CREATEWORLD 2016

THE CREATIVITY OF THINGS

CONFERENCE PROCEEDINGS

AUC

Conference Committee

Tony Gray, Seth Ellis, Daniel Della-Bosca, Dale Patterson

The CreateWorld 2016 papers contain cutting-edge and insightful research articles in the field of creativity applied through the use of technology. Overall we had 32 submissions, from which 9 were selected as full papers, 1 as a poster, as well as a number of workshops, seminars and exhibited works.

All submissions were thoroughly evaluated in a review and meta-review process by the Program Committee consisting of distinguished experts from around Australia. We are grateful to all our reviewers and sub-reviewers for their hard, timely, and meticulous work that provided extensive and constructive feedback to all our submissions and had a decisive contribution to the success and high quality of this event.

The keynotes for CreateWorld2016 were Dr Natalie Rusk from the MIT Media Lab Lifelong Kindergarten Group, Mr Adam Jefford from Education QLD as well as an invited talk by Professor Andrew Brown from the QLD Conservatorium of Music, Griffith University.

The paper refereeing process was conducted according to the specifications of the Australian Government for the collection of Higher Education Research Data

International Peer Reviewer Jury

- Dr Tim Kitchen, Adobe (Senior Education Specialist) & Swinburne University of Technology
- Dr Jason Nelson, Griffith University (Fulbright scholar - Norway)
- Dr Dale Patterson, Griffith University (Visualisation, Interaction & Immersive Design)
- Mr Daniel Della-Bosca, Griffith University (Visualisation & Immersive Design)
- Mr Seth Ellis, Griffith University (Interactive Media)

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Accepted Papers

Interpreting Complexity **page 25**

Daniel Della-Bosca

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A Computational Approach to a Mobile Musical Structure **page 35**

Andrew Garton

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The Power of Play Based Apps in Patient Self-Management of Diabetes **page 40**

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The Craft of Creating Accessibility in the Post-Digital Era **page 45**

Pamela See

The elevation of traditional craft practice as a form of resistance against technological development is a key attribute of the post-digital era. In this paper, I posit a sympathetic relationship between Chinese papercutting and computer art (CA). An arts-based research methodology will be applied to analyse the outcomes of an international community art project titled ‘The Float’. Undertaken between January and June 2015, it engaged over 100 young people in traditional Chinese craft workshops across Australia, Canada, China, and the USA. The project culminated in a series of exhibitions that emphasized humanity’s shared stewardship of the oceans. The artworks presented included both computer-assisted animation (CAA) and computer numerical control (CNC) cut paper. In this case study, the oft-polarized media of craft and CA were simultaneously engaged.

Seeking Spectacle – Digital Design & Construction of Interactive Physical Sculptures **page 51**

Brad Atkinson, Daniel Della-Bosca and Dale Patterson

This paper describes a project involving an extensive investigation into the manufacturing methods utilized by businesses’ seeking spectacle within the context of themed interactive physical environment’s. Two manufacturing methods in particular are in question as they have fairly similar processes, 3D printing and CNC machining. One process is additive, the other is subtractive. The paper begins by observing the theoretical ground-works of spectacle, archetype, and co-operative inquiry, including how they are used by media culture, and consequently in themed interactive environments. Subsequently a critical examination of key exemplars is described, analysing the processes and methods used to produce an understanding of not only the current industry but to expose the successes and failures of the manufacturing methods under investigation.

subtractive manufacturing’s superiority in contemporary society over additive manufacturing processes contextually grounded in large-scale themed environments and props that seek spectacle.

Digital Disruption **page 59**

Rae Cooper

The exposure of the ‘real or alternative’ has potential to be dangerous, social and interactive media allows society to communicate and share ideas that disrupt mainstream culture. Visually, these messages have potentially more power when they entertain and engage with an audience. This mode of creative communication isn’t always sustained, progressive or democratic, however they act as an archive of resistant practices and representations of ‘the other’. Practitioners such as ‘Ministry of Agnes’ are exploring protest design within the context of social media and using interactive digital communication to disseminate visual messages. This process acts as both a springboard for conversation and discussion around this creative process and design methodology.rtual Reality Rehabilitation for Special Needs

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Anjelica Hazelwood

This paper is a research document outlining whether the use of Virtual Reality devices could facilitate a new way of learning or rehabilitation for children with special needs. This document includes a test survey of students undertaking the year three curriculum and implementation towards this research question. Can using Virtual Reality films and devices improve learning for children who have special needs?

3D Scanning of Heritage Artefacts as an Interactive Experience – Creating a Window into the Past **page 71**

Chris Little and Dale Patterson

This paper uses Mephisto, the only remaining German tank from the First World War, as a case study to examine the methods available to accurately record this iconic piece of war history. It introduces 3D scanning workflows as a method to create an accurate three dimensional model of Mephisto and how to use this complete, to scale, colour model of the tank to preserve, analyse and present Mephisto in ways never been seen before. Combining 3D scanning workflows with forensic analysis and historical war records, this paper explores the possibilities of how to best communicate and present this 3D information through Interactive Realities. It describes how augmented and virtual realities can create the window into the past, possibly answering some of the questions surrounding the tank and allowing visitors an interactive user experience to give people's memories of Mephisto even more meaning.

Dancers & Technology, a Collaboration Celebrating "Corporeal Difference" **page 78**

Sonia York-Pryce

This paper examines the role of dancers who extend beyond the paradigm of age and their contribution to current dialogues in the field of dance through film documentation. This project aims to make visible the older dancer through film giving new materiality and value by celebrating the older body on screen. The research seeks to investigate which is the preferred performing body, the youthful or the mature? These older dancers choose to ignore the rationale and perform which In turn could be considered inappropriate behaviour by the western dance world. There is a need for the mature dancer to be acknowledged not only for their 'corporeal difference' but recognition that their practice rather than their age defines them.

"Collaborative Design of a Virtual Community: Engaging Students through Online Simulation (Poster)

Caroline Robinson, Ryun Fell, Tracey Parnell, Rachel Rossiter, Jane McCormack and Kerri Hicks

'Riverina Shore' is a virtual community which has been developed within the School of Community Health at Charles Sturt University as an online learning resource for students. The virtual community is presented as an attractive webpage in which client scenarios are embedded in a range of community places and spaces. This project used activity theory to inform the process of interdisciplinary collaboration between diverse groups of practitioners to create this virtual community. A reimagining of the academic hierarchy facilitated effective collaboration between media technologists, educational designers, practitioners and academics to enable the development of authentic resources. The value of Riverina Shore as a virtual community is the participation of real people in the development of the audio-visual resources. Real people, telling their unscripted story in authentic contexts, ensures that the 'messiness and complexity' of their lived experience is not diluted. Simulation scenarios must be truly contextual, reflecting effectively the real life tensions and issues which people cope with on a daily basis. The evaluation feedback from students, practitioners and academics demonstrates clearly the value of these authentic narratives in facilitating critical thinking, clinical reasoning and visualising opportunities for inter-professional practice. The learning benefits of these scenarios in which students can see clearly the connections between person – family – environment – occupation, may be more extensive than is possible through the use of digital stories. This virtual community could be used effectively to help prepare students for workplace learning experiences, especially in terms of empathy development and holistic person-focused care.

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Welcome

Welcome to **CreateWorld** - the product of a wonderful and ongoing partnership between the AUC and the Queensland College of Art at Griffith University, and now in its 10th year.

This is a unique event. Our goal is to create a space that explores the intersection of technology and creativity.

This year, our theme is “The Creativity of Things” - a play on the internet of things, and an exploration of how innovative people are using small, ubiquitous, connected devices to create art, to stimulate learning, to inspire, and to share.

The major conference tracks include peer-reviewed papers, presentations, workshops, an exhibition, and, new for this year, a hands-on area we’re calling “The Shed” where you can interact with exhibitors on a range of technology that relates to our conference theme.

Another particular focus this year is the Scratch programming language, and we’re thrilled to have Natalie Rusk, one of its creators, as a keynote speaker.

No AUC event would be a success without the hard work put in by the paper authors, session and workshop presenters, exhibition contributors, supporters and sponsors, and we thank them all for the many hours they’ve spent preparing, as well as the time they’ve given up to be part of the conference.

I’d particularly like to thank my co-chairs, Daniel Della-Bosca, Seth Ellis and Dale Patterson for the substantial work that they’ve done to bring everything together. Pulling together an event of this scope and quality is always challenging, and Danny, Seth and Dale have been a delight to work with.

I hope that you find that the next 2 days are inspiring, rewarding, and valuable, and provide you with new perspectives, new techniques, new and renewed friendships, and that you’re inspired to do great things - perhaps you’ll even consider running a session at next year’s event!

I wish you a great conference!

Tony Gray,
Chair, AUC

Our Code of Conduct

We aim to provide welcoming and professional environments so that people regardless of age, race, gender identity or expression, background, disability, appearance, sexuality, walk of life, or religion can work together to share experience in the use of Apple technology.

Please be respectful of others and be courteous to those around you. We do not tolerate harassment or offensive behaviour.

Complaints about harassment or offensive behaviour may be made to the conference organisers. All complaints will remain confidential and be taken seriously.

Any person asked by an organiser, convenor or moderator to cease harassing or offensive behaviour must comply immediately.

At the discretion of the organisers, a person violating our code of conduct may be excluded from the conference without refund.

Unacceptable behaviour includes, but is not limited to:

- offensive verbal or written remarks related to gender, sexual orientation, disability, physical appearance, body size, race or religion
- sexual or violent images in public spaces (including presentation slides)
- deliberate intimidation
- stalking or following
- unwanted photography or recording
- sustained disruption of talks or other events
- disruptive intoxicated behaviour
- inappropriate physical contact
- unwelcome sexual attention
- sexist, racist, or other exclusionary jokes

Our full code of conduct can be found at:

http://auc.edu.au/policies/code-of-conduct/

Supporters

Gold Sponsor - Adobe

Enhancing creativity in the teaching and learning process is a priority for Adobe. We believe that both students and educators can have a positive impact on a massive scale, if they have the ability to think, collaborate and communicate creatively. Industry is crying out to employ people who can creatively come up with solutions to problems that are yet to exist and Adobe have the tools to help make this a reality. Adobe is committed to supporting educators with a wide range of software and training support solutions to help improve learning outcomes.

Xcerio is a major Adobe business partner, and specialises in building and validating digital proficiency skills that lead to industry recognised certifications. They advise and educate community, academic, industry and government organisations to demonstrate how digital literacy and proficiency can advance an individual and an economy.

Exhibitors

Visit our exhibitors in The Shed (S03 Grey St. Studios, Level 4) daily from noon. In addition to their presence in The Shed, our exhibitor partners are running the following sessions:

- Steve Iuliano from Mac1 will be giving a presentation on Hyperpad—a simple iPad programming environment—on Thursday at 11:30 in S07 2.16.
- Little Bird Electronics will be running a workshop on Makeblock (an educational programmable electronic robot kit building platform) on Thursday at 1:00 in The Shed.

Partners

Pakronics (pakronics.com.au) offers components, sensors, single board micro-controller platforms and kits for makers, inventors and students of all ages to realise their electronic projects.

ATOM QLD advocates for media education in Queensland by providing professional development opportunities for teachers, advising education authorities on policy and curriculum development, and providing students with opportunities to engage critically with the media.

The Queensland College of Art (QCA) is a specialist arts and design college and, founded in 1881, is the oldest arts institution in Australia. The South Bank facility comprises public exhibition spaces, a cinema, conference rooms, a multimedia art gallery and the most modern and versatile studio facilities in Australia.

Griffith University was created to be a different kind of university—challenging conventions, responding to trends and pioneering solutions. Ranking in the top three per cent of universities worldwide, its future-focused degrees are developed in consultation with industry, based on cutting-edge research, and taught by Australia's most awarded teachers.

Keynotes

9:40 Thursday - S07 1.23

Natalie Rusk

Natalie is a Research Scientist in the Lifelong Kindergarten group at the MIT Media Lab, where she develops creative learning initiatives. She is one of the creators of Scratch, a graphical coding language that enables young people to create their own interactive stories, animations, and games, and share them with others around the world in a creative online community.

Earlier in her career, she started the Computer Clubhouse, a creative out-of-school learning environment where young people design projects with support from mentors—which now has sites in 20 countries, including four Clubhouses in Australia.

Recently, she has been inspired to meet the growing international community of educators and young people offering opportunities for others to learn coding for creative expression.

10:30 Thursday - S07 1.23

Dr. Tim Kitchen, Adobe Update

Dr Tim Kitchen is the Senior Education Advocate at Adobe for Asia Pacific and the Vice President of DLTV (Digital Learning and Teaching Victoria). He is also the Co-Director of the Building Bridges interfaith dialogue program in Melbourne schools.

Tim is on the sessional teaching staff at Swinburne University of Technology in Melbourne where he teaches ICT in Education and also works casually with Wilkar Productions as a video producer, camera operator and editor. A passionate advocate for creativity in education, Tim is a regular writer and presenter for a wide range of national and international journals and conferences.

Tim will talk about Adobe's latest product updates, including announcements made at the recent Adobe Max conference in San Diego.

9:00 Friday - S07 1.23

Adam Jefford

Adam is the Head of Creative Industries at Pimpama State Secondary College and a past Queensland-Smithsonian (Cooper-Hewitt) Design Museum Fellow.

In 2016, Adam was awarded a Good Design Award (one of Australia's most prestigious and diverse design assessment programs) for Jump Start – a design thinking and social entrepreneurship program empowering school students to make a positive change in the world through design-led creativity and entrepreneurial endeavours.

Adam is passionate about opportunities to engage critically with contemporary learning experiences in Art & Design education in Queensland.

The Shed

The Shed is an iconic fixture of Australian backyards—a place to tinker, experiment, build, invent, and be creative, and at this year's CreateWorld we've used the shed as inspiration for a new kind of conference space.

Lunches and afternoon tea will be available in The Shed, as will our exhibition partners. But The Shed isn't a static space - it's a place to socialise, engage, interact and take a break from the main conference sessions.

Scheduled events in the shed include:

Thursday	
12:00	**Lunch**
1:00	**Workshop: Makeblock and Mbot by Little Bird Electronics**
3:00	**Afternoon Tea**
3:30	**Workshop: Build Your Own Guitar Distortion Pedal**

Friday	
1:00	**Workshop: iPad Game Development Using Pythonista**

In addition, the following booths will be open from 12:00 until 5:00 Thursday, and from 12:00 until 4:00 Friday.

- ATOM Qld
- MAC1
- LittleBird Electronics (Thursday only)
- Xcerio, discussing Adobe, Microsoft & Autodesk Certification options.
- CJ Anderson, demonstrating AutoDesk Fusion.
- Paul Bardini, demonstrating AutoDesk Circuits.
- James Novak and Troy Baverstock - hosting the Queensland College of Art student showcase.

Exhibition

Digital technology is moving beyond the digital ecosystem, off the screen and into the physical world. The work in the CreateWorld 2016 exhibition, *The Creativity of Things*, explores the way in which different practitioners have engaged with technology, objects, physical experience, and the limits of the seen and unseen worlds. Works range from interactive objects, to investigative photography of the microscopic world, to projects that combine the two.

The *Creativity of Things* features artists based in Brisbane and elsewhere, including several U.S. artists represented in video documentation. Artists include:

Robert Andrew
Jenna Baker
Paul Bardini
Troy Baverstock
Sophie Brueckner
Chris Cassidy
Roland Graf
Louise Harvey
Matt Kenyon
Ross Manning
Phoebe McDonald
Jane Prophet
Svetlana Trefilova
Anastasia Tyurana
Lee Walton and Derek Toomes

The exhibition is open to the public 6-11 December in the Webb Gallery, on the 2nd level (ground floor) of building S02, the Webb Centre. The gallery's hours are 10-4pm daily.

An informal reception for the conference will be held in the gallery 8 December 6:00-7:15, ahead of the conference dinner.

Papers Track

Each session in the papers track is expected to last approximately 20 minutes, with up to 10 minutes of followup questions and discussion.

1:00 Thursday - S07 1.23

Interpreting Complexity

Daniel Della-Bosca

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Papers Track (cont.)

