other mediums of storytelling present in the show.

Every day of development would begin with a group meeting where the creatives could plan and discuss which scenes would be developed during the course of the day. Each department would work on their respective mediums in the morning, and the early afternoon session was spent integrating the choreography with one or more different elements. In the evening, all of the updated elements were combined to display a small run-through of whatever material had been developed so far. This run-through was recorded and a video was provided for all creatives to critically reflect on the work, in preparation for the next day's development cycle. This development process strongly resembles Kemmis and McTaggart's method for *Participatory Action Research* involving planning, implementing, observing and reflecting (1988). The iterative method was repeated daily and while implementation was largely performed in isolation, the planning, observation and reflection would be made on the production as a whole in a bid to tightly integrate the work. The process of working together in the same space was seen by the Creative Director as a vital part of the development process, and was key to integrating all of the elements into one unified stage show.

> "I think a lot of work where you see projection is because people haven't been making the work all together, so it does look like an add-on. It does look like it's not dramaturgically integrated because it's not." - Creative Director (*Creature: Dot and the Kangaroo)*

### Creature development: Interactions

While *Dot and the Kangaroo* ended with an intense but unified development period that facilitated the integration of many separate elements, the *Creature: Interactions* workshop was fractured throughout the entire development period. The majority of interactive audio-visual content was generated four months prior to the show opening, while the dramaturgy, script and task-oriented workshop elements were developed only three weeks before the installation opened. The audiovisual content was originally designed to be a self-guided installation and was created well before the director, lead actor or teaching artist for the workshop were even brought into the project. The team in charge of the live dramaturgy were funded by an independent grant which was only approved very late in the process. By the time these artists became involved, the interactive artists were consumed by the intensive development period of the *Dot and the Kangaroo* theatre show. The visual artist behind the bush landscapes was also unavailable during the dramaturgical development of the workshop as he was employed by an unrelated project. With the absence of technical or visual expertise, the live, educational and dramaturgical portions of the work had to be repurposed from the existing installation components. Geography further fractured the development of the experience as the dramaturgical team were based in Queensland where the show was set to premiere, while the rest of the Stalker team were rehearsing and developing the show almost 1000km away in their home town of Sydney. The live team were flown in to see the installation in the rehearsal space on two occasions, but mostly relied on email as the main point of contact. The repurposing of technology, poor availability of artists and distant locations of both teams had a negative impact on the integration of the live and virtual components. The fractured development undoubtedly contributed to the chaotic nature of the initial workshop performances.

> “There’s a lot to be said for the drama or the workshop being created at the same time as the AV. [...] Both sides get to go ‘what are you thinking, what are

> we thinking, what are we creating and how does it work?"' "...one side is not struggling to match up with the other. They are genuinely being created at the same time in a cohesive artwork." - Director (*Creature: Interactions)*

The Queensland team struggled to match up a dramaturgy, script and pedagogy to the predetermined interactive and visual palette of the immersive system.

The spatially and temporally dislocated nature of the workshop development periods, created a sub-standard live experience that (as discussed in Section 7.3.1) was overrun by the chaotic energy of physical child's play.

> "... when I went in to see that first show I was pretty disappointed at how it had emerged. [...] It seemed to me that you had managed within the time to create something that was quite a good experience, but I reckon it's about 20% of what you could do if you'd actually been clear about the intention and worked together from the beginning" - Scholar in Residence (*QPAC)*

The workshops improved as the season progressed to become a successful experience, but despite its exciting potential for embodied play and social pedagogy, it remained somewhat less cohesive than the theatre show. The theatre show was developed with a daily iteration of planning, implementing, observing and reflecting in an integrated environment. This cohesive development facilitated the creation of a highly ambitious piece in an extremely short period of time. Although showing an enormous potential, the *Creature: Interactions* experience may have been significantly improved by an integrated development.

### 8.5.2 Trust in the team

> "It was so big and so confusing... it was a bit like driving blind for a long time. I just couldn't see where it was going to go." - Rigging Master (*Creature: Dot and the Kangaroo)*

With the interdependent nature of all the elements, an integrated development period was necessary to allow all of the pieces to react to the aesthetic and technical needs of one another. Even within the integrated development period of the theatre show, it took some time for a solid direction to emerge. The team was 'driving blind' for a long period of time as no one knew exactly how all of the elements would fit together. Everyone knew that it was going to be a theatrical performance based around the book *Dot and the Kangaroo* combining physical performance, interactive visuals, spoken word and music, but no-one knew exactly what role each of these elements would assume and how they would inter-relate. In a similar fashion, the original *Creature: Interactions* was stated to be an interactive workshop that combined live facilitators with immersive 360 graphics and interactive technology, but no one knew how any of these elements would actually fit together.

The level of uncertainty caused the performers a certain level of anxiety during the development period.

> "I found it a little bit on the stressful side but I was happy with where it ended up in the end. [As a performer], it was hard to tell during the rehearsal and during the development, without having a full idea of what it was that we were going to have in the end." - Narrator (*Creature: Dot and the Kangaroo)*

The unknown extent of the work put pressure upon the creatives designing the work as well.

> "I think the pressure of having to develop a show without knowing exactly, because we didn't really know what we were doing. We didn't know whether we were doing an installation, didn't know anything about the theatre show at all."
> - Visual Artist (*Creature: Interactions & Creature: Dot and the Kangaroo)*

While the lack of a clear outcome caused some levels of anxiety within the team, a certain level of uncertainty was not only expected but actually desired. The combination of script and interactive technology was a departure from traditional theatre practices, and the immersive workshop was viewed as a complete departure from traditional performance, sitting somewhere in-between immersive theatre performance, interactive installation art and experiential learning practices. Only by embracing the unknown could the new experiences be successfully married with the more traditional (and therefore more thoroughly understood) elements.

> "... there was a certain amount of not-knowing that we all had to stand in. And I think some people struggled more than other people in that not-knowing, but I felt that unless we stand in that not-knowing we are going to come up with something that's not integrated." - Creative Director (*Creature: Dot and the Kangaroo)*

It seems that where a level of 'not-knowing' was part of the process and necessary to successfully develop the complex performances, the creative practitioners of *Dot and the Kangaroo* used their trust in the team to alleviate much of their anxiety.

> "The team was great. I never doubted that it was going to be a fantastic piece. I just didn't know how we were going to get there. " - Rigging Master (*Creature: Dot and the Kangaroo)*

> "... you do have to kind of trust the creative team that you bring together, and I really had trust in that." - Creative Director (*Creature: Dot and the Kangaroo)*

Some of the team working on *Creature* had been working with Stalker Theatre and each other on various projects for many years prior to these productions. The familiarity and respect with one another's creative output helped to establish a trusting relationship and allowed a streamlined development approach.

> "Being back in that group was kind of like family in a way, and collaboration gets deeper and more real in that kind of circumstance because you know everyone and there are shortcuts through conversation and levels of trust where

> we kind of know one another's work. And we needed it because there was such a short time to get that show together with so many sort of complexly relating pieces." - Costume Designer (*Creature: Dot and the Kangaroo)*

The *Dot and the Kangaroo* project also introduced a number of new performers and creatives to the Stalker team who quickly established levels of trust and kinship with each other and the more established Stalker crew.

> "It's a difficult thing to get a team of people that can actually respect each other's individual contribution and can come together as a whole and I think Stalker and you know, the *Creature* team did that. I believe they did that really really well." - Performer 1 (*Creature: Dot and the Kangaroo)*

Interestingly, while almost every single creative and performer that was interviewed from the *Dot and the Kangaroo* theatre show expressed a notion of 'trust' in the entire team, none of the *Creature: Interactions* artists or performers expressed a level of trust in the entire team. There was no indication of personal conflict or lack of professionalism revealed by the interview process and no conflicts were observed during the performance of the workshops. Many of the interviewees did describe a certain amount of trust for the peers that they worked most closely with, but not of the entire extended team that included the facilitators, directors, performers and interactive artists. There were no doubts placed on the skill levels of any of the *Creature: Interactions* team members, with many interviewees detailing a mutual respect for each others work. This mutual respect, however, never evolved into a strong sense of trust and the fractured development of the work is most likely to blame for this. Without the integrated development period, there was no shared 'water-cooler' to bond over and the daily contributions and compromises of each individual artist went largely unnoticed. The dislocated development period prevented an establishment of trust within the group and the feelings of 'not-knowing' were left largely unchecked throughout the *Creature: Interactions* work.

The integrated development period of *Dot and the Kangaroo* enabled an iterative process where each element could be cohesively observed and redesigned on a daily basis. This cohesive development environment promoted a sense of trust between the entire team which allowed the creatives to be comfortable navigating the progress of their work, despite having an unclear destination. While the effects are impossible to quantify, the *Creature: Interactions* team was denied the same luxury of trust and a less cohesive work resulted.

### 8.5.3 Access to the immersive system

A major downside of having a custom-made and relatively complex immersive system is that it is difficult to replicate outside of a dedicated performance or rehearsal site. The system will comfortably run on a laptop and allow interaction through a web camera but while this is extremely convenient for the developers of the system, the difference in scale between a 15 inch laptop and a 15 metre projection screen is enormous. For those who are less experienced with the system, it is extremely difficult to view the laptop version and then imagine the effect of large-scaled and full-bodied interaction. The integration of dramaturgical content was considerably difficult for the Queensland-based *Creature: Interactions* team who, aside from a quick demonstration, didn't have access to the system prior to the workshop opening and were not experienced with the particular interaction aesthetics of the system.

> "Some if it was really hard and some of it was easier but kind of came to us when we were doing it, which I also think is a key thing with this type of work. Often you need to just play in the environment for ages and see people do it and then you have ideas based on that." - Director (*Creature: Interactions)*

The lack of access to the technology prevented the dramaturgy team from trialling any of their ideas in a meaningful way and made an iterative design process practically impossible.

Without any iterative process behind it, the workshop opened with the initial design and relied heavily on consistent refinement as the season progressed.

> “It was never really fine-tuned until we were right in there with it and so it was all a little bit hypothetical with regard to what the purpose was. So on that front, and also not being privy to the capabilities of the technology, [there] was a lot to be decided on the floor and I think that’s where it really started to take shape.” - Dan the Bushman (*Creature: Interactions)*

The complete lack of access to the interactive and immersive system was an extreme situation caused by the large scale and bespoke nature of the project coupled with the remote location of the dramaturgical team. In contrast, the theatre show was developed with the interactive system and designers in the very same room, however it too suffered from a lack of access to the interactive system. To save on money, the interactive system installed in the rehearsal space used a cheaper type of projector and a large drop sheet of grey material rather than a dedicated projection screen. The result of this budget setup was a usable but exceptionally dim projection setup. The brightness was adequate for final rehearsals where the space was blackened and lights were turned off, but the projection screen was near invisible when the main house lights were in operation. There was a serious health and safety risk in working without the main lights during development as the choreography was constantly changing and some of the actors were learning how to use their dangerous physical apparatus for the first time. The bulk of the development period was therefore spent with a relatively bright environment that rendered the dimly lit interactive projections useless. Despite being in the same rehearsal space, much of the choreography was developed without the interactive system being present on stage. The lights were turned off for the run-throughs at the end of the day, allowing the projections to be seen and this is where the bulk of decisions integrating choreography and visuals were made.