9:45 Friday - S07 1.23

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11:00 Friday - S07 1.23

Virtual Reality Rehabilitation for Special Needs

Anjelica Hazlewood

This paper is a research document outlining if the use of Virtual Reality devices could become a new way of learning or rehabilitation for children with special needs. This document includes a test survey and implementation towards this research question.

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Papers Track (cont.)

2:00 Friday - S07 1.23

Collaborative Design of a Virtual Community: Engaging Students through Online Simulation

Caroline Robinson

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The evaluation feedback from students, practitioners and academics demonstrates clearly the value of these authentic narratives in facilitating critical thinking, clinical reasoning and visualising opportunities for inter-professional practice. The learning benefits of these scenarios in which students can see clearly the connections between person – family – environment – occupation, may be more extensive than is possible through the use of digital stories. This virtual community could be used effectively to help prepare students for workplace learning experiences, especially in terms of empathy development and holistic person-focused care.

Dancers & Technology, a Collaboration Celebrating "corporeal difference"

Sonia York-Pryce

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Presentations Track

11:30 Thursday - S07 1.23

Cloud-based Data Collection in Academic Research

Stoo Sepp, University of Wollongong

This presentation will cover a novel experimental design that uses cloud computing that Stoo is using for his PhD, specifically BaaS (Back end As A Service) to remotely collect and analyze data. Using Google's Firebase Real-time database, an app designed for learning geometry will track user interactions, record scores and automatically upload the data, immediately ready for collection and analyzation. By taking this approach, data collection and data analysis is drastically reduced, giving the researcher realtime results, instead of having to wait for it.

11:30 Thursday - S07 2.16

HyperPad – Coding & Game Design

Steve Iuliano, MAC1

Use simple block and visual based coding techniques to do amazing game design including creation and inclusion of original art work, music, sound effects, animation, and more. Line coding can be incredibly complex if you are new to coding, but imagine creating a professional looking game that you can sell on the App store in an incredibly short period time using your own creations, media and materials instead of relying on inbuilt images and sounds. Coding seems to be in fashion, but many find it hard to use coding across multiple KLAs (outside of Maths and Science) in educational institutions – and this can all be done from an iPad… and for FREE!

3:30 Thursday - S07 1.23

Developing Students' Thinking Skills through Coding in the Primary School

Garry Falloon, University of Waikato

Coding and computational learning activities are becoming integral components of school curriculum in many countries. Often arguments for this centre on the need to develop what are seen as future-focused skills and competencies, and to engage more young people in ICT-related careers or study. These competencies comprise more than technical skills, encompassing dispositional elements such as creativity and innovation, and general cognitive capabilities such as complex and higher order thinking. Indeed, the development of a digitally literate, innovative and flexibly-skilled workforce is seen by many governments as key to future economic prosperity and social well-being. However, while these goals are admirable, limited empirical evidence presently exists that computational activities like coding actually support young students to develop these capabilities.

This presentation summarises findings from a two year New Zealand Government-funded study into the nature of thinking skills students apply when engaged in coding activities. It used an innovative recording tool installed on class sets of iPads to capture video and audio data while 5 and 6 year old students were completing a range of coding tasks that were integrated into a Geometry topic, using Scratch Jnr. Data were analysed against a thinking skills model based on Krathwohl's (2002) adaptation of Bloom's Taxonomy (cognitive domain) and Brennan and Resnick's (2012) framework for evaluating computational thinking, to discover the extent to which coding provided a useful means of building general and higher order thinking skills. Data will be presented and discussed highlighting key outcomes from the study, and useful guidance provided for teachers wanting to explore coding as a means of building thinking competencies in their students.

Presentations Track (cont.)

4:15 Thursday - S07 1.23

Podcasting for Fun and (sometimes, but rarely) Profit

Peter Wells, UNSW Australia

Join the podcast renaissance with this fun talk from Peter Wells, who's been podcasting now for almost 10 years. This will be a hands on demonstration on the tools to use to get your lecture series turned into a podcast – or to create a show for your faculty, school or department. Or maybe just for yourself.

5:00 Thursday - S07 1.23

Using the Smithsonian Learning Lab to Promote Innovation Thinking

Chris Campbell (UQ) and Kathy Mackey

Innovation Thinking is a broader cycle of inquiry that allows teachers and students to use and embrace STEAM problem solving across a range of curriculum areas. This builds on the traditional design cycle and explores economic and historical applications including the pre-conditions for invention, how we learn to recognise the unusual and to see new connections and possibilities. This presentation will combine the innovation thinking and the Smithsonian's new Learning Lab. Participants will work to remix and repurpose resources to form digital collections online in the Learning Lab and will plan how to draw from museum resources to design an innovative solution, product or service. The Smithsonian Learning Lab is a new online platform that allows educators and students to discover the 1.5 million resources, as well as create their own collections using a variety of resources including the Learning Lab's. Participants will also share their created collections with others such as other teachers and potentially their students.

This presentation is hands on with participants completing activities on the cycle of inquiry and also using the learning lab to enhance their knowledge of Innovation Thinking.

9:45 Friday - S07 2.16

Designing Meaningful Interactions for 3D Touch

Stoo Sepp, University of Wollongong

This presentation will cover the visual design of interactive objects intended for 3D Touch on the iPhone 6S and later. Given that depth is a new way users can interact with apps, developers and designers need new ways to demonstrate these affordances. As part of this presentation, we'll look ways to indicate depth visually, as well as demonstrate ways to indicate to the user how 'deep' they are pressing, as well as going into the basic APIs that allows this sort of functionality using Xcode.

10:15 Friday - S07 2.16

Final Cut Pro X: Way Better Than You've Heard

Iain Anderson

Since its release, Apple's flagship non-linear video editing app has battled the internet hive mind's collective opinion. While the initial release had its rough edges, today it's a professional package used far more widely than the herd suspects. The latest 10.3 release adds in new features for professional workflows, like roles-based audio mixing and MXF export for broadcast, along with a clean new UI for everyone and countless handy little features besides. This session is for anyone who's heard of Final Cut Pro X but never really seen it in action, for anyone working with video or teaching editing, and for experienced users who want to know what's new. After a quick look through the UI and all the new features, I'll show how fast it really is to import, organise, edit, add titles, color correct, and export in FCP X. Bring your questions and I'll do my best to answer them honestly. Pretty pictures promised.

Presentations Track (cont.)

11:00 Friday - S07 2.16

Creating Apps and eBooks for Education with Adobe Experience Manager Mobile and the Adobe Creative Cloud Suite

Hohepa Spooner, Auckland University of Technology

Mobile applications and eBooks can be built in number of ways. At AUT University we have chosen to use the Adobe Experience Manager Mobile system, the Adobe Creative Cloud Suite. Using iMacs and MacBooks with Adobe InDesign and Adobe Muse and other Adobe Creative Cloud applications the process concentrates on the design, layout and functionality of the app and eBook without the need to code.

This presentation will look at the Mobile Apps and eBooks that we have created at the AUT Centre for Learning and Teaching, and the Faculty of Māori and Indigenous Development – Te Ara Poutama and how they are used in teaching and learning in various faculties and departments within the university, and AUT University events on our three campuses.

The use of the Adobe Experience Manager Mobile system and Apple iBooks Author for producing student assessment work will also be presented.

11:30 Friday - S07 2.16

Arduino + Music

Matt Gray

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects. This session will take you through using Arduino as the basis for various music projects.

We will cover MIDI interfaces and how to code an Arduino to be the bridge between your instrument and the real world. You'll learn how to either take input from the physical world and turn that into music, or how to play music and have that affect real world objects.

Hardware requirements will be covered, so you will learn what you might need to purchase to get started. We will also go through some of the cool music related projects that the Arduino community has put together.

3:00 Friday - S07 1.23

Human-machine Agency in Interactive Music Systems

Andrew Brown, Griffith University

Much of my creative work involves the design and use of algorithmic music systems intended to facilitate a close creative partnership between musician and machine. But what does it mean to design and construct such instruments, to make an interactive music system with a sense of creative agency that evokes a rich sense of creative interplay? In this presentation I will discuss some of the issues that arise for me in this activity; examining both conceptual and design perspectives in the context of making and playing original interactive musical systems and devices.

Workshops

1:00 Thursday - S03 4.18 The Shed

Makeblock and Mbot

Marcus Schappi, Little Bird Electronics

Makeblock and the Mbot range are not just your regular off the shelf STEM project in a kit form. Makeblock, which is the programming environment based upon the Scratch framework and the Mbot range offer true creativity with robotics. Using precisely made and interchangeable chassis, mechanical and electronic components, there is no limit to what can be created and explored from all terrain robots to drawing machines. Makeblock and Mbots are designed to make learning and understanding the underlying technology and engineering pleasurable and that makes them the perfect tools for creative expression.

1:00 Thursday - S02 3.06

Adobe's 3D Solutions with Photoshop, Fuse and Project Felix

Richard Turner-Jones, Adobe

Creative content has evolved from the two-dimensional space of the printed page to an immersive experience of rich media. 3D tools have traditionally had a steep learning curve and difficult to quickly achieve results. With that in mind Adobe's design apps brings a rapid and intuitive workflow to the third dimension, whether generating images, characters for games and videos or 3D printed objects.

This workshop, which will be run by Richard Turner-Jones (Adobe Solutions Consultant across all three Clouds) will demonstrate adding extra dimensions to the creative work flow with Adobe Fuse (Preview) for creating humanoid characters, Photoshop's box of tools for creation, texturing, rendering and 3D printing as well as the recently announced Project Felix (Beta).

2:00 Thursday - S02 3.06

Great looking Websites without coding using Adobe Spark Post, Spark Page, Photoshop & Adobe Muse

Dr. Tim Kitchen, Adobe

Most people who are serious about website design and development have Adobe Dreamweaver as their tool of choice however, there are other options, especially for those designers who are not so keen on coding. Adobe Muse is an HTML development tool that requires no coding knowledge. It builds great looking and very functional websites that are responsive aware for all screen sizes.

This workshop, which will be run by Dr Tim Kitchen (Adobe's Senior Education Specialist for Asia Pacific) will go through the workflow of building site assets via the free Adobe Spark Post app as well as Photoshop, then linking them to an Adobe Muse website. It will also demo the simple free Adobe Spark Page app that makes free web pages in seconds that are hosted for free by Adobe.

Workshops (cont.)

3:30 Thursday - S03 4.18 The Shed

Build Your Own Guitar Distortion Pedal – an Introduction to Electronics

Matt Gray

This workshop will get decidedly old school, showing how to make your own guitar effects using actual hardware (rather than clicking buttons in Garage Band). Bored with the two billion transistors in your Macbook? Come see how creative you can be with two transistors instead.

We will start with electronics basics, including resistors, capacitors, diodes and transistors, and move on to how to stick them in a box to make your guitar playing sound just like Hendrix.* We will talk about sourcing your components, including hard to find 'mojo' parts for that special unique sound.

For those who are interested in creating stuff other than guitar stomp boxes, this workshop will cover basic electronics and hardware prototyping. If you have been interested in electronics but didn't know where to start, this workshop will get your diodes pointed in the right direction.

(*Workshop may not result in you actually sounding like Hendrix.)

3:30 Thursday - S02 3.06

HTML Animations & Mobile App Development with Adobe Animate CC

Richard Turner-Jones, Adobe

Adobe Animate CC (formerly known as Flash Professional CC) is an application with a rich history of animated and interactive content creation. Whilst Flash output is still forefront it shares that stage equally with additional content types. Mobile friendly formats including HTML5 and WebGL, video export up to 4K and iOS & Android mobile app development, testing and deployment are all part of this creative tool box.

This workshop, which will be run by Richard Turner-Jones (Adobe Solutions Consultant across all three Clouds) will demonstrate core functionality of Animate CC, including HTML5 and Video output as well as Mobile App publishing. In addition the workflow for content creation and enhancement with the Creative Cloud tools will be exhibited.

4:30 Thursday - S02 3.06

Simple Video Solutions with the free Adobe Premiere Clip (iOS & Android) & Adobe Spark Video

Dr. Tim Kitchen, Adobe

Adobe are the industry leader in video editing software. Premiere Pro & After Effects are standard tools in TV, video and film production. Most students and teachers however don't need the full functionality of Adobe's professional video making tools so a great alternative is the free Adobe Premiere Clip (iOS & Android app) and the free Adobe Spark Video app (iOS and Web based).

Clip & Spark Video allow the user to make a great looking and sounding video in minutes. This workshop, run by Dr Tim Kitchen (Adobe's Senior Education Specialist for Asia Pacific) will show how easy video production has become.

Workshops (cont.)

1:00 Friday - S03 4.18 The Shed

iPad Game Development Using Pythonista

Chris Robinson, Aberfoyle Park High School

Would you like to write an entire app or game on your iPad using nothing but Python code? This beginner workshop is based around using the Pythonista app to rapidly prototype an iPad game right on the iPad. No computer required!

Participants do not need to have any prior Python or app development knowledge. This workshop will also showcase some of the work I am currently doing with my student app developers and feature a how-to on packaging the finished code ready for distribution on the App Store.

1:00 Friday - S02 3.06

Introduction to Robotics with Arduino and Scratch

Alex Jacobs and William Douglas, Coder Kidz

A lot of people label Arduino as “Lego for techy adults”, and it’s true, at least in the sense that it lets you create amazing things by combining a bunch of tiny little components together into all kinds of arrangements. But it’s much more than that, too. Not only is it a lot of fun, but along the way you’ll sharpen your mind, pick up several useful real-life skills, and build a bunch of satisfying stuff.

You don’t have any coding experience? No problem, you don’t need to! Using our Scratch Extension called Eve you can start working on your first Arduino project within few minutes and learn how to control servos, motors, LEDs as well as reading and using data from sensors.

1:00 Friday - S02 3.05

TouchDesigner; Audio-reactive Visuals for Performance

Jason Haggerty

Join Jason in creating audio-reactive visuals and a custom made control-panel in the procedural programing platform, TouchDesigner. Perfect for artists, developers, and all kinds of tinkerers, TouchDesigner allows for very flexible programing from user-interfaces and complex real-time geometry, to data visualisation and interactive environments.

3:00 Friday - S02 3.06

Mobile App Design with Adobe Experience Design

Richard Turner-Jones, Adobe

Up until now UI and UX designers have had to juggle multiple tools to plan, develop and review their mobile apps. Looking to address the need for a single streamlined application, Adobe Experience Design (XD) has been released. Designed and developed from the ground up and actively involving the creative community, it brings wireframing, design and rapid prototyping of desktop and mobile app development under one application.

This workshop, which will be run by Richard Turner-Jones (Adobe Solutions Consultant across all three Clouds) looks to develop an application from idea to interactive review, highlighting tools and workflows that bring the rapid to RAD (Rapid Application Development).

General Information

Registration Desk

The registration desk will be based inside the entrance to S07 The Graduate Centre.

Meals & Refreshments

Lunch and afternoon tea on Thursday will be served in "The Shed" on level 4 of S03 (Grey St. Studios).

The **conference dinner** will be held on Thursday night at the Ship Inn, a short walk from the S07 (The Graduate Centre). Spaces are limited to people who indicated they would be attending at the time of registration.

Friday morning refreshments will be on the ground floor of S07 (The Graduate Centre).

Friday lunch will be in the board room on level 7 of S02 (The Webb Centre).

Caterers have been provided with special dietary requirements as specified by delegates at registration time. Please understand that it may be impossible for caterers to address any special requirements not notified at least 7 days in advance of the event.

Please note that QCafé in the Grey St. Studios building is privately owned and operated, and not part of the catering for CreateWorld. You are welcome to purchase food and beverages at your own cost.

Internet Access

Wireless internet access is available and access details will be provided at registration time. If you are from an institution that supports **Eduroam**, you can use your originating institution credentials to connect.

Emergency Contacts

QCA Campus Security - dial 7777 (from internal telephones) or call 3735 6226.

For all emergencies, call triple zero, 000 or 112. Most mobile phones will call 000 (for Emergency Services) even when no credit is on the SIM card.

Conference Contacts

Tony Gray - 0432 018 441
Daniel Della-Bosca - 0419 735 095
Seth Ellis - 0490 220 740
Dale Patterson - 0402 817 403

Conference Chairs

Daniel Della-Bosca is a lecturer in fine art, design and interactive media at the Queensland College of Art, Griffith University. He has worked and exhibited nationally and internationally as a designer and artist and is committed to the advancement of art and design education. Daniel's primary research focus is the application of fractal mathematics to the field of aesthetics, and his specific skillsets are the interdisciplinary bridges between art, design, CAD software and algorithmic generation of image and form. Daniel has a portfolio that spans public sculpture, exhibit design, jewellery and animation, all for the purpose of engaging in visual and haptic discourse.

Seth Ellis is senior lecturer in interactive media program at the Queensland College of Art, Griffith University, where he is program director of the Bachelor in Creative and Interactive Media. He is a narrative artist and interface designer; his work draws upon local history, allegorical narrative, and experience design to create stories both historical and fictional in new, experiential forms. Seth as worked with local museums and galleries on their collections and exhibitions; his own projects have shown in galleries, streets, symposia and festivals throughout the U.S. and Europe, and at a few places in the Atlantic Ocean.

Dr. Dale Patterson is a computer scientist and lecturer in Digital Design, Visualization and Interaction. Dale has worked in the field of computer science both commercially, in education and research for more than 20 years (focusing on 3D computer graphics and its applications). Dale's primary areas of interest include human computer interface design, VR & AR, 3D computer animation, visual effects and games. Dale also has strong research interests in computing as applied in bio-medical applications (e.g., scientific visualization, applied games & learning, artificial intelligence).

Tony Gray has been Chair of the AUC since late 2010. He is a software developer and educator with over 25 years of experience providing IT support in the University sector, and is co-chair of the AUC's other two conferences–/dev/world for software developers and X World for system administrators. Tony also writes for O'Reilly Media on the Swift programming language.

About the AUC

The AUC was established towards the end of 1984 as a partnership between Apple Computer and nine Australian universities.

At the heart of the relationship was the ability for departments, staff and students to obtain Apple technology at reduced prices and to enable the development of innovative solutions using the Macintosh. The AUC grew to form a network of educational technologists across the universities of Australia and New Zealand, growing to 37 member universities by 2012.

The history of the AUC is one of adapting to change, and in 2013 we reinvented ourselves as a not-for-profit association with no formal relationship with Apple. Our mission is to support and build communities around the use of Apple technologies by sharing experience, insights and know-how amongst members, developing people as leaders, and inspiring and fostering innovative use of technology.

Each year, we hold three conference events for specific subsets of our community. **X World** is for system administrators and support staff, **CreateWorld** is for performance artists, teachers, and those working in the creative spaces, and **/dev/world** is for software developers. Our conferences are open to all.

Learn more, including how to become a member, at www.auc.edu.au.

Interpretations of Complexity

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Abstract
Three dimensional fractal forms are most often generated as point clouds and then converted to mesh objects. The resultant meshes are subsequently quite large in file size and irregular when viewed alongside similar parametrically derived forms. Mesh conversion to NURB curves and surfaces is a conventional process of reverse engineering from scan data but is unique when used to interpret algorithmically derived fractal forms. This paper explores the process of translating the forms in a technical sense but is largely concerned with the conceptual issues of navigating software applications of shape grammar and of the issues regarding spatial reasoning within the Cartesian frame

Keywords
Fractal, Complexity, Holon, Mesh, NURBS, Creativity

Introduction

Generating new forms is difficult and time consuming. It is expected that an artist or designer produces works of novelty or for novel purpose. This pressure to innovate requires creative output that equates to, new combinatory outcomes. The requirement to innovate is both simultaneously exhilarating and exhausting, that is my experience and perhaps the experience of many.

Creating new forms requires a substantial inventory of pre-existing forms and a requisite capacity in human memory of shapes and forms and all of the subsets of those shapes and forms, inclusive of line and curve type, surface pattern, texture, colour, dimension and more. In stark contrast to memory however, Computer aided modelling uses predefined workflows and regulated operations in order to generate new forms, and at the core of this process is the initial generation of two dimensional curves or lines that can then be extrapolated to three dimensional forms through processes such as extrusion and lofting to name but a few.

The parametric workflow is common to many CAD software applications and functions well because it preserves a history of all mathematical operations used to describe an object or objects. What is however restrictive is that this process uses a limited parameter set and many examples of industrial design software in particular (to a novice) uses the language of industrial processes, subtractive fabrication for example.

The idea of mechanical and industrial design is that the outcomes can be manufactured, and importantly can be manufactured to great dimensional accuracy at large quantities and are repeatable using conventionally available manufacturing processes. CAD and Parametric workflows were designed around manufacturing processes and are still heavily influenced and somewhat constrained by those processes and the economical imperatives of large scale manufacture. The constraints are shifting of course and new processes such as additive manufacturing permit changes to how objects/forms are mathematically described.

As someone who is relatively experienced at using solid modelling applications that contain parametric kernels, I must admit that there is something quite comforting and obsessively pleasurable about repeating the same processes and being constrained by them in turn. There is a creative challenge in seeking answers to new problems posed by goals constrained by restrictive workflows. That creative challenge however can often reveal the burden of design software and the angst that ensues when the creative brain is conditioned by pre-defined algorithms, as to how something should be made.

As someone who began my career as a sculptor, I was initially attracted by a discipline containing a vast array of intrinsically deep and rich processes, stretching back millennia. Shape grammar alone owes a great deal to sculptural processes and enquiry, especially from periods when sculpture and architecture were intrinsically interconnected. Thousands of years of working with clay alone exhibit a complexity of forms that CAD modelling is only now beginning to describe. It is obvious that for a time design and art had differing purposes and the foundations of consumer culture beginning in the industrial revolution certainly helped shape manufacturing processes which in turn helped shape design paradigms. The functional artefact has left its mark on society and its echoes in computer aided design.

I believe in the view that, we, as a society have certainly been conditioned by our tools. CAD software for instance shapes how we think, it liberates the repetitive task but it constrains the set of opportunities. It is however just a tool and can be refashioned or adapted or co-opted at will, with experience and dedication of course. Some tools are easy to refashion, making changes to software requires particular and unique skillsets, this is imperative, but to most of us, adaptation co-option and even subversion is certainly applicable.

Philosophically, it becomes imperative to address the notion of the tool and as Alva Noe states, Tools and technologies are central to our lives and they become habitual and organize us[1].

The tool as in the modelling process is refashioned from application to application. There are some old favourites that have a trusted user base particularly in the engineering community, software from pro engineer and Autocad through to contemporaries such as Solidworks and inventor. The commonalities are the communities of users they serve, and the paradigm of the engineer and industrial designer. Shape creation using the toolsets of solid modellers as mentioned have had a history of tending toward subtractive manufacturing frameworks. It could be said; that the process fashions the tool which in turn fashions the process.

The disruption of additive fabrication affords a reshaping of process or the adoption of new processes which permit a change in tool. The software applications now have the ability to radically change, grow and adapt to changes in additive manufacturing processes. The users of the applications and processes also have the ability to change and adapt to new (and unusual) creative potentials. The paradigm of engineering and industrial design shifts and we in turn, are reorganized by our tools.

The points I wish to raise in the next section are in regard to how the lexicon of shape grammar, grows, changes, adapts as a result of the affordances of new and changing tools. Design and particularly industrial design has had a tendency toward the refinement and simplification of form. The simplification of form in industrial design however, can be seen as a circumstance of process and tool. The artefact is not the best artefact it can be simply because it is simplified it is simplified to suit the economics of the manufacturing process.

Sometimes the tool, the software, is very useful in modelling highly complex forms. This is becoming increasingly more apparent as new software applications emerge to service additive fabrication, or as software applications unintended for the manufacturing paradigm adapt, as it is realised that new potentials exist and can be attained.

Cartesian Reasoning

Education used to include and favour some very old and revered notions of geometry. A good foundation of the understanding and application of geometry, geometrical systems and application underscored a ‘classical’ education right through to the end of the twentieth century. It is my experience as an educator and practitioner that unfortunately, (from my perspective as an educator) geometry has less support in secondary and tertiary education than it should. The chief reason I make this argument is that spatial reasoning which underpins our navigation in the world and negotiation of the world, is not well developed unless a thorough body of knowledge regarding geometrical systems is experienced, applied and critiqued. The Cartesian co-ordinate system is crucial to the understanding of space and yet it is applied but rarely understood in terms of its historical origins, and its necessary conventions. Cartesian coordinates define objects precisely in computer displays, software applications for three dimensional design and modelling and has been the dominant method of definition for the history of computing.

The reason I speak of the Cartesian system now is so the premise can be entertained that Cartesian space is (mostly) required to define the geometries that we commonly understand. And it must be thought of as a premise, as Cartesian space is an elegant tool for enabling many, many processes, but it is just that, a tool, the tool could be changed and the result would be, that the processes of definition would change as well.

It is a simple premise, possessing a mindset shaped by the three dimensional domain of length, breadth and height lends itself well to applications of this tool in processes that exploit the simplicity of Cartesian space. If we are conditioned to think in boxes, we will continue to build boxes. The cliché is true, it often is applied in the most banal and metaphorical environments, but our spatial reasoning in regard to Cartesian space requires constant critique.

Rene Descartes shaped his view of coordinate space to house Euclidean geometry and support it with a algebraic framework. There is no denying the brilliance of Descartes coordinate system and why it has shaped our world till now. Many mathematicians have contributed to the geometries described within the parameters of this space and countless new contributions to shape and form have been made, but the space itself, just as the software applications that utilise it, is just a tool that requires us to understand it as such. By this I mean we need to understand its constraints as well as its benefits.

Using the language of computer aided design, terms such as curve and spline have real world significance in respect to the object being modelled for specific purpose. Cartesian space requires a curve or a spline to have a precise mathematical definition which most users are not overly conversant with. These definitions are precise and concrete but in a sense they are conceptually abstract to the designer or user of the software. What I mean is, these definitions are not usually directly relational to the intent of the designer, and they exist to achieve a goal. It seems as software applications for CAD and solid modelling in particular become more user friendly, a true understanding of their function or underlying rules slips away. Of particular note with CAD software is the inherent necessity of refinement and simplification, every curve, every spline if not refined by the user will be smoothed and fixed by the software, or at least the user will be prompted to refine. These toolsets are there to support the engineering and manufacturing paradigm. The model/ object require refinement and simplification to make the file structure and subsequent process of manufacturing it efficient.

Conceptually it is necessary to return to Cartesian space and geometry and critique it as an abstract tool. Descartes did not claim the coordinate system as his own and it may very well have a very long tradition dating earlier than Eratosthenes perhaps, but Descartes in his *Discourse on the Method*, writes of the philosophical standpoint regarding the position of ego. Ego may, in Descartes view, correspond to the origin in coordinate space. This

ontological position is inferred in his writings but not explicitly stated [2]. The importance of this idea is that when we attempt to understand coordinate space we potentially assume the position of origin or ego. .We are at the centre of our own worlds, as it were. The essays published with *Discourse*, importantly, *Geometry* are disconnected in position but certainly not in intent. Descartes tools of analytical reason are clear and explicit in their instruction and this is how from Descartes through Leibniz we are entrained with a clearly useful set of tools in the form of Cartesian Space. Cartesian philosophy on the other hand asks us to critique these tools. Descartes in his four precepts [3] gives clear instruction regarding methodological scepticism. Descartes instructed all who followed to be critical of even his theories.

The reason it is essential to conceive of Cartesian space and philosophy together, is that the fields of mathematics and physics have evolved considerably from the time of Descartes but Cartesian space remains in place as a dominant paradigm. Geometries such as fractal forms are difficult to describe in Cartesian space, and higher dimensional forms such as quaternion algebra for instance, require translation to three dimensional Cartesian space. It is possible to define forms in a four dimensional or Quadray space but the dominant paradigm in computer graphics is still three dimensional Cartesian space.

Navigating, and modelling within Cartesian space does not require the designer to possess high levels of geometrical and mathematical ability, I certainly do not. The position I state though, is that users of CAD software must remain aware and be critical of the environment that we operate within especially with geometry which departs from simplicity.

Old Tools, New Tools

Now that I have set out a rough framework of Cartesian space it is essential to move on to geometries and topologies that are a challenge to our conventional uses of Cartesian space. I am speaking of geometries that possess characteristics of roughness instead of smooth and complex instead of simplified, edges and surfaces. By this I mean shapes and forms that exhibit fractal and complex characteristics.

Solid modelling which is the norm for industrial design and engineering software is reliant upon precise mathematical definition and consistent translation and communication. Geometrical form of certain characteristics can be described simply and repeatedly using solid modelling applications but not all geometry can be described this way and what can sometimes requires complicated procedure. Solid Modelling software is just one kind of tool, there are many others, particularly now that the barriers to fabrication are shifting away from a subtractive paradigm. Geometrical Modellers that once existed only in the domain of modelling for cinema, animation, computer games and visualisation have long possessed the ability to comfortably describe complex objects in Cartesian space. The paradigm for manufacture has shifted, so too has the awareness that many software applications including geometrical modellers and all of their requisite subsets can accurately model form that solid modellers cannot, and have it physically realised.

The reason this is possible is that the mathematics has evolved to permit the description of extremely complex objects in Cartesian space, and yet it is common practice at a novice level at least to accept the constraints of the old paradigm.

In contrast to some of the earlier constraints of applications reliant upon the paradigm of constructive solid geometry, polygonal modelling for instance goes a long way to producing forms efficiently that solid modelling cannot. There is still a perceived distinction in industry (albeit changing) that CAD and computer graphics speak of and service differing realms, solid modellers representing applications for computer aided design and polygonal, implicit surface modellers and even voxel modellers reserved to service the Computer Graphics industry.

Much is changing thankfully as many realise that the existing tools can serve new purposes and the existing and changing processes of manufacture permit the co-option and adaptation of tools. Simply put, we can now make new things with old tools and use new tools to make things using old processes. The tools we speak of are the mathematics underpinning the modelling operations within software.

There is something crucial that I wish to discuss as distinctive to design, as design is the purview of the manufacturing paradigm. This contextualises the limitations of the protocols of design simplicity and function. Alva Noe proposes that we are designers by nature and that we are organised by the technologies that we make and consume, but his caveat is that we are organised only insofar as those technologies become embedded in our lives [4]. Conventional geometries conceived in Cartesian space represent for us the designed object. These objects, these artefacts are fashioned from familiar technologies and activities, processes of design and manufacture that we understand. The familiar technologies to the design process are those that replicate well the industrial design and engineering paradigm, the shapes, forms, and geometries that we are accustomed to. Alva Noe differentiates between design and art when he states; ‘Design, the work of technology, stops, and art begins, when we are unable to take the background of our familiar technologies and activities for granted [5]’.

As a designer at times and an artist at others it is an imperative for me that technologies, tools and processes speak of intent rather than simply used to fashion an outcome. As a practitioner with experience in physical media it is obvious that media such as clay can be shaped quickly and masterfully in ways that computer aided design software cannot for instance produce complex and organic form. The same media however can be co-opted for the design paradigm. Utilitarian objects can be designed and produced in clay. Replication and mass production in turn, may disguise the input of the creative process rendering the whole set of technologies as transparent. The crucial question here is what is creative and does than represent any distinction between art and design? The utilitarian object may have started as a novel work, something that exhibited unique characteristics never before seen. At some point however in the processes of replication the object gained familiarity and thus is perceived as designed. Where this occurred however is not easily able to be

identified. One ceramic object may be art. A roomful of similar ceramic objects in the right context may be art. A shipment of identical ceramic objects distributed to department stores presumably renders the object as designed.

The question in this context is, when is the shape or form unique? Is it when it can be perceived as separate from the background of familiar technologies? If this is the case as Noe argues, the geometries described in software applications must break with the normal set of characteristics of geometries modelled in computer software as to be perceived as art or even just novel. The authors of *Organic Creativity and the Physics Within,* a creativity workshop held at Leiden University in 2013 offered a succinct definition of creativity, they stated

'Creativity is the production or emergence of novel combinations out of pre-existing components and that it occurs at all levels of organisation of the physical and psychological world [6]'.