The brief periods in development where the interaction system was active yielded certain movements that became part of the choreography. The idea behind the chasing of the hare in the opening scene came from a playful encounter with the interactive hare totem during a break in rehearsal. Similarly, the kookaburra and snake comedic fight scene was embellished and exaggerated through unscheduled play with the interactive system.

> “... in rehearsal when they would do things while the brolga was up or the bunny was up and someone would walk past and you’d go ‘Aww do it again!’...I used to watch them and my little brain came up with a story very quickly about why it’s moving like that” - Performer 1 (*Creature: Dot and the Kangaroo)*

Chance encounters and unstructured play with the system is important to push the boundaries of the system, finding new meanings in the interaction and ways to integrate the physical storytelling with the visual medium. The poor visibility of the budget projection system was not the only difficulty of the setup in the rehearsal space. The large-scale digital visuals were projected onto the wall behind the stage so that the audience would see the live performers effectively superimposed together with the interactive visuals. This projection setup gave the choreographers, directors and interactive artists a good perspective that was reflective of the ultimate audience experience. Whilst advantageous to the creative team, the particular setup meant that the actors who are trained to face the audience had their backs to the projection screen for the majority of the development period. One of the performers recalled a frustration with not being able to see the projections at all during the show’s development.

> “I think we needed a better introduction or conversational relationship with the actual projection...I had no idea that was on the screen behind me. No idea whatever.” - Performer 1 (*Creature: Dot and the Kangaroo)*

In a devised theatre production where the choreography is entirely generated within the development period, improvised movements with the professional performers can greatly influence the early stages of choreographic design. When the actors are not able to see the projections in these early stages, they are not interacting with the graphical system and a potentially large source of interactive choreographic material is being left unexplored.

In direct contrast to the inescapable interactivity provided by the 360 degree immersive system of the workshop, the rear of stage projection setup stopped the actors from seeing the graphics and caused the visuals to become 'reactive' to the actors, rather than 'interactively' having an influence over the movements of the live performers. In future developments, it would be advisable to provide a viewing screen for the performers as well as the creative team. This was achieved in the *Blue Space* and *Sticks with Viz* projects by projecting onto a transparent scrim at the front of the stage, allowing the performers to physically react to the visual feedback of the system in a truly interactive exchange. If a scrim is not available or is not appropriate for use in the rehearsal space, a second projector could also be employed to display the visuals at the front of the stage in combination with the rear. Ensuring that the physical performers can actually see and interact with the visuals wherever possible would maximize the development period and allow for a more tightly integrated and interactive choreography.

With the difficulty of obtaining extended development times for modern artistic endeavors, it would be advisable to utilize the short periods of time as efficiently as possible. The immersive and interactive system has been found to assume and/or inter-relate with almost every other element of a contemporary theatrical production, and as such, an integrated development period with all of the creatives present was found to be advantageous. The highly iterative development cycle of the theatre show allowed each element to observe, reflect and react to changes to the rest of the production and facilitated a more integrated performance. The novel aesthetic and enormous potential of the immersive visuals created a sense of anxiety and uncertainty during the development period which could be alleviated by generating a high level of trust between all members of the team. For a diverse team to trust and successfully engage with an interactive system, they need to develop a common understanding of the technology. This common understanding can often develop organically through extended periods of play (Turner et al., 2005). Both of the major *Creature* productions were found to lack a suitable presence of interactive system during choreographic and dramaturgical development which may have impacted negatively on the cohesive inclusion of interactivity in the final performances. This presence could easily be addressed with the addition of a transparent projection scrim or secondary front-facing projection system, allowing the performers to see, interact and improvise with the projections during the crucial development period.

### 8.5.4 Summary

The novelty of combining live performance with immersive and interactive technology created a level of uncertainty and anxiousness in the artists. This anxiety was alleviated through a trust in the competency of the team which was fostered through an integrated development period. Having access to an immersive system during the development of these works is important to facilitate a unified production. Although a very successful work in its own right, *Creature: Interactions* suffered from a fractured development with limited access to the system and as a result, the live performance team had to significantly evolve the piece throughout the season.

## 8.6 Conclusion

The artists in the theatre show *Dot and the Kangaroo* were found to identify the technology through theatrical terms such as **character**, **set**, **lighting** and **theatrical mask**. The artists from the *Encoded* dance performance saw the technology as providing roles based around **movement,** indicating that the style of performance genre alters the way the artists approach the virtual elements. The technology was found to impact on a large range of elements including **acting, lighting, costumes, music, sound, sets** and **script**.

The two *Creature* works examined in Chapters 6 and 7 were found to share similar interactive aesthetics which provided **expressive** interactions to the movement of the performers and hidden **magical** interactions to drive the narrative and dramaturgy. While the interactions were similar in both pieces, the audience **perspective** of these interactions differed significantly. *Creature: Dot and the Kangaroo* was viewed from outside of the system while *Creature: Interactions* was experienced from within, highlighting their roots in live performance and interactive art respectively.

The combination of interactive visuals with physical theatre in a scripted adaptation of a children's novel was a new concept that introduced a level of **uncertainty** in the cast of *Dot and the Kangaroo*. Similarly, the exact way that live action and immersive visuals would be combined with the interactive artwork was a large unknown for all artists involved. The amount of uncertainty in the development of the work caused some **anxiety** amongst the artists, but a level of **trust** and confidence in the team was able to alleviate these negative emotions. An **integrated development** was seen as advantageous to creating a unified work that dealt with so many interdependent elements, and also helped to establish trust between the artists.

As physical interactive systems are still a relatively new concept in theatrical performance, much of the choreography and interactions can be discovered during **improvisations** in the development period, rather than relying on established practices. To facilitate these discoveries, it is advantageous to have the interactive system **accessible** and operational in the development and rehearsal space as much as possible.

The next chapter introduces an ongoing evolution of the *Creature: Interactions* artwork that has provided some interesting seeds for future research.

# Chapter 9

# Future Research

## 9.1 Introduction

This chapter examines a new evolution of the *Creature: Interactions* work that increases the level of immersion through stereoscopic 3D projections and spatialized sound. This work has only been displayed as a technical demonstration as yet, but has produced an unexpected 'phantom limb' effect which provides an interesting avenue to explore in future works.

As the immersion increases, the use of proscenium arch theatre venues become increasingly impractical. The need for a tourable solution for immersive artworks is also flagged as an ongoing concern for future productions.

## 9.2 Creature: 3D

*Creature: 3D* is currently a technical demonstration where the animated landscapes, totem animals, fluid particle systems and flocking particles from *Creature: Interactions* have all been updated for use in stereoscopic 3D. The animated landscapes were rerendered from TouchDesigner with two separate virtual cameras, producing one image and one depth map for each eye. A real-time and depth-aware compositing algorithm was developed to ensure that the rules of occlusion applied between layers of the video and particle systems, creating a more believable immersive environment where the particles would pass in front of or behind the rendered elements as applicable.

The work has been presented inside the Data Arena, a 360 degree stereoscopic visualization facility housed at the University of Technology Sydney. The network architecture was once again exploited to synchronize the edge-blended display across six high-definition active-shutter stereoscopic projectors. An omnistereo rendering system was developed to ensure that the display did not warp around the edges and would be seen correctly from a number of different angles inside the cylindrical interaction area.

The interactive system was modified to use the accurate Optitrack 3D optical marker-based system installed in the facility. Participants were provided with native animal hand puppets which had infrared markers attached to them. The use of fluffy native Australian animals themed the interaction devices and added another element of fun to the work (see Figure 9.1).

The sound system was also upgraded for the immersive Data Arena showing. The three-dimensional interactive particles of birds had bronze-winged pigeon sounds attached to them that would follow their location around the room, using a distance-based amplitude panning system outputting to 16 independent speakers placed around the room (see Section 5.7.2). The pitch of playback was automatically matched to the speed of each individual bird traveling around the room, creating a strong link between the three-dimensional stereoscopic visuals and the spatialized playback of flapping bird sounds. Similarly the interactive moons created ‘swooshing’ sounds that were tied to the location and speed of movement of the moon-shaped particles. When shown the *Creature: 3D* technical demonstrations, participants enjoying the interactive sound design were overheard commenting that the sounds ‘add a real depth to the movement of the birds’ and more simply ‘wow, I really like the swooshing sound of the moons’.

Figure 9.1: Motion capture with koala hand puppets
Photo: Andrew Bluff

Figure 9.2: Cooling off in the virtual rain

Video Still: Jaina Kalifa

## 9.3 The phantom limb experience

> "Well you know it's the phantom limb experience. It's not there but it is there. You know, everyone swore to god that when the rain came, the temperature in the room dropped." - Artistic Director (*Creature: Dot and the Kangaroo)*

During the *Creature: Interactions* workshops, members of the audience reported that they would feel the temperature drop during the rain sequence despite the centrally controlled temperature remaining constant throughout the entire experience. Within the workshops, the children were quite actively running around and scooping imaginary buckets during the bushfire scene. As the digital rain extinguished the virtual bushfire, the children were encouraged to lie on the floor or stand against the walls, imagining that they were indeed standing in the middle of a real rain storm (see Figure 9.2). However, when the installation was trialled as a self-guided experience using the same sound and visuals on one wall, the same drop in temperature was not observed. As the effect was not observed during the self-guided trial with identical visuals and sounds, the temperature may have been raised by the exuberant physical activity of a large group of children during the fire scene, only to be subsequently dropped when the children were stilled for the rain sequence. The facilitators in the workshop also told the audience to actively engage with their imaginations in order to physically interact with the hot bushfire and the incoming rains. It is possible that these suggestions were enough to instill an actual perception of temperature change within the audience.

In direct contrast to the crowded audiences in the workshop for children, *Creature: 3D* was experienced by smaller groups of 15 - 20 adults at a time. While the same general dramaturgy was used in this experience, the didactic 'action-research' dynamic was dropped and the adults were largely allowed to interact as they liked. The experience became somewhat more similar to the self-guided origins of the installation than the fully-facilitated *Creature: Interactions* workshop. The adults were not asked to actively put out the fire or stand in the rain, and were not told to engage with their imaginations in any way. Instead, they remained largely stationary through the whole fire and rain cycle. Despite the lack of physical engagement or imagination exercises, many participants remarked that they observed a noticeable drop in temperature when the rains began. In addition to this, two of the participants also remarked upon a rise in temperature during the initial bushfire sequence. The phantom temperature effect was not only present in *Creature: 3D,* but the additional feeling of temperature rising during the bushfire suggests that the effect was potentially stronger than that witnessed in *Creature: Interactions.* While no formal experiments have been undertaken to critically examine this phenomenon, the lack of effect in the initial one-wall self guided experience, and its presence in both the workshop and *Creature: 3D* suggest that the shift to 360 degree visuals may be the biggest contributing factor. The extra immersion created by the surround visuals tricks the brain into actually believing in the experience and empathetically triggers other senses that are known to strongly correlate with the immersive situation at hand. The greater realism of stereoscopic visuals in *Creature: 3D* may increase the level of presence within the virtual environment and strengthen the phantom temperature phenomenon.