It is basic combinatorial theory that permits us to understand the potential combinations from a given set of shapes and parameters that change or modify those shapes. 3d modelling software possesses potentials for creation of initial geometric primitives and parameters to modify those primitives in many possible ways. Primitives in this context refer to two dimensional points, lines, splines, planes, circles, ellipses and polygons, and to 3 dimensional forms such as spheres, prisms, cylinders and so on.

The potential combinatory potential is significant when it is considered that lines, splines, planes, circles, ellipses and polygons and the development of them to three dimensional forms permits an extraordinary capacity for shape creation. But yet there are still significant limitations to the repertoire of three dimensional geometric primitives for instance in many applications.

The five platonic solids have been known to us since Plato described them in Timaeus but yet we won't find a complete list of platonic solids as primitives in any commercial 3d modelling application, and yet we often will find the Utah teapot (for good reason). Many findings of geometers from thousands of years of discoveries have yet not made their way into 3d modelling software as geometric primitives. Imagine the explosion in combinatory potential if the history of geometry and mathematics is included in the libraries of modelling software from non-Euclidean geometry through to fractal form.

Novelty, an often used definition of creativity, Mihály Csíkszentmihályi, states can simply result from the juxtapositions of differing ideas [7]. Solid modelling software often contains a short list of primitives. It is true that with experience the tool is adapted or co-opted for us, but often objects of similar characteristics are created by many users. In contrast graphics software can contain a much higher number of geometric primitives and the potential for combination, recombination and juxtaposition of diverse elements is, by comparison far greater.

Solidworks and Inventor for example permit 10 different types of two dimensional geometric primitives where by contrast Rhino permits 18. Solidworks contains no 3D geometric primitives yet 3DS max contains 23. This is not to say that there is a preference for one or another, it simply is to illustrate the potential combinatory output from 2D and 3D primitives.

Holons, Fractals, and Combinatory Potential

One of my favourite software applications is not a cad package, nor was it produced for the film, animation or games industry. In essence it has no serious application. Xenodream [8] according to its maker Garth Thornton just evolved from an application that produced 3D objects for rendering. Xenodream is exploratory, playful, whimsical, and fits the criteria most adequately for what true creativity should feel like with software, especially in a divergent sense. The software showcases combinatory creativity by permitting divergent processes in shape creation. Geometric primitives form the basis of the software as shapes called constructors. Many shapes are available that don't quite operate as standard geometry that we are used to however, in Xenodream each primitive can operate independently or inherit characteristics from other building blocks. The software introduces each shape as a Holon, in honour of Arthur Koestler who derived the term to describe something that is both a whole and an identifiable part of a larger whole [9]. Philosophically the idea of the Holon is important as it discussed in terms of self-organising systems. What is of note in the context of this dialogue is that here Xenodream represents concrete representation of the opportunities afforded by recursive and iterative processes and shows genuine opportunities for realising new contributions to shape grammar.

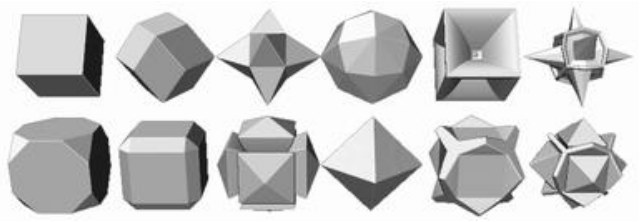

Figure 1 Xenodream; cube and box variations

Xenodream possesses 49 shape sets in its 'constructor' set alone; each constructor can be manipulated with three sets of variables with positive and negative values. Each initial Holon can in turn be transformed using 'metamorphs', preset formulas that modify the original form. There are 380 metamorphs (including constructors) with 3 independent sets of variables each. To permit an analogy in terms of shape grammar 6, six by four Lego bricks can be put together in 915,103,765 different ways

A shape or Holon within Xenodream can inherit the characteristics of other Holons, it makes a copy and transforms it with its own parameters of scale, orientation, position and skew, and its own metamorphs (formulas that modify its form). Because it inherits itself, it makes more copies and transforms them [10].

Figure 2 Xenodream; Examples of metamorphs applied to a cube

This process is referred to as iteration and mathematically this is significant as the classification of shape creation within the software is referred to as an iterated function system [11]. The process of creation is iterative and produces self-similar results; therefore it can be referred to as fractal. In mathematical terminology the Holons as described in Xenodream are referred to as transforms or functions hence, iterated function system.

What differentiates this software particularly from CAD is that it is play based, in many senses that removes it from the design framework. The intent of the software is pure exploration, and not production for purpose. That is not to say that it is not useful. As a divergent process it is incredibly beneficial to creative thinking. As a tool it lends itself to the curious definition of a strange tool as proposed by Alva Noe [12]. Xenodream in some respects is game-like. Noe's examples of art seem to exclude game and particularly software. His examples of art are mostly constrained to the pictorial, although I believe it is a mere extension to incorporate game, software and the permutations of both.

Xenodream may be a software tool for producing artworks but may also be seen as an exploration in self–similar combinatory potential and in itself a method of producing something more than mere novelty. Margaret Boden states, 'A merely novel idea is one which can be described or produced by the same set of rules as are other familiar ideas [13]'. The enormous potential offered by combinations and Holonic interactions in Xenodream stretch far beyond the familiar. Most of the algorithms for example underpinning Xenodream's functions far exceed the included parameters within conventional CAD and 3D Modelling software.

Xenodream and applications like it that break the conventions of CAD and 3D modelling software represent changes to conceptual space, and as Boden offers, a conceptual space is a style of thinking, 'it is the generative system which underlies that domain and which defines a certain set of possibilities [14]'. Xenodream is one example of a conceptual space that differs from familiar spaces developed for the industrial design and engineering paradigm, that is not to say that it is any better or worse, it simply differs. By presenting a rich and complex conceptual space it affords opportunities that break from convention and introduces the artist, designer or experimenter to the unfamiliar.

Translation and Interpretation

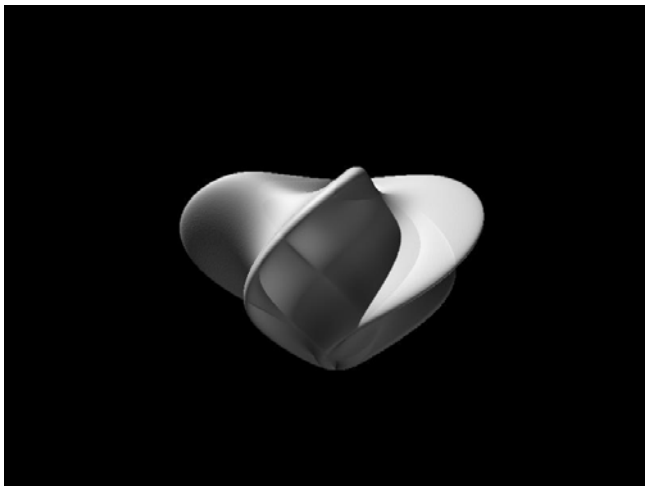

Figure 3 Xenodream: Example of constructor and metamorph

The object in figure 3 represents a simple form made with a constructor/ geometric primitive, in this instance, a sphere that is inflated in one axis and pinched in another. The sphere is again transformed by the parameters of one metamorph with three parameter variables. The variables apply radial ribs to the sphere of a certain number with a twist of a particular strength. The form is not complex and does not really represent self-similar features to a high degree. It is possible to generate this form in Cad software or in 3D modelling software. 3DS Max or Rhino could produce this form reasonably well. The point is though in Xenodream the 'idea' of the form is generated within seconds permitting an almost instantaneous capacity for revision and reselection.

I find the process of shape creation with these processes liberating. It feels like discovery, rather than the burden of complicated procedure with CAD software. I also find that the shapes, edges, and curves generated, present an elegance that is either difficult or very time consuming to achieve in other ways. The shortfalls however are in translation, attempting to translate from one language to another. Xenodream generates objects as point clouds; each point is calculated as an iteration of the formula until millions of points describe the object

Xenodream uses the chaos method for calculating points, starting with a point that is probably not in the shape and with each iteration, successive points converge towards the shape. The shape is sometimes called the attractor for the set of Holons. The software ignores the first thousand points in the random sequence to be fairly sure that the points are in the shape before it starts plotting them [15]. Xenodream plots points in space that are more akin to biological processes, those familiar with solid modelling find this strange and imprecise to begin with at least.

To translate a point cloud a polygonal mesh must be created of the object, either in Xenodream or the point cloud exported to other software for a mesh to be generated. This is where the surfaces generated differ greatly from the surfaces in solid modellers.

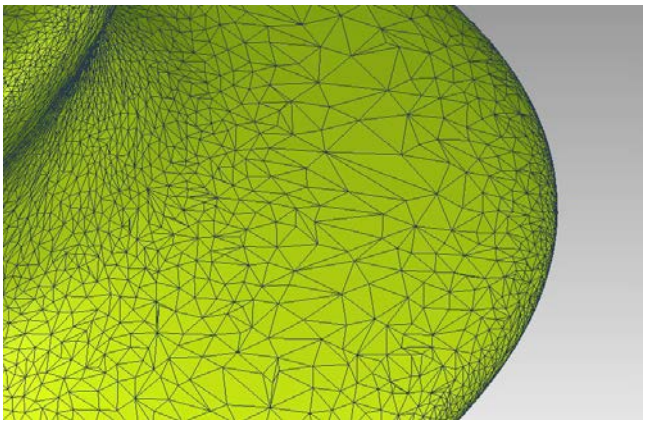

Figure 4 Mesh creation in Xenodream

Mesh creation in Xenodream can often produce results which are less refined and regular than mesh creation and manipulation in 3d modelling software. Geomagic is one software application that is useful in converting point cloud data to usable mesh objects and surfaces. Geomagic is usually used to interpret, and repair scan data from a variety of sources, either from laser scanning systems or medical scanners such as magnetic resonance images or CT scan. Interpreting data from fractal formula seems to be a fairly novel exercise, so efforts that I have made in interpreting and refining form using Geomagic have required that I adapt workflows from the medical and paleontological sciences, rather than design and engineering.

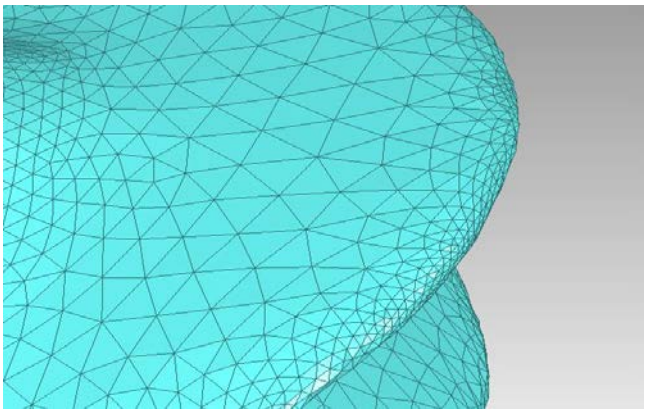

Figure 5 Mesh creation and refinement in Geomagic

Working between software applications is akin to communicating between languages. The chaos method of point cloud rendering of points to permit the expression of formula is quite a different method to the description of objects using precise informational completeness within solid modellers. The object so far illustrated is reasonably simple and lacks complexity and roughness evidenced in more natural forms, nevertheless there is a great deal of work to do in translating an object such as this into a form that is understood within a solid modeller. Geomagic offers numerous operations to interpret and extrapolate curves and subsequently redefine mesh surfaces as NURBS, (Non Uniform Rational Basis Splines/ or Surfaces). Without spending a great deal of time explaining NURB splines and surfaces I do wish to point out that this mathematical representation of form is growing in popularity and efficiency as a method of communicating and translating form between software applications. It is simply another method of representing form but one that bridges the divide between solid and 3D modellers. It is a descriptive method that is mathematically accurate and permits high degrees of manipulation. The reason I am fond of the potential of NURB splines and surfaces is that like the objects described using fractal formula and iterative process NURB surfaces have the opportunity to exhibit complex and elegant qualities. I personally am drawn to objects created using iterative formulae such as Xenodream. There is unexpected geometry in what algorithms and Holonic interactions of algorithms can produce.

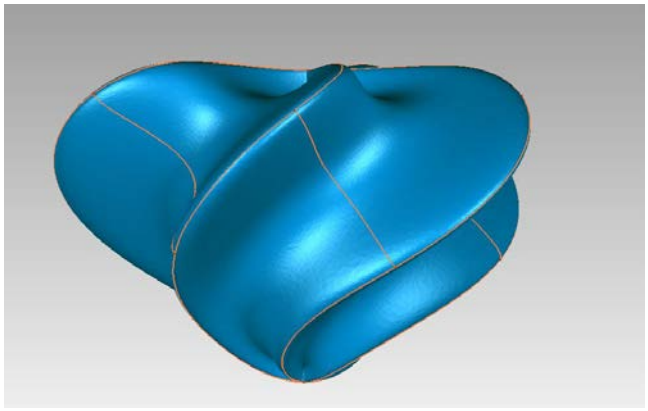

Figure 6 Geomagic; extrapolation of NURB curves

The aesthetics of discovering form in many ways is more pleasing than being the 'creator' of it. In contrast to the joy of discovery, there is considerable time and effort involved in the translation of point cloud to mesh to NURB surfaces but the process in itself reveals new potentials for curves and surfaces that would otherwise be overlooked.

It is a subjective opinion that I hold as an educator that artists, designers and craftspeople are subjective in their use of tools. Proficiency comes with use and familiarity but most creative practitioner's still possess a limited repertoire of preferred lines and shapes. I do not excuse myself from this summation. An elegant, sinusoidal line can be drawn by hand with practice but is much more time consuming with a computer mouse and still vaguely annoying with a stylus. Again I say as an educator, what I observe of myself and others is that it is easy and efficient to repeat the same practised set of lines curves and shapes. Tools that permit exploration rather than repeat constraints can certainly be liberating for the user. My experience has been that the constraints of modelling software offer an intellectual and technical opportunity to express form in new ways. I certainly would not have explored forms in such detail were it not for having to understand and solve the problems in translating and interpreting those forms.

Boden regards the constraint as crucial in the creative process [16], which I certainly agree with.

Moving and translating between many software applications exposes creative opportunity identified by the constraint of just one application or just one tool within the application.

The exploration of Holonic interactions allows for serendipitous outcomes, and it is these unintended consequences of play and exploration that have the potential to reveal forms that have applications elsewhere. If I were to intentionally design an object all of the time I would forsake the opportunities offered by chance. Some examples in my research involving the creation of forms for tactile interaction have led to the creation of objects for instance, that potentially can serve another purpose. As Xenodream offers an enormous range of variables to transform objects, the resultant outcomes can be evaluated as to their potential for the task at hand or for unintended application.

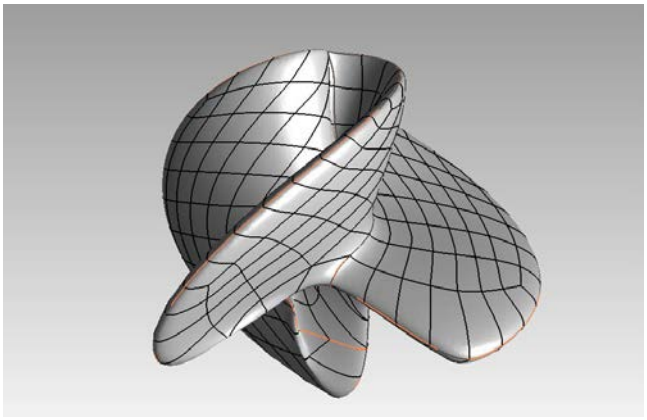

Figure 7 Hypothetical Design Outcome

The object in Figure 7 represents one object in a series of forms that point to an unintended, but probable design solution. A particular coalescence of parameters was explored as a departure from the task at hand because the resultant forms offered contributions to impeller design.

There is much work to do in terms of refining and testing these forms but Figure 7 shows one outcome of refining curves and extrapolating NURB surfaces for potential use. The potentially functional artefact arose, to borrow a term from evolutionary biology, from a process termed exaptation, (an evolutionary technique where an adaptation that occurred for one particular purpose becomes useful in another function or purpose).

Stephen Gould speaks of adaptation as the model driving evolutionary fitness and exaptation as co-option [17], serving a particular use for unintended purpose. Peter Stebbing's conceptual leap however is that even our ability for aesthetic organisation could have evolved from the ability to recognise form by pre-adaptation or exaptation [18].

Interpretation does invoke some aesthetic rationale. Generative software such as Autodesk's project dreamcatcher, Paragen or Galapagos for Grasshopper and Rhino may well offer design alternatives and options by interrogating and interpreting forms using evolutionary algorithms, but it is the aesthetic choice to stop, refine and ultimately decide on outcome that substantiates the act of creative convergence. There are many shapes that I may consider either beautiful or useful, but that is based upon my principles of aesthetic organisation, I make the choice as to where and how my thoughts and practices converge, software cannot and should not dictate that. But someone else may make a different set of choices

The Special case of Fractal Interpretation

Benoit Mandelbrot famously asked in his last ever lecture; what are fractals good for? To which he replied, Very little [19].

Mandelbrot spent a good portion of his career building the field of fractal geometry, not just for the sake of mathematics, but to help describe many mathematical opportunities for many disciplines. The language of fractal geometry is interwoven with descriptions of complexity but in terms of shape grammar helps describe certain classes of forms in terms of the tenets of self-similarity, iteration and recursion.

Mandelbrot summarised in his last lecture that his research had been about the pursuit of roughness [20]. This idea as a conceptual focus brings into light the difficulties and inherent problems with CAD environments, as the mathematical descriptors used do not cope very well with rough edges or surfaces of fractal forms.

Fractal forms (mathematically speaking) have the potential to possess an infinite surface or edge. Roughness is revealed at each magnification as a new series of points is iterated. Translating those infinite edges requires a decision about where to start and stop. In the software that renders fractal form stopping is referred to as bailout position. Translation of edges requires a decision based upon permissible time devoted to the task, as complex forms could take days or weeks to translate.

Figure 8 Julia Set, Rendered in Xenodream

The formulae mathematically described by Gaston Julia in 1918 [21] evidence roughness that is difficult to describe in Computer Aided Design space and any attempt to do so is somewhat inadequate. Gaston Julia only glimpsed the potential; of his formulae, having to plot each point by hand, but producing fractal objects such as the Julia Set requires little effort with contemporary computing. A variation of the

Julia set as shown in figure 8 can be rendered in fractions of a second but again this represents a point cloud in a two dimensional plane, the translation of these points is another matter entirely. For the shape to be useful in CAD or 3D modelling software it has to be interpreted. Most vector applications are time consuming to use for a shape of this complexity and lack the control of curves to effectively approximate this shape. Some CAD software such as solid modellers cannot deal with this kind of information at all and frequently fail. Rhinoceros is one application that can deal with thousands of control points on one curve and contains a large repertoire of curve descriptors and modifiers that can effectively interpret complex form.

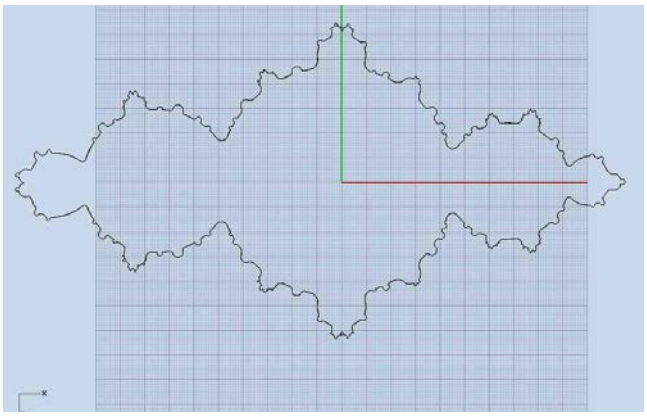

Figure 9 Julia Set interpreted in Rhinoceros

As I have intimated, Figure 9 shows an approximation of the shape, it represents nearly 80 hours' worth of careful work slowly interpreting the edge of the Julia set as well as could be done but it is also restrained by the capacity of the software to utilise the resultant curves in further processes. It is still an approximation and a fairly crude interpretation that under close scrutiny does not do justice to the elegance of the pure point cloud created by the formula. This is the issue with interpreting fractal shapes. But it is a worthwhile exercise in learning from the shape, exploring its asymmetries, finding the nuance of curvature and negotiating with how far the software can be coerced.

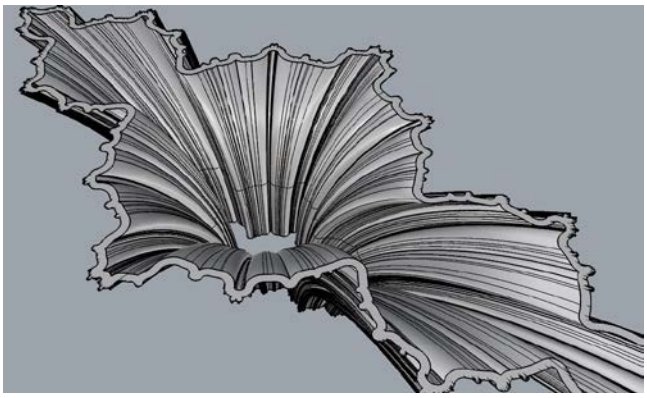

Figure 10 Julia Set Lofted

The object in Figure 10 shows a three dimensional form lofted from the two dimensional Julia sets created in Rhinoceros. The object evidences an extrapolation of a set of curves and subsequent offsets and scaling of those curves to then describe a lofted surface. This is a difficult and memory intensive shape to process and it seems only Rhinoceros is capable of achieving this outcome. Many experiments were done with Solid modelling software, but none were capable of producing this shape. The creation of NURB curves and surfaces within Rhinoceros presented the only viable set of outcomes. Just to achieve one lofted and watertight shape acceptable for export for additive fabrication took in excess of 200 hours' worth of trial and error.

Figure 11 Lofted Julia Set, 3D Print, Polyamide

The lessons learnt in interpretation are many. The greatest must be though, the discovery of form through the processes of interpretation. Following the edge of something new and learning about its curvature and not enforcing a predefined notion of shape is revealing, rewarding and humbling. The goal of additive fabrication enforces constraints on shape creation and drives the creative process with its necessity to accurately describe surfaces and volumes in a fashion that can in turn be interpreted by build software in fabrication technologies. Point clouds can only really exist in virtual space; machines require a different set of descriptors.

Figure 12 Julia Set variant

The object in Figure 12 represents a form that evidences holonic interaction and inheritance. It is based on a variant of the Julia set and currently resides at the edge of the ability to fabricate. It is possible to be printed in a small range of additive processes, and has been produced at a small scale, but it remains a time consuming and difficult entity for translation into NURB surfaces

What do I now do with all of these fractal forms and NURB interpretations of fractal forms and all of their subsequent exports into the physical realm? To paraphrase Benoit Mandelbrot; ‘very little’.

If I was a product designer I should be concerned but I am not. These objects represent for me intersections between art, design and the ontological explorations of both. By stubbornly navigating the methods of translation between fractal creation and 3d modelling applications I believe I have helped bring to light some of the countless forms that fractal mathematics describes, and maybe there applications for some of them.

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A Computational Approach to a Mobile Musical Structure

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Abstract
This paper presents a new method using open source software R [1] and ImageMagick [2] to create an animated graphic score for a musical composition entitled “Blue Mobile” that features a mobile structure inspired by Earle Brown's “December 1952”.

Keywords
mathematics, mathematical programming, graphic score, animated score, Earle Brown, December 1952, improvisation, Blue Mobile, R, ImageMagick

Introduction
Earle Brown’s composition “December 1952” [3] has been described as “an intriguing work of art” [4], “a work that changed the course of the history of notation, a work without precedent” [5] and “one of the earliest, most elegant and famous examples of graphic notation” [6]. Earle Brown noted that “Under the influence of [Alexander] Calder, I considered this kind of thing to be a mobility, which is to say a score that was mobile - a score that had more than one potential form and performance realization” [7]. The piece was composed in December 1952 in a series of works that were published under the title “Folio” (Brown, 1954). Earle Brown described this group of compositions as follows:

> In highly experimental works from 1952 and 1953, collected and published as “Folio” and “Four Systems” (subtitled “experiments in notation and performance process”), the Alexander Calder-inspired “mobility” finally found a practical (for me) notational expression. The scores were in different invented notations of a highly ambiguous graphic nature, subject to a number of different - but all inherently valid - realizations. [8]

The score for “December 1952” is presented as a series of randomly generated vertical and horizontal lines of varying length and thickness on a square piece of paper. In addition there is a paragraph of text and a small diagram in the prefatory notes with the score. While it is most simple to view the graphical elements of “December 1952” as representative of musical duration, range, or dynamic, Brown [3] indicates that a much wider interpretation is welcome and something he encourages in performance, saying he aims to “provoke performers to work together and react to their own poetics, their instantaneous communication with themselves and with the people around them” [7]. The work can be conceived as a two-dimensional projection of a three-dimensional mobile (or even four-dimensional if this conceptual structure is moving over time). The prefatory notes for the score state that it “may be performed in any direction from any point in the defined space” [3]. Additionally, “In a performance utilizing only three dimensions as active (vertical, horizontal, and time), the thickness of the event[s] indicate the relative intensity and/or (where applicable) instrumentally [sic] clusters” and if four-dimensions are being considered ”the relative thickness and length of the events are functions of their conceptual position on a plane perpendicular to the vertical and horizontal plane of the score.”

Whether a three-dimensional or four-dimensional interpretation of the score is utilised in performance, the most important implication of the notation used by Brown is that of approaching the same structure from many different changing perspectives, thus reflecting the mobile structures created by Alexander Calder.

A New Compositional Concept
A Reflection on “December 1952”
In composing a new work for improvisers in response to “December 1952”, a concept was developed for a composition entitled “Blue Mobile” that features a mobile structure based on a solar system, where there are several orbits around a central idea. The performers could view this structure from different angles, thus presenting different material across the ensemble when interpreting the outer orbits with less variation towards the centre of the structure.

From the Universe to an Atom
This visualisation of orbits around a central idea suggested a useful representation of compositional convergence, where the orbits become smaller and contain less information closer to the centre, thus guiding the performers towards the core of the piece.

Two simple ideas became the building blocks of the composition: the blues, and the symmetrical division of an octave. One of the simplest harmonic forms for a blues chord progression is I-IV-I-V-I and this lead to the use of five orbits, reflecting pitch centres of (from the outer orbit) E, then A, then E again, then B, then finally returning to E as the central tonality of the work. All possible symmetrical divisions of the chromatic scale were then applied, with the scale divided into six parts for the outer orbit (whole tones), then four parts (minor thirds), three parts (major thirds) and two parts (tritones). Finally, an intervallic scheme of minor and major thirds (inspired by the dichotomy of major and

minor tonalities found in many blues performances) alternating for each orbit was applied, thus resulting in the pitch classes in Figure 1.

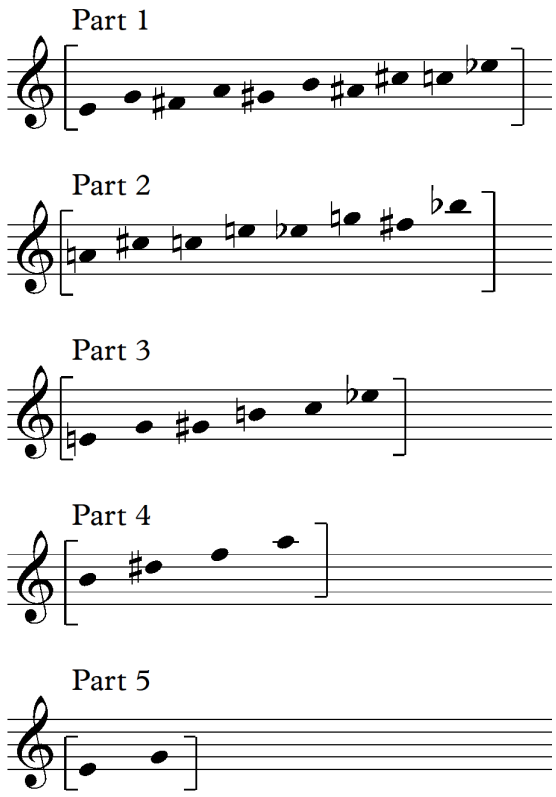

Figure 1. Blue Mobile's harmonic scheme.

Representing a Physical Impossibility

The physical structure of this piece was then imagined as a hanging mobile structure. Each orbit would be made up of a large orbit with pairs of pitches attached and rotating around each other (see Figure 2).

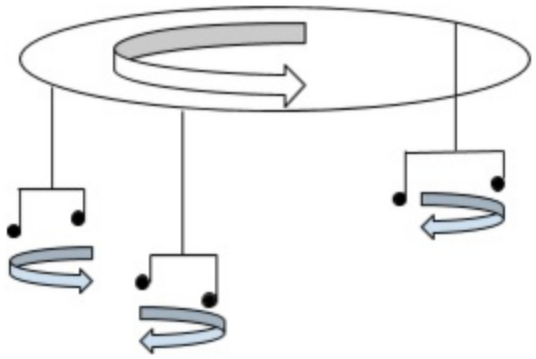

Figure 2. An orbit.

The performer would see the pitches moving towards and away from view. They could "play what they see" and let their imagination guide their interpretation of the structure. They may choose to focus on the pitches that are most prominent at any time or they may choose to follow a pair of pitches and vary the dynamic level or intensity as the pitches fade from view. They may take rhythmic indications from the distance between pitches, or their speed of rotation. Many other interpretations are possible.

There was some thought towards creating a physical version of this structure, particularly as this would add an interesting visual component in performance and clearly demonstrate the primary concept of the work. While the note heads themselves could easily be created physically and the various rotating structures could be constructed, the necessity for the five lines of musical staff presented a physical impossibility. A musical staff could be placed behind the mobile structure so that the pitches could be specified, but performers viewing the work from different heights would see different pitches, counteracting the pitch structure of the composition.

From here, it was decided that an animated version of the score would be effective in conveying the desired structure to the performers.

Possible Approaches

In considering what he calls computer generated "screen scores", Vickery [9] notes that "Academic discussion of this approach is, however, quite recent, gaining momentum as recently as 2004 with the publication of research by Didkovsky [10] and Winkler [11]". While many of the techniques developed by Didkovsky and Winkler focus on realtime generation of scored material (and not animated scoring as such) Hope and Vickery [12] outline the development of their Decibel Music Player [13] which includes a "scrolling score" component. This tool is the most similar to the concept of "Blue Mobile" but given the complexity of accurately representing pitches moving in and out of the foreground in a circular fashion Decibel could not be used in this instance and a customised approach was required.

Generating an Animated Score

From three dimensions to two

Since a physical three-dimensional structure had been ruled out, it was necessary to start considering how to represent the mobile structure in a two-dimensional animation. Inspired by Earle Brown's projection of a theoretical mobile structure onto a score for "December 1952", it was decided that the animation could simulate viewing the hanging structure from the side. The animation would also portray depth, with the notes growing larger as they came into view and disappearing as they recessed into the background.

While it would be possible to also simulate the orbits of the composition being nested within one another, this could become confusing when a performer tried to view, for example, the third orbit by looking through the two orbits outside of it. To solve this problem, a chandelier form (see Figure 3) was chosen, where each orbit would sit below the previous, thus allowing for clear viewing.

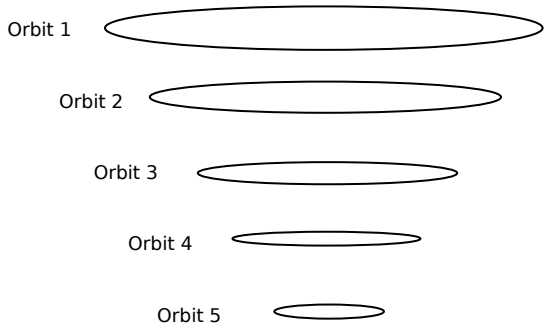

Figure 3. Chandelier form.

A Mathematical Solution

In order to plot the positions of each pitch of the structure, the parametric equations for a circle [14] were used:

$$x = R\cos(T)$$
$$y = R\sin(T)$$

where *R* is the radius of rotation and *T* is time. By repeatedly plotting these formulas and varying the time component, a series of plots were created which then became frames of the animated score.