Temperature was not the only phantom sense activated during the stereoscopic *Creature: 3D* experience. At the beginning of each session, one or two of the participants were given plastic flowers with tracking markers attached and told to hold them out at arms length. Controlled by the rigid body flocking algorithm and rendered seamlessly across all six surrounding projection screens using the omnistereo algorithm, butterflies would fly through the space and appear to land on the participants outstretched hand. While a shared display can never be tuned for every single audience member, the motion tracking was deliberately scaled in this scene to align the perceived position of the stereoscopic butterflies with the participants outstretched hand. When the participant moved their arm, the butterflies would scatter and gradually fly back down to their outstretched arm. Many members of the audience remarked upon the impressive illusion of the three-dimensional butterflies during this section and were observed discussing the butterflies long after the demonstration had finished. While appreciated by many, on two separate occasions the participants described feeling more than just impressed by the effect. They physically felt the butterflies touching the ends of their fingers as the digital swarms appeared to land on their outstretched hand.

*Creature* was not the only work to have produced a ‘phantom’ sense in the Data Arena. As an experimental precursor to *Creature: 3D,* the stereoscopic *DataStorm* installation included a scene where users threw digital flowers into the air within a 360 panoramic photo of an Australian rural hillside. One of the participants throwing virtual flowers through 3D space remarked upon the air smelling ‘fresher’ during this particular demonstration.

Further research is needed to thoroughly investigate the phenomenon, but anecdotal evidence suggests that immersive sound and visuals might be able to incite other senses such as temperature, smell and touch. This phantom effect may be improved by the embodied interaction that was present in both the flower and butterfly scenes. It should be noted that in all cases, the actual senses that received phantom information were held in a fairly neutral state throughout the experience. The temperature was kept at a constant and pleasant temperature, the fingers of participants were left exposed and untouched during the butterfly sequence and the space was constantly reminiscent of a neutral 'new car smell' during the early *DataStorm* demos. It is possible that actual excitation of these senses may prevent the phantom effect from occurring.

A similar phenomenon has been identified by Ramachandran and Hirstein where amputees report a 'phantom' pain or physical sensation in their amputated limb (Ramachandran and Hirstein, 1998). They were able to elicit feelings of control and sensations of touch in the phantom limb when patients could visibly see the limb move via a mirror reflection of their own remaining limb.

Similarly, the effect may also be related to the 'rubber hand illusion' in which researchers place a subjects left arm out of view underneath the table and substitute it with a realistic looking rubber hand. By simultaneously touching both the real hand and the visible rubber hand in random patterns, a feeling of ownership is transferred to the rubber hand. The rubber hand starts to feel like a part of the body. The researchers have described the phenomenon as a "a result of the interaction of vision, touch, and position sense (proprioception) and the dominance of vision over proprioception" (Ehrsson et al., 2004). This may have some commonality with the phantom senses described, although in this case it would be a combination of vision, sound and interaction and the dominance of vision over *touch, smell* and *temperature*. The phantom limb effect has already been studied in the field of neuroscience but its application to physical theatre and immersive installations provides an interesting direction for future investigation.

The *Blue Space* performance used an early generation of the fluid software to create audio visual responses reacting to the sound and gestures of a live oboe musician. In Walsh's doctoral thesis detailing the work, the researcher describes an experience of immersion never before experienced by the seasoned performer.

> "...the performer experienced a particular sense of actually 'being' in the scene: blowing ice crystals into space, floating in air, and making it rain. When the performer experienced this state, the body and the oboe temporarily disappeared from awareness, and a direct link was formed between imagination and visual output, creating a different experience of reality." - Walsh (2017)

The performer does not detail the awareness of any phantom senses in operation, but as the work was using a similar interactive system, the described altered sense of awareness and link between imagination and visual output may be a precursor to the phantom limb experience. Whether the altered experience uncovered by the researcher is related to the phantom limb effect or not, both phenomena came unexpectedly and surely warrant further research into how it can impact immersive theatre performances.

## 9.4 Touring Creature

The push to a more immersive stereoscopic environment for *Creature: 3D* was enjoyed by many participants who particularly enjoyed the butterfly, birds and moon particles as they virtually floated around the interior space of the installation. Following a demonstration of the work, many clients have indicated a desire to present a production of the 3D installation. Unfortunately, one of the key successes of the *Creature: Interactions* and *Creature: 3D* works has been the large 360 degree setup which, although impressive, is proving difficult to find suitable venues for installation. The requirements for active shutter stereoscopic projectors in *Creature: 3D* exacerbates this problem as it is often difficult to hire stereoscopic projectors, especially at more remote locations.

To combat the need for dedicated space and stereoscopic projectors, we are currently investigating portable projection domes. It is hoped that these commercial products could easily be deployed with a standardized projector setup and toured to remote locations, increasing the potential impact of the work in rural communities. The portable projection dome will hopefully provide an integrated development environment from which to devise new works that can further hybridize the live performance and interactive art form aspects of *Dot and the Kangaroo* and *Creature: Interactions* within an immersive environment similar to *Creature: 3D*.

## 9.5 Conclusion

The use of stereoscopic visuals and spatialized sound in *Creature: 3D* has brought an increase in immersion and has anecdotally facilitated a phantom effect in certain participants where they can feel heat, cold, touch and smells that were not actually present in the room. While more evidence and research is needed, this may be linked to the 'phantom limb' research undertaken in the field of neuroscience and the feelings of immersion felt by the performer of *Blue Space*. The *Creature: 3D* demonstrations have excited participants, and research is currently underway to determine how best to tour this immersive artwork.

# Chapter 10

# Conclusion

As stated in the introduction, the aim of this practice-based research was to explore the combination of interactive art and immersive technology with live performance.

In order to achieve this aim, the following objectives were identified:

- To create a **technological system** with immersive and interactive capabilities suitable for use with live performance (Section 10.2).
- To use the system to develop **performances** and **artworks** that combine interactive art, immersive technology and live performance (Section 10.3)
- To examine the **impact** of combining these fields on the **development** and **production** of these performative works (Section 10.4).

## 10.1 Methodology

To meet these objectives, this practice-based research was undertaken according to the following steps as represented in Figure 10.1:

1. **Literature review** (Chapter 2): Search the literature and existing artworks to identify what type of technology design may be suitable.
2. **Artefact design**
   (a) **Software design** (Section 3.3.4): Create a prototype immersive and interactive system that is capable of use in live performance.
   (b) **Devised theatre** (Section 3.3.3): Collaborate with expert artists and performers to develop a new performance utilizing the technological system.
   (c) **Software design** (Section 3.3.4): Extend and refine the technological system with new features inspired by the theatre performance.
   (d) Iteratively repeat steps (b) and (c), developing new performances and improving the technological system, refining both the system and its use in live performance from a technical and **embodied** (Section 3.3.5) perspective.
3. **Grounded theory** (Section 3.4)
   (a) **Data collection** (Section 3.5): Observe and interview the artists involved in developing the artworks and performances.
   (b) **Data analysis** (Section 3.6): Analyze the data and final system to derive a framework for immersive system design and use in live performance.

The artistic productions, technological system design and extensive reflections that were produced with these methodologies are presented as the major contributions of this research.

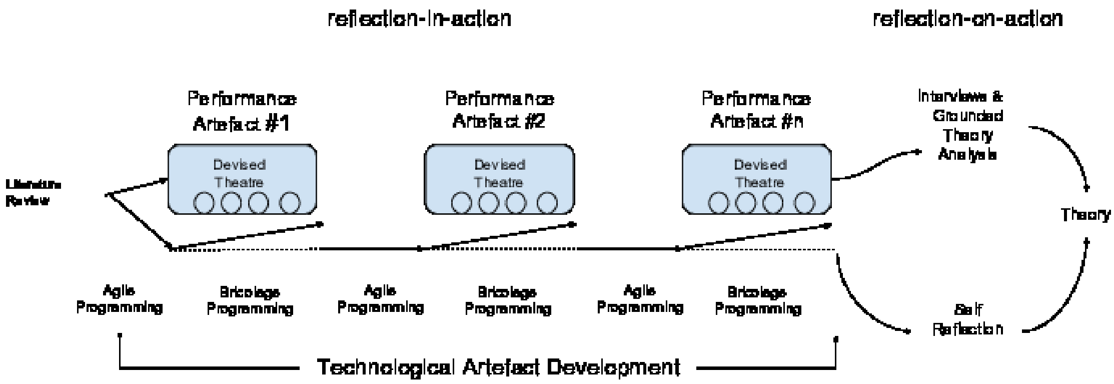



Figure 10.1: An overview of the research strategy undertaken

## 10.2 Technological system

The literature review (Chapter 2) revealed a long and established history of using technology within the live performing arts, and explorations into immersive technology and computer-based interactive art dating back to the early 1960s and 1970s. Interactive technology was split into three separate sections of motion capture, mapping and audio-visual output. Motion capture was found to require compromises between accuracy, range of use, physical restrictiveness, portability and cost, with different solutions appropriate for different situations. Mediating the input with a complex physical or organic simulation was found to provide a conversational interaction where the reaction was transparent but possessed an element of non-determinism. Attaching a particle system to the physical simulation and rendering with simple shapes or granular media was identified as an approach to allow emergent behavior in a complex system. Real-time collision systems, three-dimensional motion capture systems and a good alignment with the live performers is deemed important for a mixed-reality blending of real and virtual elements. Stereoscopic visuals, depth-aware rendering (including occlusion, shadows, and blurs), large-scale projected environments and spatialized sound were all identified as immersive technologies to be explored.

A technological system, entitled ParticleStorm, was built and refined over the entire period of research. The system utilized multicast networking and standard protocols to provide a flexible and scalable architecture suitable for use on a single laptop for small performances or a network of computers, projectors and cameras for large immersive environments. A real-time compositing system was created to allow multiple particle systems and pre-rendered media to be displayed concurrently, whilst still respecting the laws of occlusion. Depth-aware visual effects were added to blend the layers more creatively and increase the visual palette of the system. A granular synthesis and spatialized sound engine was added to link the visuals and sounds to the same underlying particle systems and position them in three-dimensional space. An omnistereo rendering system was developed to create an immersive 360 degree stereoscopic 3D display that can be viewed by many participants simultaneously.

## 10.3 Performances and artworks

The system was used in a body of work consisting of 15 separate artworks and performances that were developed collaboratively during this research (see Chapter 4 and Appendix A). These works explored the intersection of interactivity, immersion and live performance in a number of ways.

The main contribution, focus or novelty of these works can be summarized as:

**Music performance**

- *Airstorm* - audio-visual music performance exploring a rigid body collision system and 3D rendering
- *Sticks with Viz* - audio-visual performance combining electronic and traditional music instruments, fluid and rigid body physics engines and visual effects projected onto a translucent scrim and combined with theatrical lighting techniques
- *CIMF Sticks* - purely improvised interactive audio-visual performances
- *The Hour* - stereoscopic 3D performance including projection mapping and interactive visuals
- *Airflow* - fluid simulation as an audio-visual granular synthesis instrument, exploring cohesive multi-modal input and output
- *Blue Space* - audio-visual granular synthesis and visual effects to create an exploration of a specific theme

**Physical theatre / dance**

- *Encoded* - interactive performance with simple projection mapping for indoor theatre venues
- *Pixel Mountain* - interactive performance with projection mapping onto buildings, shipping containers and museum facades
- *Frameshift* - interactive performance with 360º projection mapping onto multiple structures

**Theatre / physical theatre / musical**

- *Creature: Dot and the Kangaroo* - use of interaction as a storytelling device in physical theatre

**Interactive art installation**

- *Creature: Siteworks* - combining live dance performance with participatory interactive art installation
- *Creature: Interaction* - live performance to facilitate interaction and learning within an immersive 360º interactive art installation
- *Creature: 3D* - interactive art installation with immersive stereoscopic 360º visuals and spatialized sound
- *DataStorm* - stereoscopic 3D immersive installation experimenting with different interaction styles including physical props
- *Scream* - interactive audio installation where gesture and spatial position triggers compositional sound elements

**Immersive precomposed media**

- *Showreel* - precomposed video soundtrack combining stereoscopic 360º visuals with spatialized ambisonic sound

## 10.4 Impact on development and production

*Creature: Dot and the Kangaroo* and *Creature: Interactions* were selected for further reflection as they were significant works performed in high-impact venues and involved a team of professional artists and performers. Interviews with the cast and crew of these works were conducted and analyzed with a grounded theory approach to examine the impact the interactive and immersive technologies had on their artistic and performative practice.

### 10.4.1 Interactive art in live performance

The interviews presented in Chapter 6, revealed that a select number of scenes were viewed by the practitioners of *Creature: Dot and the Kangaroo* as more successfully utilizing the interactive system than others. In combination with the interviews, these scenes were analyzed and compared with the rest of the show, revealing:

- The projections described the **location, spirit** and **magic** of the story. These descriptions could then be removed from the spoken word, allowing the physical action more room to 'breathe'.
- The interactive **physical simulations** endowed the 'totem' animal characters with a sense of **aliveness** which connected the backdrop to the human actors.
- A **variety** of **mapping techniques** (fluid, rigid body, flocking, attraction), **visual effects** (blur, warp, trails, masks) and **render styles** (lines, dots, 3D models) were used in the successful scenes.
- The successful scenes all involved a reasonable amount of **physical movement.**
- This physical movement resulted in **reactive animations** over the **entire projection canvas,** creating a more spectacular visual display and higher field of view (**FOV**).
- The successful scenes placed an emphasis on actors **acknowledging** or **actively interacting** with the projected backgrounds.
- The interaction was most successful when it was being used as a **narrative storytelling device.**

### 10.4.2 Immersive technology in interactive art

The theatre show was presented alongside a similarly themed interactive installation called *Creature: Interactions* which allowed the participants to immerse themselves in the locations and themes of the show in a 40 minute guided experience. The interviews presented in Chapter 7 revealed a number of points with respect to the immersive **360 degree** presentation of the work:

- It was described as **immersive, striking, amazing, impressive** and **overwhelming.**
- The format placed the audience **inside** the virtual environment.
- It **promoted interactivity** because there was **no escaping** the piece... it was surrounding the audience.
- It **removed** any **preconceptions** about the work being an interactive film, a theatrical stage or a classroom.
- The **scale** and **novelty** of the surrounding virtual environment **promoted interactivity**... the children wanted to play with it.
- The 360 degree format allowed up to 90 children to interact simultaneously in a shared space, enticing **social interactions** amongst participants.

### 10.4.3 Live performance and facilitation in immersive interactive art

The mix of interactive art with a large 360º immersive environment promoted social interactions amongst children to such an extent that the joyous playing quickly escalated to a wild and unfocussed energy in the early showings of *Creature: Interactions*. As the season progressed, the lead actor and volunteer facilitators introduced a number of steps to improve the richness of the physical interaction, promote positive social interactions amongst participants and focus the energy throughout the experience. These steps were discussed in Chapter 7 and include:

- **focusing energy** by using the Facilitated Interaction Framework stages of **induction, interaction** and **debriefing** for each scene of the installation (Loke and Khut, 2014),
- **sculpting energy** by highlighting the less interactive and more dramaturgical moments such as the fire, rain and transportation scenes,
- **promoting group work** by creating ad-hoc groups to interact with the totem animals and designated groups for the fire sequence,
- facilitating a **richness of movement** by demonstrating and promoting dances and animal movements, and
- adding an **educational** aspect through the introduction of question and answer sessions.

### 10.4.4 Developing hybrid works

The development processes of *Creature: Dot and the Kangaroo* and *Creature: Interactions* were examined and contrasted in Chapter 8. The full-bodied interactions of both works were found to be **expressive** while hidden **magical** interactions worked to facilitate the dramaturgy. Although *Creature: Interactions* exhibited interactions of both a staged and participatory nature, the audience's **perspective** of being within the system placed it predominantly in the field of interactive art, while *Dot and the Kangaroo* sits firmly in the performing arts due to audience's outside perspective and the proliferation of staged interactions.

The practitioners of the *Creature: Dot and the Kangaroo* theatre-show perceived the interactive technology as fulfilling a variety of traditional theatrical roles such as **scenery,**

**character, lighting** and **theatrical mask**. When comparing this to the research around the 2012 dance work *Encoded*, we can see that the change of performance genre has shifted the role of the technology, from the dance-oriented **movement accentuation** and **contact improvisation dance partner,** into the aforementioned theatrical roles.

The new technology created a sense of **uncertainty** in the production teams of both works, where the exact nature of the productions were not completely understood before the development period. An **integrated development period** was identified as an important step in progressing through the 'unknown' and developing **trust** in the team. Providing **sufficient access** to the interactive and immersive technologies throughout the development period was identified as an important factor to the development of these works.

The *Creature: Interactions* work was trialled in a cylindrical CAVE environment (Chapter 9) where the shift to stereoscopic 3D visuals and spatialized 16 channel sound significantly added to the sense of immersion. An activation of non-virtualized temperature, touch and olfactory senses, reminiscent of the **phantom limb** phenomena, was observed in this more immersive environment. Its potential application to live performance provides an interesting scope for future research.

## 10.5 Conclusion

This research has explored a number of aspects at the intersection of interactive art, immersive technology and live performance and highlighted some of the ways these elements can be creatively combined. The diverse range of performances undertaken has highlighted the adaptability of the technological system, allowing for different presentation formats (2D, 360º and stereoscopic) and its use in different performance genres (music, dance and theatre). The focussed discussion of two major works has demonstrated the impact that introducing this technology and cross-pollination of genres has had on the development, presentation and reception of these live theatre and interactive art productions. The findings from these two productions are representative of the extended body of work presented, but do not exhaustively cover all aspects at the intersection of these three fields. The enormous variety of performance genres, interaction aesthetics and immersive techniques that are suitable for cross-pollination provide an almost endless potential for creativity and research in future explorations. While examining only a small portion of this intersection, I hope that this research can inspire others to creatively explore the boundaries between interactive art, immersive technology and live performance.

# Appendix A

# Additional Artworks

In addition to the artworks documented in Chapter 4, a number of performances and works were created during the course of this research. These works have been omitted from the main discussion as they do not significantly further the arguments already presented throughout this dissertation. They are included here to document the evolution of artefacts throughout the entire body of work and to provide further context to the techniques and aesthetics highlighted within this dissertation.

## A.1 Pixel Mountain

Running time: 30 mins
Total Audience: 17,000
Collaborator: Stalker Theatre
Director: David Clarkson
Performers: Lee-Anne Litton, Rick Everett, Jin Young PARK, Hye Jin SHIN
Visuals: Andrew Johnston, Andrew Bluff, Boris Bagattini, Alejandro Rolandi
Video: https://vimeo.com/76746676

Gwacheon Festival, Gwacheon, South Korea (2013)
Hi Seoul Festival, Seoul, South Korea (2013)
Cerventino Festival, Guanajuato, Mexico (2014)
SummerSalt Festival, Melbourne, Australia (2015)

*Pixel Mountain* is a physical theatre show developed by Stalker Theatre in collaboration with a team of South Korean performers. It uses the technology and techniques developed for *Encoded* to create an interactive outdoor performance inspired by the unique urban mountain setting of Seoul city. The show has been performed on the side of high rise buildings, shipping containers and man-made structures in South Korea, Australia and Mexico to an audience of thousands.

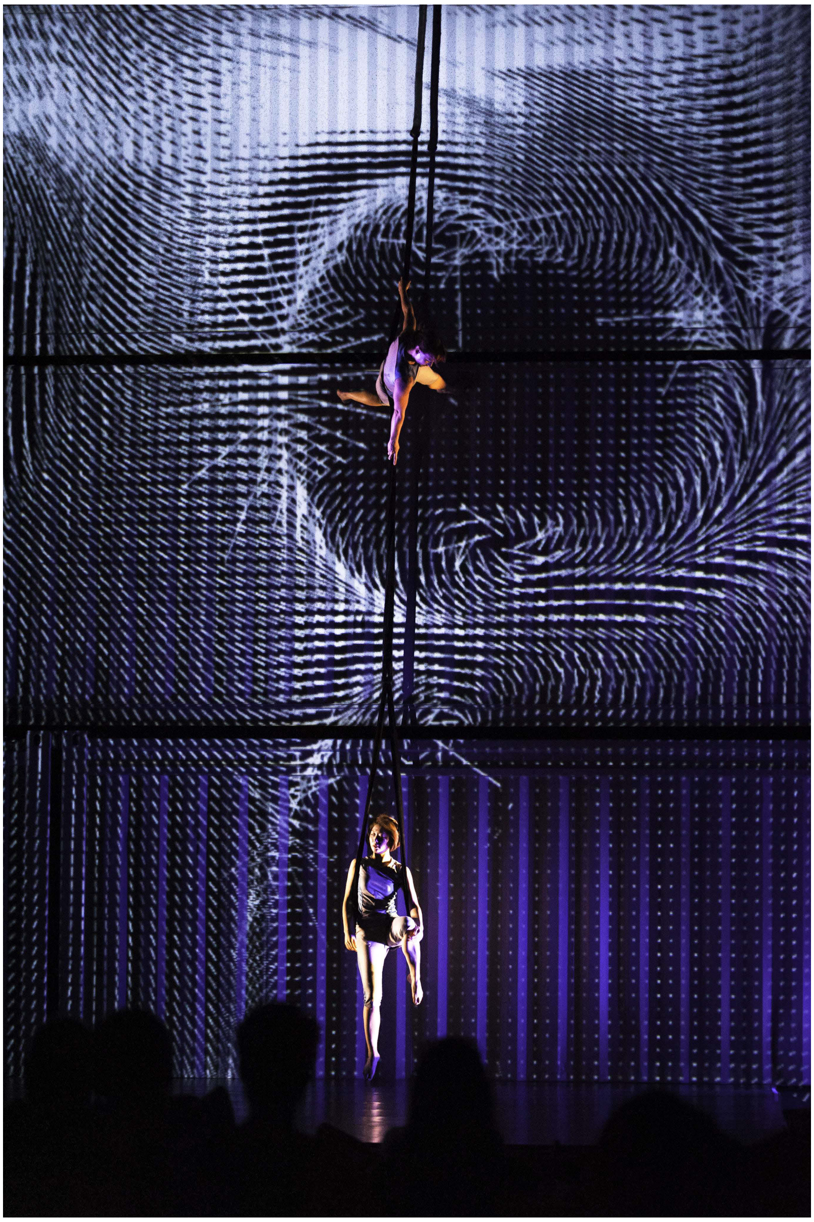


Figure A.1: Pixel Mountain

## A.2 Scream

Running time: 5 mins
Total Audience: 600
Collaborator: Chicks On Speed
Programming: Andrew Bluff
Visuals: Alex Murray-Leslie, Melissa Logan

Artspace, Sydney, Australia (2013)
Design Hub, Melbourne, Australia (2014)
Freemantle Arts Centre, Perth, Australia (2014)

An untitled interactive audio-visual collage was created for *Scream,* an exhibition of interactive new music instruments, ipad applications and fashion items curated by the art/pop duo *Chicks on Speed*. Audiences were invited to move about the space in front of a visual collage where they would trigger various sound loops and snippets of *Chicks on Speed* music. The exhibition has toured to Sydney, Melbourne and Brisbane.