As a two-dimensional projection of the orbits rotating in a horizontal plane viewed from the side is being used, the *x* axis represents the left and right movement of the pitches, and the *y* axis represents the size of the pitches, thus reflecting depth in the image.

For each pitch, the necessary equations were in fact a combination of two circles, the larger orbit and the smaller rotation with its pair. The equations that were plotted were:

$$x = R_{small}\cos(T) + R_{large}\cos(T)$$
$$y = R_{small}\sin(T) + R_{large}\sin(T)$$

Thus for each orbit a different value of R_{large} was used, and for each pair of pitches attached to the orbits a different value for R_{small} was randomly generated to reflect Earle Brown's use of random number tables in creating "December 1952". Brown [7] noted that "the elements were placed and their thickness and length and horizontality or verticality were fixed by a kind of program I worked out based on the use of random-sampling tables... Working with nonprejudiced material, one could get a very bland and consistent kind of result."

A Computational Method

The basic approach to creating the animation of the mobile structure of the composition was to generate all of the frames of an animation from plots of the pitches. The number of frames required for a smooth animation and the complexity and quantity of calculations for each pitch would make this task impossible without the use of a computational method.

While there is a large array of different animation software available, mathematical software with a highly customisable graphing capability was most appropriate for this application due to the accuracy and ease of generating the positions of the pitches in the mobile structure. In this case, the open source software R [1] was chosen.

In R, a generalised function was written where any number of pairs of pitches could be plotted on an orbit of any diameter. Additional variables were radius, speed and direction of rotation for the small circles. This R code specifies the number of frames to be created (500 in this case) and initiates a loop which carries out the following steps:

1. The code generates the names of the .png files that will be used as the frames of the animation.
2. The function loops through each of the pairs in the orbit (j) and calculates the position and size of each pitch with the following code:

```
smallcircle[1,j]=smallcirclerotationdirection[j]*smallcircleradius[j]*cos(smallcirclespeedfactor[j]*(i/frames)*2*pi)

smallcircle[2,j]=smallcirclerotationdirection[j]*-smallcircleradius[j]*cos(smallcirclespeedfactor[j]*(i/frames)*2*pi)

smalldotradius[1,j]=0.8+0.2*sin(smallcirclespeedfactor[j]*(i/frames)*2*pi)

smalldotradius[2,j]=0.8-0.2*sin(smallcirclespeedfactor[j]*(i/frames)*2*pi)

bigcircle[j]=bigcircleradius*cos(noteshift[j]+(i/frames)*2*pi)

bigdotradius[j]=1+0.5*sin(noteshift[j]+(i/frames)*2*pi)
```

This code expresses the rotation of the pairs of pitches (smallcircle[1,j] and smallcircle[2,j]) and the rotation around the larger orbit (bigcircle[j]) using the *x* component of the parametric equation for a circle discussed earlier. Adjustments are included for rotational direction and speed of rotation, both of which are randomly generated prior to input into the function using the following code:

```
smallcirclespeedfactor=sample(5:50,pairs,replace=T)

smallcircleradius=sample(2:8,pairs,replace=T)

smallcirclerotationdirection=sample(c(1,-1),pairs,replace=T)
```

Here the code randomly assigns a speed factor for the small rotations of each of the pairs of pitches. This is controlled so that there will be between 5 and 50 rotations while traversing the larger orbit. Radius for the pairs is also chosen randomly

between 2 and 8, thus ensuring that their radius is less than that of the larger orbit (if not there may be some visual confusion and the image would be a less convincing representation of the physical concept of the mobile). Finally the rotational direction for the pairs of pitches is randomly assigned. This was not included in the initial code, but it adds visual interest to the animated score to have the pairs of pitches rotating in different directions and ultimately provides more musical stimulation to the performers.

The *y* component of the parametric equation for a circle is then used to calculate the size of the dot for each pitch in the image (smalldotradius[1,j], smalldotradius[2,j] and bigdotradius[j]), thus representing their depth in space and giving the animation the illusion of three dimensions.

3. The function then plots all the pitches in the orbit for the frame by combining the equations for the small and large rotations and dot radii.
4. The function completes each plot by adding five musical staff lines.
5. The function then writes the plot to a .png file before continuing to loop through each frame.

Once the loop is completed and a .png file has been created for all 500 frames, the R function calls on another open source piece of software called ImageMagick [2]. This software's "convert" function is then used to combine the frames of the animation into a single animated .gif file for each orbit.

```
creategif=paste("magick convert *.png -delay 1 -loop
0 ",outname,".gif",sep="")
system(creategif)
file.remove(list.files(pattern=".png"))
```

The final line of this code deletes the .png files that were created for each frame, leaving only the animated .gif file. This process is repeated for each orbit so that there is one animation for each. The piece was initially conceived for performance where the ensemble would change between the orbit animations as the performance progressed. Following workshopping of the "Blue Mobile" with a group of musicians, the chandelier form discussed above was developed as a solution to the inconvenience of navigating between .gif files in performance.

To combine the .gif files for each orbit into the chandelier form ImageMagick is once again used, this time applying the "convert", "coalesce" and "layers" functions as follows:

```
magick convert CScoreBlueMobilePart1.gif -repage
1000x500 -coalesce null: CScoreBlueMobilePart2.gif
-geometry +0+250 -layers Composite
bluemobile1and2.gif
```

This code re-sizes the first .gif file's canvas using the "repage" command and fills it with blank space using "coalesce". The "layers" command then adds the second .gif file with its position determined by "geometry". This process was repeated to vertically combine all five orbits of the composition. An example of one of the frames from the final animation can be seen in Figure 4.

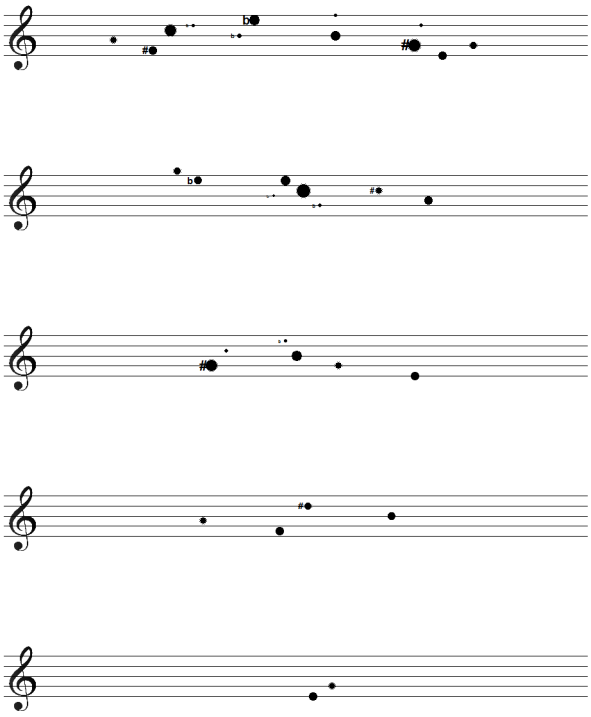

Figure 4. The final form of Blue Mobile.

Performance

Tablets in the Orchestra

While several different file types for the animation would be possible, .gif files have several strengths – namely that they are widely used across the internet and as such are likely to be playable on the majority of modern devices such as mobile phones and tablets. This is the simplest option for performance, where each member of the ensemble uses their own device to view the animated score. Other possibilities would be to use one or more projections of the animation that performers could read from and the audience could also view to gain insight into the structure of the work.

Simulating Different Perspectives

The animated score effectively portrays a moving structure from a single viewing position, and if several musicians were to interpret the same animation this would be a representation of the entire group viewing the structure from the same position. As the aim of the work is to represent the many possible viewings of the same structure, this needs to be simulated in performance. This is achieved by offsetting the start of the animation for every performer, thus ensuring that each is viewing a different rotational position of the mobile at all times.

The chandelier form also assists with this as once the animation is started the offset will remain in effect as

different orbits are navigated. This issue also highlights the main strength of using separate personal devices (mobile phones or tablets) for each performer as a much higher level of variation of viewing angles can be achieved compared to a performance using projectors, where the number of projections is limited in a practical sense due to their size and expense.

The Future

The techniques of animated scoring and the mathematical representation of animated musical elements developed in “Blue Mobile” provide stimulation to further explore this area in order to achieve outcomes that are not possible with traditional fixed scores. In particular, continuing to explore composing in this manner for improvising ensembles and incorporating graphical notation (the Oxford Dictionary of Music [15] defines “graphic scores” as scores that “employ drawn visual analogues in order to convey the composer's intentions with regard to the required sounds and textures … Others deliberately omit any notational sign or music indication, seeking only to stimulate the performer's creativity”) into this method will open new areas and outcomes that have not been previously achieved.

Cat Hope from the Decibel new music ensemble (see [16] for an extensive list of Hope's publications) has explored digital notation with a focus on graphic scoring. This work has led to the development of the *Decibel Score Player* [13] for iPad and the subsequent composition of numerous works that utilise this technology including Hope's “Wolf at Harp” (2011) and Lindsay Vickery's “Ghosts of Departed Quantities” (2011).

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The Power of Play Based Apps in Patient Self Management of Diabetes

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ABSTRACT

Interactive animated 3D computer graphics provide a rich and engaging mechanism with which it is possible to enhance interactions with complex information. This research focused on the use of "flow", in the form of 3D animated movement of items through depth over time, to display changes in diabetes management and blood sugar levels. It also utilizes "play", in the form of interactive 3D game play, to demonstrate 3D systems to present complex health information for Type 1 diabetes in a more engaging form. The flow based "Diabetes Visualizer" interface described here uses circulating 3D graphical structures that flow around the users point of view to present information relating to diabetes management tasks. The Diabetes Visualizer utilizes complex diabetic blood sugar, activity level and insulin delivery information, and presents it in an interactive 3D time based animated game form. Utilizing the mechanism of the 3D flow interfaces, this 3D interactive form is quite different to other diabetes management tools (primarily 2D chart based and static) and shows potential in providing an improved interface to this complex condition and its management. Results from early experimental studies of the visualizer tool show potential in providing a more engaging form of presenting this type of information through the use of interactive 3D "flow" based systems. being presented on a globe of the world) as a significant feature but also highlighted the fact that the use of depth in the 3D tool allowed them to more easily see locations where there were significant spikes in impact and this advantage appeared to play a key role in the 3D tools preference over its flat 2D counterparts. These results indicate that the use of 3D web based applications for the visualization of world health data, in differing fields through the reusable nature of the tool, offer the potential to enhance the users interaction with the data.

Categories and Subject Descriptors

• Human-centered computing~Visualization techniques • Human-centered computing~Visualization systems and tools • Applied computing~Health informatics

Keywords

3D Data Visualization; 3D User Interface; Human Computer Interaction; Computer Game.

1. INTRODUCTION

The concept of using objects in motion, through depth and passing by the viewer, in common selection tasks, as outlined by Patterson (2007), has been demonstrated as effective for some types of information presentation [9-18]. This project extended that concept and looked at applying the flow principles in more advanced applications including more complex health information visualization and interaction. In particular this work looked at new ways to present information for type 1 (Insulin dependent) diabetic patients who manage their own blood sugars on a day to day basis. The tools primary focus is to more effectively convey information about the complex relationship between food, activity, sugars and insulin interactions. These new, flow based 3D animated forms of presenting this complex diabetes information, were designed with the purpose of providing both a tool to help with diabetes management and also a tool to assist in learning and understanding the complex task of managing blood sugars effectively.

Existing 3D flow based systems largely deal with generic search or library information, assisting in tasks such a locating items in a large search list or searching through a large structured store/library scenario. These interactions largely involve using time and movement to provide options flowing past the viewer until they actively make a choice or alter the flows features. For the case of the 3D Diabetes Visualizer the information also uses the flow but in a different way. In this case the flow is used to represent a transition in time (representing the changing state of the blood sugar/insulin levels over time and the effect that food, activity and insulin choices make).

The Diabetes Visualizer is a 3D visualization/game designed for use by the patient in self managing their Insulin Dependent Diabetes Melitis (IDDM), often more widely known as Type 1 or Juvenile Diabetes. In this condition, patients generally manage their own blood sugar levels by carefully keeping track of food intake and matching carbohydrate intake levels with calculated and injected insulin doses. This balance of food to insulin takes considerable care and the relationship between the two can be difficult to manage and understand. It is this complex relationship that the 3D Diabetes Visualizer aims to present in a simpler to understand form and thus assist patients with management and understanding of their condition.

Improving the management of the condition is important, particularly for the patient, as poor management leads to serious health complications and costs for both the individual and society at large. Diabetes represents one of the worlds biggest health concerns.

‘ *Immediate action is needed to stem the tide of diabetes and to introduce cost effective strategies o reverse this trend* ‘

[World Health Organization 2012 [25]]

With this in mind the 3D Diabetes Visualizer aims to take the complex set of information that is involved in managing diabetes and present it in a simpler interactive 3D visual form. By doing so it represents a comparatively low cost tool that can assist in improving outcomes.

2. Diabetes Management & Visualization

For the patient managing their diabetes is a very involved process. Most patients independently manage their condition, monitoring their successes as they go. This management involves calculating the required amounts of insulin to inject to match food/carbohydrate intake whilst also accounting for other factors such as activity levels and stress. These calculations are quite complex and difficult, particularly for an inexperienced patient, to understand. Most patients use regular blood sugar testing to gain an insight into how their calculations have functioned. For example a patient may wake in the morning, test their blood sugar level, then using that existing level, in combination with their intended food intake and activity plan for the morning, they will make a calculated judgment on how much insulin needs to be injected.

To make these calculations the patient must be aware of the amount of insulin needed to cover the food, the rate at which the insulin will be absorbed and become available, as well as the rate at which the food will be digested and become available in the form of blood sugars. Hence a diabetic must have a thorough knowledge of the carbohydrate content of foods as well as absorption rates and the matching amounts of insulin required. For most diabetics these are skills that take many years to develop.

2.1 2D Diabetes Management & Charts

Diabetes software already exists in a range of forms. Most are simple 2D charting tools, offering a selection of different chart types, to display blood sugar data in the form of simple static bar, line and other charts (see example in Figure 1). There is some evidence that use of these simple software tools assists in improving blood sugar level and diabetic control. As shown in Blazik and Pankowska (2012), this software is safe and reduces blood glucose levels and glucose variability. There are several tools that work in this way, ranging from simple web based charts (Holl et al 2011, Hughes 2012) through to simple interactive 2D games (Bresinka 2011) [1,6,7].

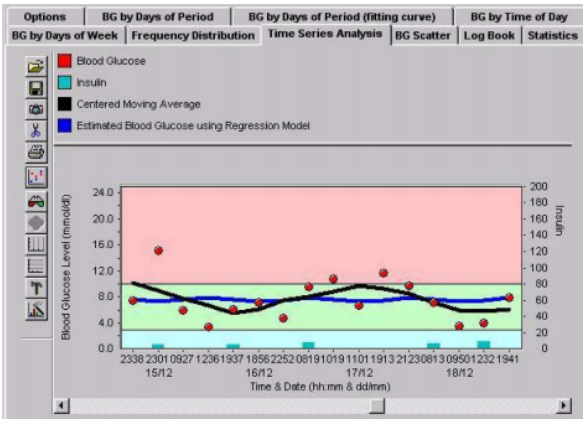

Figure 1: *Diabetes software example*

Most diabetics use these charting tools in longer-term management, where they collect a series of blood sugar tests, over a period of weeks or months, and then analyze these long term averages to identify issues. For example in Figure 1 the patient might identify that there are more high values in the morning (the left of chart) and therefore there is a need to increase insulin levels overnight to address this. This type of post analysis is useful but doesn't assist the patient in learning how to judge and match food to insulin levels, nor does it provide any advice on how to "predict" the effect of choices.

One of the key limitations of these 2D charting tools is that they are very mathematical in nature and often intimidating to the patient. The study by Tse et al. (2008) demonstrated the fact that many diabetics had limited skills with statistics and charting and found they needed specialized induction into the use of tools of this type [24]. Fortunately patients learnt quickly, but had difficulty engaging initially and staying enthusiastic about the tool use. This demonstrated a need for a more engaging way of presenting this complex diabetes management information.