## A.3 CIMF Sticks

Running time: 40 mins
Total Audience: 200
Performer: Alon Ilsar, Daniel Pliner
Visuals: Andrew Bluff, Andrew Johnston

Canberra International Music Festival, Canberra, Australia (2015)

During the development of *Sticks with Viz,* a series of fully improvised audio-visual concerts were performed for the Canberra International Music Festival. The concert featured two visual artists and two musicians and was an important testing ground for many of the visual effects created for the *Sticks with Viz* concerts.

## A.4 Airflow

Running time: 10 mins
Total Audience: 450
Performer: Linda Walsh
Visuals: Andrew Bluff, Andrew Johnston
Video: https://vimeo.com/81872794

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Newcastle Conservatorium, Newcastle, Australia (2013)
New Instruments for Musical Expression, London, UK (2014)

*Airflow* was a collaboration with oboist Linda Walsh which predates the *Blue Space* project. The *Airflow* project was a ten minute semi-improvised investigation of fluid-based granular synthesis as a performance instrument. Although similar in principle, the techniques and technology were later refined for use in the more thoughtfully composed *Blue Space* project. *Airflow* has been performed at the Newcastle Conservatorium of music, the Museum of Contemporary Art (MCA) in Sydney and at the Goldsmiths University in London.

Figure A.2: Airflow
Photo: Andrew Bluff

## A.5 Data Arena Showreel

Running time: 5 mins
Total Audience: 2,000
Visuals: Animal Logic
Soundtrack: Andrew Bluff, Andrew Johnston

UTS Data Arena, Sydney, Australia (2015-2017)

A soundtrack was composed to accompany the five minute stereoscopic video designed to showcase the immersive technology installed in the UTS Data Arena. Whilst non-interactive, the soundtrack fused together music and sound effect elements and was mixed with ambisonic surround sound technology into 16 channels. It was an impressive introduction to the immersive capabilities of the Data Arena and the combination of surround sound composition with stereoscopic visuals. The showreel is an integral part of the Data Arena demonstration material and has been shown to thousands of visitors passing through the University of Technology Sydney campus.

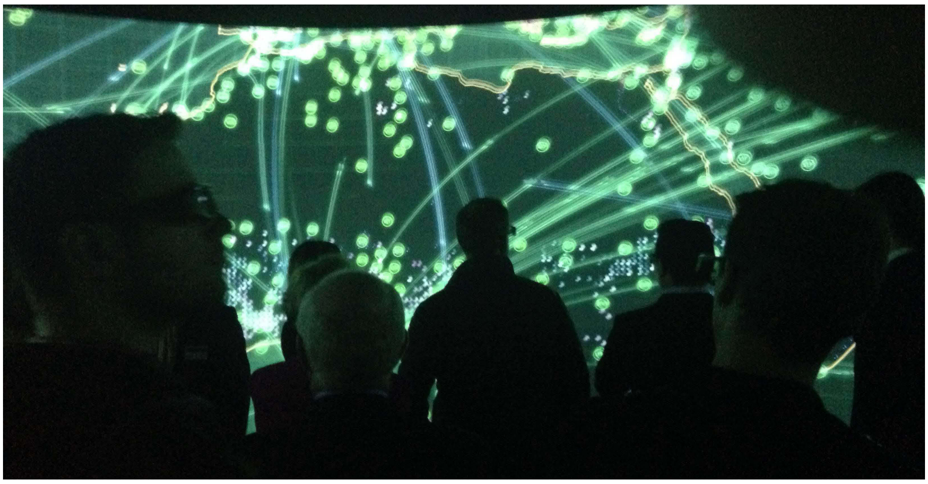

Figure A.3: Data Arena Showreel
Photo: Andrew Bluff

## A.6 DataStorm

Running time: 30 mins
Total Audience: 120
Visuals: Andrew Bluff
Soundtrack: Andrew Bluff

UTS Data Arena, Sydney, Australia (2015-2017)

*DataStorm* is the collective name for a series of 12 mini interactive works created for the UTS Data Arena. This project featured rigid body collisions in a multi-screen environment and inspired the development of the omnistereo visual technology. A number of different interaction ideals were explored, including glove-based interactions inspired by the film *Minority Report,* and the introduction of torches and water pistols to facilitate physical interactions. The interactive works were demonstrated to various conferences and educational groups visiting the UTS campus and inspired many of the technologies and interactions evident in *Creature: Interactions* and *Creature: 3D.*

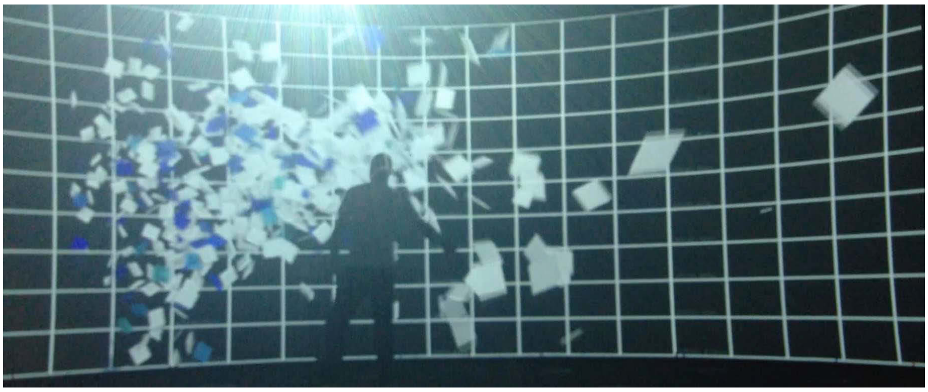

Figure A.4: DataStorm: Tron

Photo: Andrew Bluff

## A.7 Frameshift

Running time: 45 mins
Total Audience: 14,000
Collaborator: Stalker Theatre, Seoul Street Arts Festival, Creative Dandi, Drifterzcrew
Director: David Clarkson
Performers: Lee-Anne Litton, Rick Everett, Creative Dandi, Drifterzcrew
Visuals: Andrew Bluff, VuulVuul
Video: https://vimeo.com/200447205

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Seoul Street Arts Festival, Seoul, South Korea (2016)
Goyang Festival, Goyang, South Korea (2016)
Yongin Festival, Yongin, South Korea (2016)
Stockton International Riverside Festival, Stockton-on-Tees, United Kingdom (2017)

Following the success of *Pixel Mountain*, Stalker Theatre was invited to collaborate with an expanded team of South Korean artists including 5 aerialists, 3 b-boy dancers, a music composer and video artist. The production was titled *Frameshift* and explored facets of South Korean life over three separate time periods; past present and future. The work was performed at three separate outdoor festivals in South Korea and featured extensive interactive projection mapping onto three bespoke performance structures from all four sides.

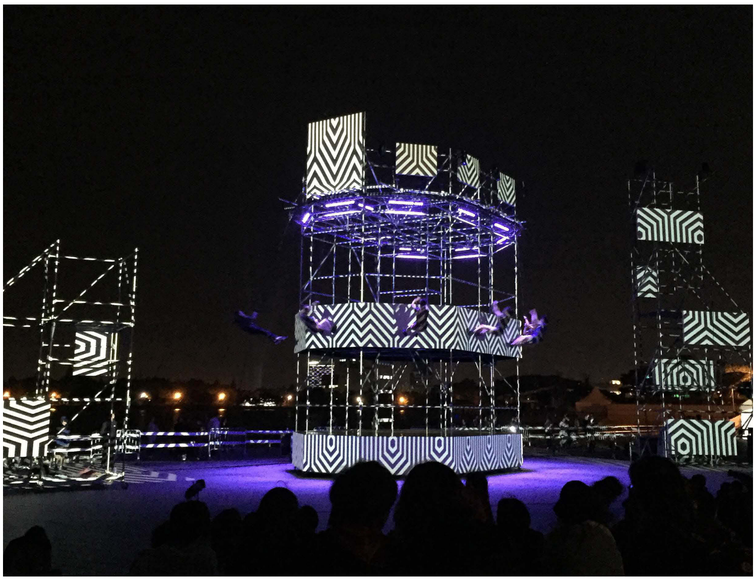

Figure A.5: Frameshift
Photo: Alejandro Rolandi

## A.8 The Hour

Running time: 60 mins
Total Audience: 300
Performer and Composer: Alon Ilsar
Visuals: Andrew Bluff, Matt Hughes
Sound Design: Danny Krass
Video: https://www.youtube.com/watch?v=ibZoayB_xuk

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Campbelltown Arts Centre, Campbelltown, Australia (2017)
Vivid Festival, Sydney Conservatorium of Music, Australia (2017)

*The Hour* is a full length audio visual concert featuring Alon Ilsar performing gestural electronic percussion with his Airsticks controllers and intricate percussive compositions on two traditional drum kits. The movements and compositional structures are visualized in real time and presented in stereoscopic 3D. The work also features live spatialized sound and projection mapping onto the two drumkits to create a three-dimensional phantom drummer.

Figure A.6: The Hour
Photo: Chris Frape

# Appendix B

# Coding

As described in the methodology (Section 3.6.2), a number of codes were generated through grounded theory's constant comparative method. They are presented here to demonstrate the way coding was performed on the data in this research. They have been grouped by chapter to indicate which sections of the discussion they directly influenced:

**Chapter 2 - Literature Review**

virtual reality, VR Continuum

**Chapter 3 - Methods**

evolution, programming, reflecting, serendipity

**Chapter 5 - The System**

depth, flexibility of technology, flocking, infrared, interactivity, point cloud, reliability, rigour, scale, simplicity, transformation, water

**Chapter 6 - Creature: Dot and the Kangaroo**

3D backgrounds, aesthetic, cast, challenge, cohesion, colour, environmental, flocking, foreground, interactivity, liveness, many elements, meaningful, multidisciplinary, music, projection as character, proscenium arch, scale, script, sound, spiritual, totem, dingo, pigeons, brolgas, moons, berries of understanding, hare, moths

**Chapter 7 - Creature: Interactions**

balance, children, crowded, dramaturgy, energy, imagination, immersion, inhibition, interactivity, magic, music, naughty, embodied, newness of the artform, novelty, passive interaction, pedagogical, play, rhythm, scale, sound, space, sublime, tasks, theatrical conventions, turning point, visibility, waving arms, workshop/installation

**Chapter 8 - Performance Implications**

budget, choreography, client, availability, collaboration, collective, developing on the run, driving blind, ego, fitting in, focussed development, lighting, multidisciplinary, music, preplanned, projection as character, projection as set, projection as mask, rigour, scrim, strategy, team, techno-fear, time constraint, trust, understanding, visibility

**Chapter 9 - Future Research**

phantom limb, sound, smell, tactile

**Unreferenced Codes**

The following codes were not directly addressed in this thesis as they lie outside the scope of the central objectives and aims of this research or lacked substantial discussion and evidence:-

avatar, satisfaction, experience, consumerism, curating, disappointed, dual characters, empathy, engagement, enjoyment, exploitation, experience, improvisation, indigenous, marketability, operation, participant as maker, permission, props, puppetry, realism, reception, restricting, self-absorbed, self-contained, slings, subversion, technology is cheaper, technology becomes dated

# Appendix C

# Memos

As described in the methodology chapter (Section 3.6.2), memos are ‘incomplete, personal and even nonsensical’ notes that are to be viewed as a part of the research process rather as any firm research outcomes. The following memos represent roughly 10% of the memos produced in this research and are presented to demonstrate the way that the grounded theory process of memoing was applied in this research:

- While A trusts D, he felt like he wanted to be more experimental. As a result he ‘disconnected’ from creative engagement with the show, focusing on ‘feeding’ others what they needed.
- ‘Driving blind’ - not knowing where it was all going to end up.
- B strategy is interesting - giving everyone a day to reflect before running off and changing things.
- We don’t know where we are going, but we have a good team, therefore we are confident it will turn out ok. This is likely to be a common theme...?
- Focusing on movement earlier on (or in more depth) would have helped get things together more quickly/effectively. Lack of choreography had an impact.
- Good to see things through ‘new eyes’ - easy to become blase about things you are surrounded with.

- Sounds a bit disappointed that the interactivity hasn't moved forward as much as it could? Impressed by the technical achievements.
- Big evolution in interactive workshops...
- Kids vs adults - Adults tend to be more shy whereas kids are less inhibited. Adults can tend to 'resist' technology but kids are more open to it.
- Can't 'just witness' interactive stuff - it demands engagement?
- Magic, fantasy, imagination - Creature left room for these. Not everything was 'hyper-realistic', overly literal. Lack of understanding or knowledge of theatrical conventions/language.
- Finding the right balance for kids in the target age group - pitching it at the right level. Respecting people's 'investment' in the work - maybe this led to decisions being made that would not otherwise have been made. Complexity of collaboratively making creative work - everyone brings their own ideas, history, etc.
- Manual control by humans over the workshop systems - as opposed to automating things? Let the person leading the workshop shape the experience - respond in the moment.
- Responding in the moment
- Reliability vs. technical evolution, cutting edgeness and stability are in opposition.
- B worked long hours because of the short time frame on such a complex piece, but B enjoyed collaborating with the team.
- Complexity of working with interactive projection and lighting. Result was simpler than originally thought.
- The difference between encoded and Creature is the narrative. Finding the costumes for Creature was more about a "Quality on body and a quality of idea".
- Wanting to make costumes become tactile through the visual sense.
- B sees that visuals become more dominent as people grow older. B is also conscious of balancing with the visuals, not being too dominent and not being dominated.

- B explains that the feeling of furry and tactile is conveyed through visuals because we have experienced it. Really nice description of artistic concept behind Dot's dress... fabric choice for reflectivity of light to give furry feeling, etching into dress to reflect the torn bush clothes and kangaroo grass is iconic grass that fed the first generations of Australian colonials.
- Digital space is related to spiritual space in Encoded.
- B explains differences brought about by projections. Interactive is easy to work with because it's white. The white clothes needed to be coffee dipped though for the lighting designer.
- B predicted the need for a coffee dip. Some conflicts are expected but must occur nonetheless.
- White costumes is a common problem with light, in theatre and in film.
- Infrared lighting didn't really bother.
- Talks about dye affecting infrared. Although markerless system is not seen, the invisible infrared system still affect the visible choice of material.
- Empathy of watching the slings and wanting to fly. Empathy is linked to immersion! Movement creates immersion and empathy.
- The 3D Backgrounds had a sense of depth. You feel like you are inside that world. The interactive projections may also contribute to this. Their response is subtle yet easy to pick up.
- The interactive projection retains a sense of 3D depth which you see in live theatre but not cinema.
- What it means to be a live work. Aliveness is an important factor.
- The beauty of theatre and humanity.
- The invite to participate in the workshop. B feels it's too structured but enjoyed the unstructured parts and E's performance.

- Facilitation was too structured educationally, would like more unstructured play She talks about ceremony, ritual and the tradition of theatre.
- We need to structure an experience for logistic reasons, but not always a good thing.
- In a gallery situation you can experience the installation as you like.
- Consumerist model vs creativity. children are too immersed in screen technology. interactive installation has an embodied response.
- The link of imagination and embodiment of children and fairy tales.
- KPIs distract adults. Adults are imaginatively blind.
- Naughty children are the best.
- B was surprised at how much she enjoyed the projections, both interactive and 3D. Good that enjoyed, interesting that this is a surprise. Could be linked to the feelings that 'I hate 3D film, but this is great!' Could be the interaction and liveness is key for 3D to make sense, or other way around... not sure.
- The projections brought a kind of old fashioned and clunky quality to the fairytale... in a good way. Kids that saw the show are relatively privileged and definitely would have seen the bush on holidays.
- VR is a bit clunky and tacky and people are daggy when they wear it.
- B likens a blindfold to virtual reality and dubs it as alienating. Interesting that a complete lack of vision and a painstakingly digitally created vision are equated so easily. It's all an aesthetic.
- Not enough time to play with things. The outcomes of development periods can be so embryonic, that it's hard to see but is the start of something much bigger.
- B didn't want props on the stage because the slings took a lot of potential room. Virtual projection can affect the physical clutter on stage... it projects a depth.
- The are three categories of light.. 3D, interactive and theatrical lighting.
- The interactive and prerendered visuals had a different depth quality even though they were both 2D. interaction and liveness give an artwork depth... theme!

# Appendix D

# Interview

In this research, 15 interviews of roughly 40-60 minutes duration were conducted with the cast and crew of the *Creature* productions. These interviews were audio recorded and transcribed. To demonstrate how these interviews were conducted, as described in the methodology (Section 3.5.2), an anonymized sample transcription has been provided.

INTERVIEWER_1: So basically if you could just start off telling us a bit about how the *Creature: Interactions* development. How it evolved and your feelings about it.

WD1: Sure. So I was initially contacted through Queensland performing arts center to get involved in the project. <Workshop Director2> was already part of the project, um, and she was heading it up from QPAC's end, um, I guess I was brought on because of my study, research and experience in using projection in live performance. And also because it was part of <Workshop Director2> 's PHD I guess, that kind of research talk or discourse that surrounds it as well. Initial meetings kind of talked about the projection and the capabilities of it in the broad way. I hadn't been down to Sydney yet and met you guys or met <Director1> and the Stalker team, so I didn't particularly get a heap out of that except kind of a bit of what it looked like and a little bit about what it could do I guess, but it was quite broad so my first...... x So my first kind of real introduction to, and I guess this was also based on the way I approached it which was from the outset I really felt like I needed a strong understanding of literarily what it could do. What are the 10-20 things that it could do so we could shape the drama workshop around that I guess, um, which was what we were tasked to do using the technology. So I didn't really get those questions answered until our first trip down to Sydney which was fantastic. We got to watch a bit of rehearsals and then during that hour lunch break we had a play with it and talked to you guys. That really was our first time of going ‘OK that’s what it does, now what workshop do we build around it that makes some sort of sense’. The other thing strangely that lead us, or perhaps not so strangely, that lead us in the creation of the workshop was what had been written by QPAC already, and I think it was written by QPAC or in collaboration with Stalker about what the workshop actually was. Because it was being advertised well before we got brought on board. So we literally went through that on the website blurb and went "OK, it does that, it does that, it has to do that , it has to do that" We kind of highlighted those things and made sure we were going to bring those into the workshop. And I guess that part of it was kind of client satisfaction really. Making sure it did what they wanted it to do and audiences got what they were expecting, what there expectations was after booking tickets and reading the blurb. And I guess those things were about, from memory. Interactive technology, child as artist, so the child making the art in the room. There was talk there about educating surrounding the Australian bush and the environment and things like that and a few other things that we tried to kind of catch them heading into it. Feel free to redirect me at any time....

INTERVIEWER_1: NO, I think that those four points that you just brought up there that were on the QPAC website. Maybe if you could go through each one of those and comment on how well we achieved those goal.

WD1: Sure I’ll just bring them up while we’re talking as well.

INTERVIEWER_1: So it was immersive, child as artist as well.... what else did you say. The educational...

WD1: Yeah I’m just bringing them up on the website. Yeah we knew one of the key principals from the festival, from the artistic director was "child as expert" so we really wanted to do that as well.

INTERVIEWER_1: OK

WD1: I’m just reading through it now. "In these workshops children take centre stage and through their artistry manipulate their surroundings." So that was kind of key to us. "They see the immediate effects that their actions have on their environment". "These exciting hands-on workshops are the perfect compliment to the Creature Experience and offer an opportunity to learn about Australia’s best loved wildlife." So heading back to the top. "An immersive digital playground. Step into and immersive digital playground." I think that was totally, you know I felt like that was there straight away. One of the greatest things I thought about it was how striking and kind of aesthetically interesting it was to stand in literally in an immersive, meaning it was around us, environment. And one of it's strongest qualities was literally how beautiful the animation was and the aesthetic choices in there. And things like the koala I heard so many times and agree how, how kind of stroking it was. I think it has to do with size, with how it moves, with how it looks. It was beautiful, and that was one of the elements that you couldn't interact with and it was one of the most striking.

INTERVIEWER_1: Did you notice people interacting with the koala despite its un-interactability.

WD1: I totally did, like but in the sense of like waving to it or calling out to it, or pointing it out to other people so that kind of more, I guess, passive interaction. But it's not particularly passive if the child was getting something out of it either. I guess the other thing that fits into the category "immersive digital playground" another of the most striking moments for me and I felt like the reaction of the audience as well was the transitions. So when we moved from one environment to another. Um, Because I thought that we also introduced those, remember during the season that we highlighted them a bit more for the kids, so "Lets climb to the top of the tree so we can see the stars" And then we all started climbing and then it went. So I guess that's a direct result of the beauty of the moment I guess, that was created through the visuals. It was like, how can we now dig into that moment and make it more immersive. More interesting, more specific.

INTERVIEWER_1: And do you think the kids enjoyed it more when you added the movement to go with the animations?

WD1: I don't particularly know the answer to that, but I would suspect as long as we didn't distract them from actually seeing it, they probably would of. So then I guess they had some more agency in the situation. They are climbing the tree therefore the projection moves and therefore we can see a different vista by the time we.. yeah. But I actually don't think I necessarily know the answer to that really.

INTERVIEWER_1: I felt like I heard as many oohs and ahhs as they were climbing up the trees, and certainly when the, <Workshop Actor1> was saying "now I'll take you to another bush" and moving his hand gesture sort of thing. There was quite a few like "oohh how did you do that. It was magic" I heard a few responses to that.

WD1: Yeah, Yeah, Yeah, So did I. Absolutely. So did I. It's interesting to, it kind of knits it all together. It makes it a more cohesive environment when a gesture can connect with the movement of the environment. As opposed to the environment just moving or it coming from words. You know just the way you moved your arms just now. That sweep was the change of the environment.

INTERVIEWER_1: I guess that's bringing interactivity into it even though it's a faked interactive presences. It's building through theatre, rather than the mechanics of the machinery.

WD1: Yeah Yeah, totally. In the past, working with this stuff I've found that as well. You know, it becomes more coherent, or visually interesting when the AV connects with movement and gesture and spoken word. You know and those two things start to connect a little bit more. So in that sense, based on that kind of principle that I've seen work before I do think, you know, the climbing the tree and then the environment changes, a gesture that suggests we are going to somewhere else, that they are good things to do.