2.1 The Animated 3D Diabetes Visualizer

The Diabetes Vuisualizer uses a simple, yet graphically rich interactive system to present the same information (see Figures 2 & 3). The key differences are in the use of interaction, 3D graphics and animation. The animation allows the viewer to see the changing status of "blood sugar" over time as an animated visualization in contrast to the more static point on a chart as shown in Figure 1.

In addition the Diabetes Visualizer was developed for use on mobile devices (thus enabling the tool to be readily available to the patient when and where they need it).

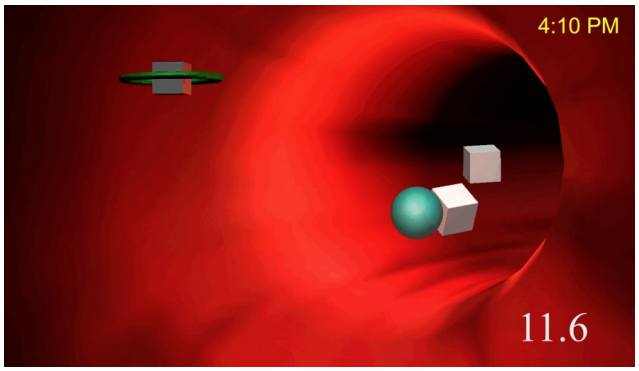

Figure 2: *The 3D Diabetes Visualizer*.

The Diabetes Visualizer tool presents a very uncluttered 3D interface featuring a large 3D tube (shown in red in Figure 2) with the viewer being positioned inside the tube (much like being inside a blood vessel/tube/ring system that is flowing past). This tube is a visual representation of the blood vessel and within that tube there are several small 3D objects. These objects can be of several different types, representing differing foods, or insulin. A variety of object types were trialed for this purpose with the simple sugar cube being chosen as most effective for sugar/food and the simple blue droplet being chosen for insulin). These objects represent unit measures (where one insulin "ball" is a match to one "cube" of food). Thus a snapshot in time of the basic display shows the amount of blood sugar at that point in time, the display is animated, with the tube flowing past the viewer and shows the changing amount of blood sugar over a time period.

The ring cycles constantly, rotating around towards the viewers position representing changing time (also indicated via the clock in the upper right hand corner). This time scale is significantly accelerated relative to "real" time, thus allowing the user to

visualize the effect of food/insulin over several hours in a very quick accelerated cycle of less than 30 seconds.

The visualization involves the tool calculating the blood sugar level (either by using blood sugar data from patients blood tests or using a predictive model based on insulin injections and food to be eaten), these calculations are then used to display the correct amount of "sugar cubes" to match the food eaten and the correct amount of insulin "balls" to represent the insulin injected. Using calculations based on the absorption rates of the food and insulin the visualization then shows the patient the effect of the food/insulin over a period of time. The objective here is for the patient to see the impact of food and insulin decisions (the main aim being to have a match in insulin to food). When there is correct match of food and insulin there will be no sugar cubes left in the blood vessel.

The patient needs to "play" with the values to attempt to get this outcome. Although this sounds simple, the delayed impact of foods and insulin and the differing amounts in food types and absorption rates can be very confusing, and this is the difficult challenge that patients have in managing blood sugars in their normal daily lives. In this game play process, the patient comes to understand how to match food eaten to insulin injected, understanding the delays and impacts of decisions in a visual interactive way. Thus improving their skills in managing food and insulin and in the longer term their overall long term blood sugar control.

There is evidence from the long term control and complications trials that demonstrates that lower blood sugar/glucose levels are related to reduced complications thus it is worth helping patients learn how to better manage their blood sugar levels to avoid these serious complications (including diabetic retinopathy, neuropathy and blindness) [National Diabetes Information Clearing House 2008] [8].

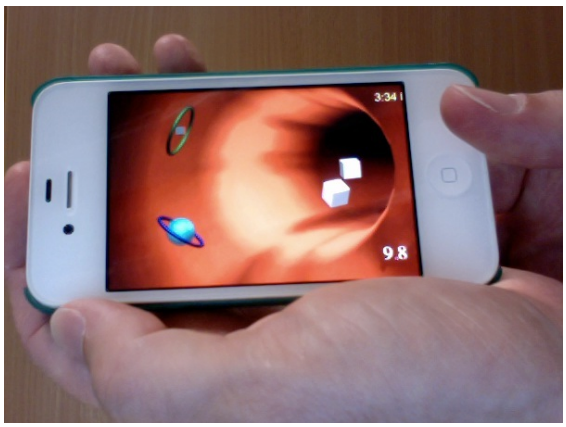

Figure 3: *The Mobile Diabetes Visualizer*.

As shown in Figure 2 & 3 the games display includes the red vessel, sugar cubes (representing blood sugars) and blue balls (representing insulin). When a blue ball and sugar cube are both in the vessel the ball moves to the cube and drags it away (as can be seen in Figure 2 where the ball is linked to cube just prior to removal), out through the blood vessel wall (this is the tools way of showing the sugar being used by the body when the insulin is present to allow absorption). Thus the insulin and sugar are taken out of the system and the user moves towards a balanced (i.e. no extra cubes) and desired level.

On the left of the game screen are the absorption rings, these show the amount of sugar and insulin currently being brought into the body (through eating for food or injection for insulin) and give the user an indication of what is coming in the near future. For example the blue ball in the ring in Figure 3 is almost full size indicating it is almost fully absorbed and will soon be able to move into blood vessel and remove one of those extra sugar cubes thus lowering the blood sugar level). As there is a delay between when food is eaten and when it appears as sugar in the blood, these absorption rings allow the user to see the level of incoming food or insulin (and as such they can visualize the rate of availability and also the times when there is insufficient supply of either sugar (hypoglycaemia) or insulin (hyperglycaemia).

The calculations of how insulin and food is absorbed are based either on a simple rule system (the default involving known absorption rates for insulin types and foods) or calculated from the users blood sugar and food data as provided by the patient. If the system is provided with information on food and insulin intake by the user and also blood sugar impact, the tool then calculates the rates of the absorption and bases its timing on those. Note that this is not a definitive system, clearly to be highly accurate in calculating blood sugars there is a need for any tool to include far more factors (eg. exercise, activity, stress). As such the tool is a simple predictive model that provides an indication of impact rather than a highly accurate blood sugar predictive tool. As its primary role is in engaging the user and helping in learning, this is not critical at this point but it does offer potential for future research to refine the predictive elements.

This visualization/game attempts to make the understanding of blood sugars easier by using a combination of rich 3D graphics in conjunction with animated 3D flow and interaction. This is much more active and graphically rich than the commonly used 2D charts and it is this rich gameplay and interaction which is the core innovation of this tool. In playing this game, and attempting to balance the insulin and sugar intakes, the player learns important skills in judging food content and matching that, both in amounts and timings, to the insulin needed to maintain good blood sugar levels.

The predictive model, although simplistic in its calculations, allows the player to propose scenarios, involving differing food intakes and then attempt to match those. This allows the patient to think through possible options and ways of handling common real-world situations and virtually play out a "prediction" of that scenario.

The "play" oriented nature of the tool allows patients to experiment with different food and insulin levels and visualize the outcomes without needing to experiment with "real" food and insulin. The game challenge of eliminating the extra cubes gives players a sense of satisfaction and in the process helps to teach the player how insulin and food interact and how to manage them more effectively.

In reality this tool is definitely slower to display the data than the equivalent 2D chart (as it will take time to "flow" through the time and changes), but it offers new levels of engagement and a much richer visual experience for the patient.

In many ways this form of data visualization is taking a leaf from the interactive entertainment fields to add "showbiz", as Hans Rosling calls it, to the presentation of statistical data. This simple addition of bright, colourful animation has a very significant effect on how engaging the information is to the viewer. Early examples of these animated charts have drawn millions of viewers to watch presentations on statistics topics such as world population, poverty and HIV amongst others [26,27,28].

Considering the positive effect that the addition of animation has caused, in relation to the impact of the data presentation to the viewer, raises the question of whether the addition/integration of other forms of interactive entertainment can also enhance viewer engagement with sources of statistical information.

3. EXPERIMENTAL RESULTS

The 3D Diabetes Visualizer was trialed in a case study scenario, with a small number of participants (six participants including both diabetic patients (2) and non-diabetic patients (4) ranging from 18 years of age up to 84 years of age) using it for a short period on a mobile device for both post analysis and predictive tasks. Given the long term nature of diabetic complications it was not possible to review the effect that the tool had on patients diabetic complications, instead the tool was measured using a qualitative survey of the participants understanding of diabetes management and how insulin and food issues are managed.

3.1 Results for the Predictive Tool

The predictive tool is the simple mathematical model used to estimate blood sugar outcomes based on input information about food, the time eaten and type of insulin injected and the time of injection. This model is relatively simple mathematically and uses simple functions to calculate absorption rates. The effectiveness of the "predictor" was measured by comparing the tools predictions to actual blood sugar outcomes with diabetic participants. In general the outcomes were closely aligned to the real values, with the tool predicting every drop and rise correctly, the key issue was the amount of the changes, with the tool overestimating the effect of insulin in some cases, this appeared to be significantly effected by activity levels and needs further research in future versions. Although slightly inaccurate the tool provided good accuracy in detecting/predicting directional changes in blood sugar levels. An example is one case where the patient started with a blood sugar level of 16.1mmol/L and then injected 16 units of short acting insulin (which would normally take 1 hour to peak and last four hours) whilst also eating 2 slices of bread (equivalent to 2 sugar cubes of carbohydrates). This scenario is quite common, where the patient started high and wanted to lower their blood sugar (from 16.1 into the ideal range of 5-8) by using more insulin than would normally be needed to match the food, while still eating normally. In this case the patient used the tool to trial different options of insulin, observing the predicted effect in the visualizer, then basing their decision on this. The patient indicated that this feature was very valuable "trialing them is excellent, I can see where it's too much and make a choice on how aggressive to go" (Patient 3 verbal feedback).

The risk here is that if too much insulin had been injected the patient could become hypoglycaemic, but if too little the patient would remain with high blood sugar levels. Based on the feedback given the tool assisted the patient in making this choice more effectively and working it out in an engaging manner.

3.2 Results for the 3D Visualizer

Participants in the study used both 2D charting tools and also the 3D Visualizer to interact with individual diabetic cases and indicated that the visualizer provided an engaging form of understanding what was happening in the blood. When questioned specifically about how enjoyable the tool was to interact with they clearly indicated that the interactive 3D Visualizer was significantly more enjoyable than the 2D chart based system with an average response of 17.3 out of a possible 20 compared to 5.8 for the 2D chart based systems (see Figure 4).

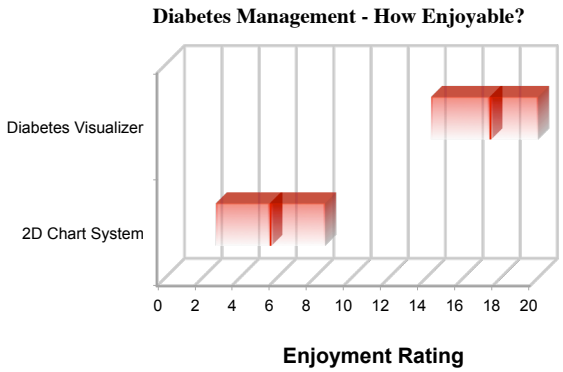

Figure 4: How Enjoyable were diabetes tools?

Overall the results showed that the 3D Diabetes Visualizer was effective in engaging participants interest in diabetes management, much more so than the 2D chart based equivalents. It also received positive feedback from diabetic patients in regard to being useful for actively managing the condition and assisting in understanding and making judgments.

4. CONCLUSIONS

The Diabetes Visualizer, is actually a relatively simple interactive 3D animated display of information, yet the results indicate that this simple form of information representation (with change over time) is more effective than the complexity of the widely used charting information tools. This shows that the participants perhaps are not gaining the most that they could from the chart tools, and there is a need to simplify how that 2D chart based information is presented in order for it to reach its potential. The visual richness and game like interaction of the 3D tool evidently attracted the participants, and this alone makes the technique worthwhile. The fact that it was also useful in helping them to learn about insulin, food and blood sugar management was the major positive outcome from this research.

There is clearly a need for further study into the effectiveness of the 3D tool in terms of its long term use. In particular the need to use the Diabetes Visualizer, not simply as an interaction trial, but as a tool in affecting long term blood sugar control. Using the Diabetes Visualizer on diabetic patients in a long term trial is needed to identify if the tool is merely a good interface design or whether it can play a role in improving blood sugar control and assisting diabetic health outcomes.

Overall the use of interactive 3D animated presentation of diabetes data was effective in engaging participants. The specific use of "flow" and "play" principles seemed to enhance their interest and desire to "get it right". The "flow" and "play" systems described here could be applied in other health management topics and clearly has benefit in presenting diabetes related information to a broad audience.

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The Craft of Creating Accessibility in the Post-Digital Era

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Abstract

The elevation of traditional craft practice as a form of resistance against technological development is a key attribute of the post-digital era. In this paper, I posit a sympathetic relationship between Chinese papercutting and computer art (CA). An arts-based research methodology will be applied to analyze the outcomes of an international community art project titled *The Float*. Undertaken between January and June 2015, it engaged over 100 young people in traditional Chinese craft workshops across Australia, Canada, China, and the USA. The project culminated in a series of exhibitions that emphasized humanity's shared stewardship of the oceans. The artworks presented included both computer-assisted animation (CAA) and computer numerical control (CNC) cut paper. In this case study, the oft-polarized media of craft and CA were simultaneously engaged.

Keywords

Computer Art (CA), Computer-Assisted Animation (CAA), Computer Numerical Control (CNC), Post-digital, Papercutting, Community Art, Community-based Participatory Action Research (CBPAR), Image Segmentation and Craft.

Introduction

The Float was designed to test the capacity of papercutting to collect and process data. To enable the broad dissemination of information, CNC cutting and CAA were also engaged. The title of the project references the 'floating' shares on the stock market. It is an allegory for democratic access for the entities seeking to distribute information and the readers/viewers seeking to access it.

In post-digital theory, crafts such as papercutting are considered the antithesis of CA [1]. In the 1980s the handmade became symbolic of the resistance against the state and corporate media. The virtual 'renaissance' [2] of paper as an independent medium in the museum and galleries sector of North America and Europe during the mid-1990s was a significant component of post-digitalism. By demonstrating the continued ubiquity of the material, this paper revival contravened the 1970s' trope of the digital era: the 'paperless office' [3]. In this case study, the method of papercutting was employed to enable greater accessibility to digital technologies.

Background

Is there precedence for using craft to collect, process or disseminate information?

The methods explored in this paper have been employed informally by activists and formally by healthcare providers. In the public health sector craft is used in community-based participatory action research (CBPAR).

The application of craft as a form of activism extends beyond the post-digital era. In Britain and the United States of America in the 1960s and 1970s craft played an integral role in both the "counter-culture" and feminism [4]. This was championed by Judy Chicago [5]. In 1979 her seminal *The Dinner Party* redressed the underrepresentation of women in Eurocentric history using embroidery, ceramics and porcelain [5].

Knitting is the principle medium in craftivism. The term was coined by writer and avid knitter Betsy Greer [4] in the early 2000s. Some feminists during the 1960s disregarded needlework as a province of housewifery [4]. It was reclaimed by other feminists in the 1970s as a form of political expression. There are presently innumerable knitting collectives aligned with social causes such as anti-materialism, environmental conservation and domestic violence [4].

In the 2000s, the *Leaving Homelessness Intervention Research Project* used quilting as a method to engage a group of homeless mature-aged African American women [6]. The processed fostered reflexivity amongst participants. It also provided researchers a nuanced insight into homelessness.

Whether an aspect of shared labour or a form heuristic inquiry, textiles are a recurrent aspect of community cum participatory art. These craft-based collaborations also transformed non-traditional art venues into sites of political resistance [7].

What is papercutting?