INTERVIEWER_2: Would that be enhanced if those gestures were actually triggering the movement, as opposed to actually appearing to. Or is it not necessary.

WD1: Ah, yeah I think it could probably help. And if we started going down that path, wouldn't be interesting if he said, "Picture a tree" and then, you know he could touch the wall and a tree gets made. nothing else yet. and then "what else might be there, animals", and he touches the wall and the animals appear. "What else might be there. A big sky" He touches the wall and a big sky comes. The more, I don't think it's controlled, but the more the body and the human being live in the space can connect with the AV the better. That may be wrong but I just feel like it's probably not.

INTERVIEWER_1: Yeah, that's definitely my opinion as well. So just, on the immersive side still. So you saw it in QPAC which was on one wall, sorry not QPAC... Sydney which was on one wall and then QPAC which was on four walls. Do you think the four walls had much of an effect and if so how? WD1: Yeah, I think there's something to be said about it being 360. I think it's just kind of striking on the body and the brain. You know, when it's just one wall I guess you are just not inside it. And I don't know what that is, I guess it's the word immersive. But when you're in a space like that it just seems like kind of better art. It seems to suit the thing better, you are inside a digital environment, you are inside an animated environment. It kind of feels like you are inside a TV, you're a computer or inside a digital environment. People talk about it a lot, but I feel that really did it. When you're inside it, you're really inside it, you know. Stretching that idea to put it on the floor and to put it on the roof, technical issues aside, that kind of extends that idea even further. So I think there's something simply aesthetic about being inside an environment like that. It may also be the same if it was a visual artwork, you know. I've never been surrounded by a static visual artwork, in galleries we stand and you look at one wall that has a picture on it, but what happens if that picture was surrounding you. you know that would be interesting as well.

INTERVIEWER_1: Mmmm. I mean certainly being in a gallery space and knowing that there is art all around somehow changes your idea from just looking at one picture on one wall. WD1: Yeah totally agree, yeah totally agree.

INTERVIEWER_1: Could you comment a bit about the sound and maybe the smell as well in the space and how that all tied together.

WD1: I guess, that's again extending the immersive thing. I don't have the exact definition of immersive in front of me, but it seems to me that the world, because people were inside the world, we immediately wanted to extend that and capitalize on that. So you know <Workshop Director2> was obviously big on the eucalyptus smell. And actually heaps of people commented on that and I thought that the sound supported that. I thought one of the best moments of the sounds again it was an interaction with the live performance in the space was when <Workshop Actor1> asked people to close their eyes and said "What can you hear" or whatever and that's when the sound came up. And it was simply atmos, it was birds it was wind and whatever and I think that was a really kind of special moment. You know, and I thought the sound supported it well, you know when we had fire, we had fire sound. When we had environment we had the sound of those environments. It just kind of made sense in terms of the visuals.

INTERVIEWER_1: just out of interest.. What were people commenting about the smell. Were they just noticing it or were they into it?

WD1: Yeah, yeah I actually it was more kind of adults than children to be honest. It was like "can I smell eucalyptus or what??" "What the hell was that when I was walking in?" I think it was nice if you can open up a sense like that it's kind of interesting. Initially we asked for, I was super keen to have a big and I guess this doesn't have to do with sound but does have to do with again trying to extend what was already in the space which was an immersive digital environment of the bush. I really wanted this big tree, you know so Brisbane had just had these big storms so I was sure there was a massive tree and we could get some truck and bring it in and put this massive tree in the middle of the space so again we could have this interaction between a real bush thing such as the smell of eucalyptus or a real tree and kind of add the immersive quality of the space as opposed to what we had which was just a black theatre floor.

INTERVIEWER_1: Cool cool.

INTERVIEWER_2: Could I ask how the interaction of it added to that sense of immersion? So you talked about the scale of the projections and the way that it transitioned from one scene to another and the smell and that sort of stuff. How about the interaction of it?

WD1: It's weird because I feel like my perspective on it is probably really different to a child's perspective on it. I think , there appeared to be a certain magic in the idea that you could, or the literally the action of being able to interact with it, um, you know the question strikes me,.."Does interactivity make it more immersive?". Yeah it probably does because again you're more connected with your environment and the things that are around you therefore it's more immersive, maybe. And the interactivity for us came down to what we really tried to dig into with the drama was, "How can we extend that?" We never used this word extend, but I kind of like it now I'm talking to you. How can we extend the interactivity that you've offered through the AV. So if we move fast we can create starts so how can we drag that into the drama workshop I guess, you know, how can we unpack that in a non-didactic way. Some of it was really hard and some of it was easier but kind of came to us when we were doing it, which I also think is a key thing with this type of work. Often you need to just play in the environment for ages and see people do it and then you have ideas based on that. Um, so you know I would call the moment when we climbed the tree and everything moved an interactive moment. You know, and then there's those more hands-on interactive moments. So to simply answer you question, yes I do think it makes a more immersive when you can literally manipulate the environment around you with your body.

INTERVIEWER_2: OK, and which bits were easy to manipulate and which were hard?

WD1: Ah, so transitions through the bush I thought were easy to integrate. Ah what else did we do??....In a loose way the moon kind of became this special moment where we could all come together and have a little quiet moment around the moon.. That image was just kind of bizarre. 50 kids and <Workshop Actor1> surrounding a large moon, like what the hell? you know, you don't often see that and we probably could have extended that even further, you know like who gets the opportunity to stand right in front of the moon. No one really and <Scholar> had that idea when we were going along that it could move to the floor and we could stand on the moon. You know, and that's probably got some technical issues like we couldn't see the moon if 50 people were standing on it or whatever. But to be honest with you it was challenging to find those extensions moments of some of the interactivity. You know, but then surprising things happened like the talk about what those interactive moons were and people called them potatoes, and then we start entering this kind of abstract world when people start saying they're potatoes. It's like why are there potatoes jumping around the bush and actually I find these conversations kind of the most interesting because the children are imagining what things are and need to figure out an imaginative reasons for why they may be there, or you-know or why they can interact with them. We start heading into a weird kind of Dali environment, you know a surrealist kind of strange space which I think is quite amazing.

INTERVIEWER_1: Yeah, I didn't notice any kids, um, I mean obviously the interactive animals are these weird giant mega-creatures that are made out of strings and the stars are these abstract things and the space-potatoes are just weird. I didn't notice any kids actually questioning the weird elements to it? Did you notice any kind of reaction to that or were they all embracing it?

WD1: I think that they were just embracing it. I think that's really interesting. Yeah, for reason they get it really quick or they accept it really quick. We go from this elaborate colorful bush environment to stick kind of.. what's that directors name who makes Edward scissor kind of stick animals.

INTERVIEWER_1: Tim Burton?

WD1: Tim Burtonish kind of animals, and the children just seemed to accept that really quick and I loved that. But yeah. I think you're right I didn't see a lot of questioning of the strangeness of it or the weirdness of it which suggests that the art is good or it sits with people well. And also I think that they were just totally interested with jumping up and interacting with it really quick to see what it would do.

INTERVIEWER_2: Can you imagine other kinds of interactions that might have, we might have put it in which might have been better or, not better but would have helped?

WD1: Um, My brain always goes to, and it might be because I'm a kind of theatre director, my brain always goes to those moments of, um, of drama where we can go where. For instance one of the most beautiful moments was where <Workshop Actor1> danced and the children were kind of sitting and <Workshop Actor1> danced with that environment for the first time and it was like this every time we did it. There was a quiet that went over the audience. I think it was people were like "What the fuck is he doing? What is going on there?". and so he had this moment that opened up where he could go for a minute or two minutes kind of, kind of demonstrating to them what was possible in the room before they got up and it was kind of magical, so interaction moments like that where for a moment the brain goes... "oooh" as an audience member the brain kind of goes.. "I'm not sure what the hell is going on here. You're dancing and the wall behind you because you are dancing and then we kind of sink into that moment and he moves differently and we go "ooh and it also does that" and he does something else and it also does that. And in these instances he was either dancing, doing random dance movements or he was being an animal. When he was being an animal it kind of served our purposes better probably for the rest of the workshop and that really activated the kids to copy that and use the animals and, you know, kind of stay in that drama world in order to manipulate the walls. So I guess to answer your question, more moments like that where the interactivity was integrally connected to the drama or the live bodies in the room. In kind of some, I don't think it even needs to be narrative. <Workshop Actor1> doesn't even need to really say anything before he just starts moving in front of the wall and the wall just starts moving behind him. That's it, it's done, it's a very rich moment.

INTERVIEWER_2: Yeah cool. One thing we had played with a little bit but didn't make it into the show, for mainly just time reasons. We start playing with some props, so rather than just being full body, maybe you have I think INTERVIEWER_1 and I played with a net looking thing where you could reach up and grab a creature and start moving it and a few of these kinds of things, they might make into Creature 2.0, who knows. But do you have any thoughts about whether that's a possible fruitful path to go down or whether it's unnecessary or..??

WD1: I think on a real practical level, because it's high the interactivity would be very specific. So if you're putting something up high, the sensors are only picking up that one movement up there, and therefore the interaction can be quite specific and the audience can see how the object is manipulating the environment, so on that kind of practical level I think it would be awesome. It adds another element to what's already going on in the space, um and again if there is a drama around it I think the more that it can be connected to the story of the drama, the better. If there's not a drama around it then it simply extends the interaction which is possible in the space which I think is a good thing.

INTERVIEWER_1: I think you were originally talking about using balls and throwing balls around the space as well. Did you, what did you feel about would you have been happier about that or did you not think it needed it?

WD1: To be honest, given the amount of kids in the space they probably would have gone nuts. There was this line that we were, which is not necessarily a bad thing, you know there is kind of when we were making the drama there was this kind of energy flow that we kind of wanted to get. You know, bring the kids in, focus them, bring the energy down a little bit, release that energy a bit, bring them in and focus them again and somewhere near the end there needs to be this big energy release again, so the idea of the balls totally fits into that and also adds another element of how can we manipulate this environment... we can now do it with these balls. However within that space because of the sound and the number of students, um the number of people in that space it perhaps would have just sent the energy a little bit too chaotic and if it gets too chaotic it's like what are we doing. We are not involved in structured play. We are not particularly focused on the interactivity of the ball and wall and we're more focused on screaming and the chaotic energy of the children when it kinds gets into crazy world. The equivalent is probably when adult drink too much, it's like what's actually going to come from this. Maybe there's not a huge benefit from that pedagogically or even play wise. I'm not sure.

INTERVIEWER_1: You mention before, that you sort of instructed or showed the kids to move like animals, which seems like it was a reasonably big part of the workshop. How did that come about and what purpose did that serve?

WD1:: What do you means by moving the animals.

INTERVIEWER_1: Moving as animals. So you taught them to do the brolga, dance or pigeons or whatever.

WD1: Early on we had this moment where we were like... 'Ohh Stalker's a physical theatre company' so initially at QPAC, they were interested in having an indigenous story teller, which I was right into. Like I thought that it made sense in terms of place and time and important stories culturally. But then when we saw the interaction of the technology, when we kind of had this revelation that 'oh Stalker's a physical theatre company' and to be honest in some of the QPAC blurb on their website they were, they had mentioned the kids being physical and dancing and all this type of stuff. That's when we decided to get someone who is virtuosic in dance and movement. So essentially we tried to connect that skillset with the AV and what was in the AV. So what are the things that can move, um what is some of the movements in the bush and it always came back to the animals. And we also, you know, in doing that hoped that there was some sort of education part of it, without it being didactic that the kids are going to hear about what animals can you find in the bush, they are going to learn about new animals like brolgas and things they didn't know about. How did they move, they started to move like them and then that movement kind obviously work in our favor when we start to interact with the technology and another specific answer to it is that the technology needs movement in order move, so what type of movement should that be. And we ended up saying let's make that pretend animal movements, as opposed to dance or opposed to just swiping your hands which is kind of a default position I guess when you are interacting with the technology you just swipe your hand and you make something move. So yes, that's one movement you can do but what happens if you jump really high, what happens if eight of you get together and you jump really high. It does different things and you get a different aesthetic experience when you do it.

INTERVIEWER_1: Do you think that these movements made the kids be immersed in the experience more, or was it just a way of moving and interacting?

WD1: Um, I think it probably did help them to an extent, we were in the bush, we did talk a lot about being in the simulated bush, in a theatre. You know so we became part of the elements that are in the bush. You know and I think that I guess, the more elements in the bush that you can have in the space and I don't think it's just the AV, I think that goes back to the tree idea as well or the buckets and the props and stuff to put out a fire and things. Yes we can imagine them which is what was our fallback position when we said we don't have any budget to pay for any of this, so we had pretend buckets and I can also a very elaborate environment that has dried leaves and dirt all of the floor and a tree that has fallen down, so you have more of the aesthetic interaction between real tangible things and a digital world.

INTERVIEWER_1: Yeah, I imagine that would have changed it a bit, or certainly the introduction where you turn up into an empty theatre space which is all a bit odd. It's an interesting moment, definitely

WD1: And I think what we tried to do there was go, ok we are entering an empty room that's kind of weird and loud. How can we know... it goes back to that I think Peter Brooke the theatre director wrote.. "All you need for drama is to a body to walk across the stage", you know and because we didn't have this elaborate environment which the AV certainly gave us part of it, but what we decided to do was to pull back to that idea of just a body in an empty space and feel the magic from there. Whether that was successful or not, whatever, there was certainly also the opposite idea was to bring them into the AV straight away which also would have been beautiful, to walk into that space and it's filled with AV, but we decided to go for the empty space that turned into a magical space instead. That was kind of the dramaturgical choice at the time.

INTERVIEWER_1: Yeah it made sense, you could talk about the theatre and imagination.

INTERVIEWER_2: Could I ask, you already talked about but I want to go back briefly, you talked about the structure of the interaction or the structure of the workshop where, it was kind of like you bring them in an focus and then they go off and have energy and bring it back again. So like kind of a trajectory or a structure to it. Is there other types of structures that you'd like to explore or you think would be worth exploring?

WD1: Yeah, I guess we were just talking about, and just so you know where that comes from I guess, I always look at shows in that way as well. Whenever we were making circus shows at circa, you know, this kind of dramaturgical structure of having, we would often have seven people in the cast so often it would be great to start with a group act and the audience goes "awww" and then focus them with a solo thing or a gentle duet and then build from there and you would often finish with seven people on stage again and there would be some chunky scenes in the middle and then it's balancing the solos and the duets throughout as you go along. So it's kind of what energy journey are you taking the audience on. And obviously the music plays a lot into that as well, so that's kind of where. I think that can be applied to any show, like how does the energy journey work in this show and therefore what's the music like, therefore how many people do you have on stage and all that kind of thing. So it's kind of applying that to the workshop in a way, so and yeah there's totally kind of flexibility in that, you know we could have brought that idea we were just talking about before. We could have brought the audience directly into this kind of, you know, make it as immersive as possible straight up and we walk into that and we try to harness that energy and then we focus and delve deeper into the specifics of the space or the specifics of the workshop from there. Or indeed what we did starting quite, very quiet and building from there. Yeah, I think other energy journeys are possible for sure. The easy one is that one of walking into the immersive environment straight up. Yeah and it also makes me think of.. what are those interactive moments that can be more focused from your end. So from the AV creation end. You know there's stuff to be said for the black screen with just the stars on their own when there's movement in front of it because it's so beautiful focused, perhaps not when you put 60 people in front of it, but when there's one or two or three or four, you know it's a very focused beautiful aesthetic moment, as opposed to one of those crazy ones where everyone is running around screaming. So yeah, I think other energy structures are possible but party-mode is kind of the ending. Lets go out on a high where the kids are pumped energetic and maybe we made a mistake actually bringing back focusing and then they walk out. Maybe we should have sent them out crazy.

INTERVIEWER_1: Give them some sherbet and send them off to the parents.

INTERVIEWER_2: Fire sherbet into the air.

INTERVIEWER_2: I kind of left after like maybe the first four or five workshops, I kind of forget how many I saw now. Four or five sounds about right, maybe a bit more. I just curious could you compare what we started with the first few workshops to where you ended up in the end, because it sounds like it really did evolve quite a lot. Just how you were structuring everything and ... yeah could you just compare and contrast those a little bit.

WD1: Yeah, it's funny. From my perspective it didn't change a heap, but it did, it did settle into itself a little more. It kind of understood what it was a little bit more. We kind of picked up on kind of key moments inside the workshop that we dug into a little bit more, such as the transition moment, such as when the moon comes down, such as the first time we see the AV when <Workshop Actor1> is dancing in front of it, you know so those kind of what became for us kind of pivotal moments in the drama, we dug into them a bit more, understood them a bit more and used them a bit more so what that did was gave the workshop a better dramaturgical structure as opposed to, you know early on it had a kind of crazy energy, like kids were just running around and going absolutely nuts, like at stage we actually want, aka party-mode, but you don't want that the whole way through the workshop otherwise there's not enough kind of pedagogical engagement, there's not enough learning, there's not enough structured play and they are kind of just going nuts.

INTERVIEWER_2: Yeah, and the quieter kids get left out or feel a bit kind of, I don't know, uncomfortable I guess.

WD1: Absolutely, totally right, yeah, yeah, yeah. So if anything the evolution of the work kind of, it did that. It became more structured and knew itself better and had a better dramaturgy to it.

INTERVIEWER_2: So if you were going to do it again, would you, is there anything you'd really want to do this time that would be different?

WD1: Um, I think there's something to be said for developing the, if it's got a workshop attached to it, I think there's a lot be said for..., and there's always time and money and stuff but that aside, there's a lot to be said for the drama or the workshop being created at the same time as the AV, so that might mean that it happens at different meetings at different parts of the AV process over a 2 year period or whatever. But developing those 2 things together we get, both sides get to go "what are you thinking, what are we thinking, what are we creating and how does it work?" and things can be built like that and I think what that means if by the time you get an audience in there, it's got a cohesion to it I guess and one side is not struggling to match up with the other. They are genuinely being created at the same time in a cohesive artwork.

INTERVIEWER_2: Sort of how the theatre show was developed as opposed to the workshop. It was more or less like here is the interactive environment, use it how you want. It wasn't really.... no we did do some things in response to your suggestions, but it was what you got is what you got. More or less.

WD1: Yeah, I mean but we got the dramatic moment, and that dramatic moment which you know in that energy flow should happen 3/4 of the way through the show there should be drama. That moment for us was fire and rain and that was a response. I mean you guys gave us that and it was amazing. You gave us the key drama in the workshop.

INTERVIEWER_1: That worked really well in the show that bit.

INTERVIEWER_2: Could also just ask one thing. If you are going to extend this so, at the moment it's like 40 minutes or whatever it was, lets say you are going to make something for a full day.... um... well. A) Could you or if you had to what do you think you'd like to do.

WD1: Um... yeah wow. You know, my kind of default position is just to say yes to these things. I think for sure it could a full day thing. It's just like what else happens around it, you know. What's going on live in the space and kind of what's the thrust of the whole day, and what part is, I mean clearly the audience couldn't play with it for the whole day. We all started to get a sense of the threshold of how long could you play with this and interact with it and it being fulfilling, and then it kind of falls away. Or you've finished essentially playing with it. So I think the answer to your question is "Yeah it could totally be a full day". But it's like, what's the idea. You know, I don't think the idea is just about the interaction and the AV, I think the idea is we have 50 people in the space form 9-12, lunch break 1-5, whatever it is. What are we doing here? Why are we here? What are we doing here? What's the story? What's the theme? And if there's strong answers to those questions and there is a collaboration in making the thing... I mean sure.

INTERVIEWER_2:: Yeah, I mean one idea that I had was, to extend it, is to bring the kids into crafting the interactions a little bit as well. So maybe they learn about some movement things, about some physical theatre techniques for example or how to behave like an animal. Some of them don't need any help with that, but then also show then the technology, you know, here's how you can change the scene. Here's how you can add more particles in if you want. Here's how you can, I don't know do whatever. And then they could craft their own little show with that material that we are providing. Which is something we have done, something similar to that with older technology, a while ago. Um, so yeah I was curious if you had any thoughts about that. Whether that sounds like a plausible or interesting response.

WD1: Yeah, Yeh, Absolutely. Totally. Yeah it's kind of sophisticated art making and crossing disciplines, it's like if you can physically learn something and then you can technically learn something and then it comes together in a cohesive artwork. It's amazing. Kind of like a multi-disciplinary art class essentially. And the more, the more agency that the artist can have, i.e. can they draw a picture and then that picture be put on the wall and can that be interacted with, could it talk to you, can it become an avatar thing, you know how far can that go. I'm sure at some stage we'll literally be able to draw a picture and it can be made a hologram immediately and then you can interact with the thing and program it's personality really quickly. At stage we are going to be able to do that. So you, know people will be creating their own girlfriends and boyfriends and all this kind of stuff. You know their ideal companion at home for watching a movie or whatever. So it's kind of like back to the children idea of that, the more elaborate the art making can be... totally, you know wouldn't that be incredible for sure.

INTERVIEWER_2: Is there anything you want to say or you think we should have asked. Anything you'd like to add.

WD1: No not really, I don't think so. Um, No. No, no, no. I think it's all there.

INTERVIEWER_2: Yeah, we've covered a lot of ground so....

[End of interview.]

# Appendix E

# Ethics Consent Form

The artists and performers from the *Creature* works who voluntarily agreed to participate in this research were given the following consent form.

# Appendix F

# Publications

Refereed publications which feature work described in this thesis are listed here.


Bluff, A. and Johnston, A., "Creative Control of Granular Synthesis Using Fluid Simulation & Motion Tracking", in *Proceedings of the 2014 International Workshop on Movement and Computing*, pp. 150–153, 2014

Bluff, A. and Johnston, A., "Remote Control of Complex Interactive Art Installations", *in Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition* pp. 197--200, 2015.

Bluff, A. and Johnston, A., "Creature Interactions: A Social Mixed Reality Playspace", *Leonardo,* 50(4):360-367, 2017

Bluff, A. and Johnston, A., "Storytelling with Interactive Physical Theatre", in *Proceedings of the 2017 International Workshop on Movement and Computing,* 2017

Ilsar, A. and Bluff, A., "'AirStorm,' A New Piece for AirSticks and Storm: Gestural Audio-Visual for Electronic Percussionists", in *Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition*, pp. 389--390, 2015.

Walsh, L., Bluff, A. and Johnston, A., "Water, image, gesture and sound: Composing and performing an interactive audiovisual work", *Digital Creativity,* 28(3):177-195, 2017

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