Papercutting involves the creation of images using a concatenation of incisions [8]. Historians concur that the practice originated in China. The technique was applied to a variety of substrates, such as gold leaf [9], prior to the invention of 'modern' paper during 2nd Century AD [10].

Distinct papercutting traditions emerged with the availability of the substrate. *Papel Picardo* evolved in Mexico with the arrival of paper during the 18th Century [11]. Infusing an eclectic of religious iconography, the tissue paper banners play an integral role in the annual Day of the Dead celebrations. The British *Shades*, which would become popularized as *Silhouettes* during the 18th Century, were an adaptation of 14th Century ecclesiastic portraiture [12]. Although the first paper mill in the UK was established at Hertford in 1495 [12], the first to achieve commercial success opened at Dartford in 1588 [13].

An example of *Papel Picado*.

The recurrent affiliation between papercutting and ethereality began at the inception of the technique. Chinese papercuts played a ceremonial role in both private and public rituals. For example, papercutting was used to create effigies of objects for the deceased [9]. The posting of talismanic papercuts for good luck is a custom maintained by Chinese people both on the mainland and in diasporic communities.

An offering ornament papercut designed to pay respect to the gods and deceased relatives [9].

Why use papercutting to collect data?

The decision to use papercutting to collect data was due to its accessibility. *The Float* workshops required few materials to be implemented. Participants have usually been exposed to at least one of the established traditions of papercutting, such as *Scherenschnitte*, *Kirigami*, or *Wycinanki* [8]. Limited instruction was required to develop proficiency in the technique. Papercutting also has precedence as a research method. Since the 1980s, Chinese papercuts have been interpreted using an ethnographic framework [14]. A ubiquitous practice among 'peasant women' [9], papercuts reposit the maternal traditions and oral histories of an illiterate proletariat [15].

In 2004, the Long March Group conducted "The Great Survey of Paper-cutting in Yanchuan County" [16]. 15,006 individuals contributed papercuts to the initiative. This ethnographic study investigated the effects of the Cultural Revolution, the policy of Social Mobilization during the 1950s–70s, and cultural imperialism.

What demographics were targeted in The Float?

The Float engaged over 100 participants in a series of craft workshops across Australia, China, Canada, and the USA. They can be differentiated into two groups by age: five to seven year olds and 16 to 20 year olds.

Compositions by the young children were processed using papercutting techniques. The young adults were directly engaged in papercutting practice.

The workshops were administered in Redcliffe, Ipswich and Brisbane (Australia); Brooklyn and Boston (USA); Toronto and Vancouver (Canada); and Beijing (China).

How were the data collected?

The younger participants were engaged in a combination of woodblock printing and calligraphic drawing. The children used barens to handprint from a series of pre-existing woodblocks. The central motif of each of these unique woodblocks was a rubber ducky. They were asked to draw a marine environment witnessed by the object cum subject. What did the rubber ducky see along the way?

Using woodblock printing, a masculine equivalent of Chinese papercutting, [5] enabled the children to participate with limited training. The technique of calligraphic drawing was familiar to the children who regularly painted on paper.

The motif of the rubber ducky referenced the research of esteemed oceanographer Curtis Ebbesmeyer. He tracked a shipment of the bath toys blown off course during a storm en route to the USA from Hong Kong in 1992 [17].

The organizations hosting the children's workshops included Riverview State School, Kelvin Grove State College, North Vancouver City Library, The Children's Art Studio (Toronto), The Western Academy of Beijing, and the Brooklyn Children's Museum.

Participants at the Western Academy of Beijing creating a background for their woodblock print using calligraphic styled pen and ink drawing.

The older participants at Redcliffe State High School and CATS Academy in Boston undertook workshops in Chinese papercutting. They received instruction in a papercutting technique adapted from Shandong Province in Northeast China. The use of 'exactor' style knives as opposed to 'box cutters' was a major point of departure.

The participants were also shown examples of Chinese papercutting. To provide context, the totemic function of papercuts in Chinese culture was also discussed.

These participants were asked to respond to the theme of the effects of human intervention in the marine environment.

How was the technique of papercutting used to process the image data?

A unique attribute of papercutting is its capacity to cohere disparate visual styles. An exemplar is the preeminent North American papercutter of the late 20th Century, Kara Walker. Her compositions enmeshed pornography, silhouettes from the early 19th Century depicting 'Boston Antebellum' [12], and the 'Carnivalesque' theories of Russian post-structuralist Mikhail Bakhtin [18].

Kara Walker's cutouts installed at the Musée d'Art moderne de la Ville de Paris in 2007 [19].

The motifs created by the younger participants were editioned from documentation of their monochromatic drawings. The majority of the compositions were laid out on a flat surface to dry and were photographed with a digital camera. Others were scanned at 100dpi. This enabled the children to keep their own artwork.

The documentation was printed out, stapled to a piece of Canson Mi-Teintes paper, and cut as an 'original' using an exactor knife. Likewise, the papercuts of the older participants were scanned or photographed. A second set of motifs were created. This also enabled the original cutouts to be retained by the workshop participants.

183 drawings of the younger participants were collected. 142 unique papercut motifs were generated from the compositions. A further 23 papercut motifs of the 35 created by the older participants were editioned.

Children at Riverview State School with their papercuts. The edition was cut using CNC technology.

How was post-digital technology used to distribute the artwork?

The Float culminated in an exhibition in Australia and a series of satellite displays in the workshop host organizations in the USA and China.

The 165 hand-editioned paper-cuts were exhibited as an original set at The Pine Rivers Art Gallery in Queensland, Australia. The artworks presented included four CAA. A further 291 cutouts were machine-edition for the satellite displays. Each on the children who participated received a papercut.

Whereas commercial production of papercuts utilizes a limited number of motifs reproduced in a large edition, *The Float* required the reproduction of small editions of a large quantity of different designs. CNC technology enabled the required cutouts to be produced by an individual within a two month timeframe.

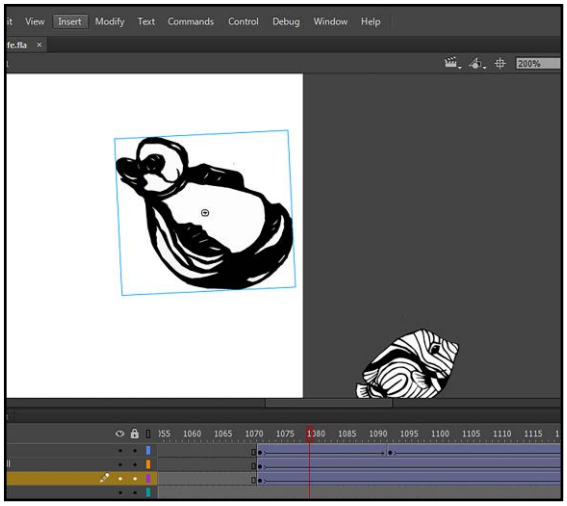
Papercuts, scanned at 300dpi and above, readily translate into scalable vector graphics (SVG). The file format is suitable for both CAA and CNC. Converting cutouts from a bitmap into an SVG requires tracing the internal and external boundaries into a series of nodes. Like cutting an object out by hand, this process can be extremely laborious [20].

In *The Float*, interactive image segmentation was utilized. The 'Live Trace' function in Adobe Illustrator CC 2015 is an example of the technology that emerged during the mid-1990s [20]. Using algorithms, the software program defines boundaries within images [8]. The tools were designed to replicate the cutting of paper images for collage [21]. For instance, a user may wish to separate a figure from the background of a composition. Interactive image segmentation has developed to negotiate shape boundaries from photographs. Subsequently, it is highly effective in tracing papercut forms.

Once the papercuts were Live Traced in this project, they were converted into Fuzzy C-means (FCM) and Shockwave Flash (SWF) formats. The lasercutting of the motifs was investigated. Lasers had a tendency to burn the edges of paper. Subsequently, the editions were made using a small router-like device call the Brother Scan'n'Cut 110. The machines use FCM files. This is opposed to typical CNC cutters, which utilize Drawing Exchange Format (DXF) files. The technology runs algorithms that cluster together objects of high similarity [22]. The machine cuts around these conglomerations. It enabled the cost-effective and accurate reproduction of the papercuts.

SWF files were developed during the late 1990s for use primarily on the internet [23]. The files use vector-based graphics and play using plug-ins embedded into internet browsers. This enables the efficient delivery of animated sequences.

The four regionally specific animated sequences were compiled for *The Float* using Adobe Flash Professional CC 2015. They were exported in MPEG-4 format, with the total length of 15 minutes and 6 seconds.



A screenshot from the production of a CAA sequence.

The host organizations were mailed their editioned papercuts and animations on USB sticks. There were two demographically specific exchanges in *The Float*: (a) between CATS Academy in Boston and Redcliffe State High School; and (b) between Kelvin Grove State College, Riverview State School and the West Academy of Beijing. Satellite displays were organized at CATS Academy of Boston, the West Academy of Beijing, The Brooklyn Children's Museum and Kelvin Grove State College.

A selection of papercuts from a satellite display CATS Academy in Boston.

Future Work

A series of workshops enabling participants to make papercuts and process them into CAA is presently in development. A pilot for the model was undertaken at Logan Art Gallery during September 2016. A second initiative involves the processing of children's artwork using CNC technology to produce sculptures.

A lasercut acrylic sample created by Mao Qing Hu from a design by a CATS Academy of Boston student.

Conclusion

This case study demonstrates the capacity of craft as a method to collect and process data. Since the 1980s, Chinese papercutting has been used as part of ethnographic studies. It is textually affiliated with a maternal, illiterate rural proletariat. In the context of community engagement, workshops can be administered with few resources and limited participant training. Papercutting also has a sympathetic relationship with CA technologies. Digital processes, such as interactive image segmentation, were designed to replicate cutting up compositions by hand. Through this inherent compatibility, craft can provide access to post-digital methods of distribution, including CAA and CNC cutting.

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The contributing art educators who facilitated the workshops included Kim Barry, Tana Eupene, Lee Fullarton, Lynn Jackson, and Justin Kramer.

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Seeking Spectacle – Digital Design & Construction of Interactive Physical Sculptures

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ABSTRACT

This paper describes a project involving an extensive investigation into the manufacturing methods utilized by businesses' seeking spectacle within the context of themed interactive physical environment's. Two manufacturing methods in particular are in question as they have fairly similar processes, 3D printing and CNC machining. One process is additive, the other is subtractive. The paper begins by observing the theoretical ground-works of spectacle, archetype, and co-operative inquiry, including how they are used by media culture, and consequently in themed interactive environments. Subsequently a critical examination of key exemplars is described, analyzing the processes and methods used to produce an understanding of not only the current industry but to expose the successes and failures of the manufacturing methods under investigation. Finally the studio methods and processes for the projects physical interrogation are revealed. From developing and capturing the likeness of an on-screen iconic creature and the digital modeling processes involved, to research and testing of materials, production speeds, programming and operation of machinery. Reaching a physical outcome that displayed both processes involved, enabling the realization of a full-scale sculpture and miniatures intended for the themed environment. The project identified subtractive manufacturing's superiority in contemporary society over additive manufacturing processes contextually grounded in large-scale themed environments and props that seek spectacle

Categories and Subject Descriptors

• Human-centered computing ~ Human computer interaction (HCI) • Human-centered computing ~ Virtual reality • Human-centered computing ~ Visualization

Keywords

Virtual Characters; Digital 3-Dimensional Construction; Digital 3D Design; User Immersion; Human Computer Interfaces.

1. INTRODUCTION

The arts and entertainment industry have generated a plethora of avenues which deliver spectacle to their chosen audience. Theme parks, museums, and public art sites are locations seeking to immerse visitors by placing them in an environment which facilitates both suspension of disbelief through fantasy worlds informed by film, nostalgia, and popular culture. An integral aspect of this experience exists within the props and sets produced by subtractive manufacturing processes (CNC Machining). As a designer, this research seeks to pursue the viability of subtractive manufacturing within this environment in the wake of an increasing shift towards additive manufacturing (3d printing). This project will expose these processes and compare and contrast the advantages and disadvantages. Therefore the central question informing this research is: ***'How can the notion of 'spectacle' be delivered for the themed environment through a subtractive manufacturing process over additive methods?'*** Within the context of these three industries that seek spectacle, my hypothesis would be that subtractive manufacturing should remain not just relevant, but a superior source of production until such a time that additive processes can become a financially viable option for projects seeking spectacle.

Each method has its advantages and disadvantages. In the near future CNC machining is likely to be superseded by 3d printing, and to clarify whether or not its limitations would extend the lifespan of subtractive manufacturing benefitting those working on projects that seek spectacle within the themed environment.

The first section looks at the theoretical frameworks used in my approach, analyzing Guy Debord's Spectacle Theory, and Joseph Campbell's theories on archetype. It will also focus on the research methodology of action-based research grounded on John Heron's theory of co-operative inquiry. Specifically investigating how these frameworks and methodologies can assist in the development of creating objects of spectacle.

The second section analyses crucial texts and images from industry exemplars such as WETA Workshop, Legacy FX, and several others that hold relevance to this project. Anticipating these key sources will reveal how processes have changed and evolved, how these exemplars came about their successes and failures, creating a foundation of principles to approach the studio project with. The final section delves into my personal studio research of both 3D printing and CNC machining with an integrated research and sculptural project. The process begins with digitally sculpting a maquette of an iconic design that is a part of both Hollywood pop culture and palaeontology, the raptor from Jurassic Park. This digital maquette is then produced at a smaller scale with additive manufacturing as a diorama of spectacle, and then to full scale with subtractive manufacturing

displayed in its raw form. Conclusively this will illustrate both processes and their strengths and weaknesses in producing objects of spectacle.

1.1 Media Spectacle

Theme parks and museums' are sites utilising themed environments, seeking to entice the masses in order to generate a profitable outcome. In correlation to a capitalist and consumer-led society, these sites play a large part within the realms of mass media in an experiential form. The purpose to enter these places is to shift our perception of reality, and to ignore the real world, even for a moment. In other words, these sites seek 'spectacle'. But what is spectacle, and why is it beneficial to these areas?

Spectacle theory, or 'spectacle' was a term coined by French theorist Guy Debord. In his book Society of the Spectacle, it is theorised we as consumers are detached from reality and are unable to perceive the true world, unable to distinguish fantasy from reality [1]. 'For Debord, the spectacle is a tool of pacification and depoliticisation; it is a 'permanent opium war' which stupefies social subjects and distracts them from the task of real life' [2]. Debord's view of spectacle does propose a negative outlook upon mass media culturally and socially. However spectacle seizes audiences and generates power and profit. From a business standpoint, spectacle is a fantastic tool to be used for manipulation and exposure as it is rife within mass media and a large influence on the consumer-led society we live in.

Critical analysis from professors such as Donald Kuspit, and Doulgas Kellner, discuss the many views one can take on spectacle. Kuspit views that ironically spectacle in terms of art, actually liberates it in a way as the capitalisation of it allows it to be experienced as something extraordinary, becoming a spectacular commodity itself, enabling it to survive in an industrialist culture [3].

Kellner views the influence of spectacle within media culture, and it’s forever shifting forms as technology progresses over time. His interrogation into media spectacles exposure of contemporary global society identifies positive features. Kellner comments that 'media culture proliferates ever more technologically sophisticated spectacles to seize audiences and augment their power and profit' [4]. This is something that stakeholders within the entertainment industry are seeking to exploit, especially within the context of themed environments. He even goes as far as to theorise that spectacle is becoming one of the 'organising principles of the economy, politics, society and everyday life' [5]. This leads to an understanding that it is crucial to achieve a sense of spectacle when attempting to successfully market commodities, especially when observing spectacle's domination over Hollywood films, product placement, and the over commercialisation of the entertainment industry.

A primary example of the circuitous nature of commercialisation and placement in film is Jurassic park, where merchandise has been positioned clearly within several scenes. Colin Trevorrow, director of the recent fourth instalment stated in an interview that *"Jurassic World is based on Ian Malcom's quote, 'you stood on the shoulders of geniuses to accomplish something as fast as you could, and before you even knew what you had, you patented it, you packaged it, and slapped it on a plastic lunchbox, and now you wanna sell it!' That to me is Jurassic World, and that's why I had all the product placement' [6]*.

It is the perfect example of media spectacle as the franchise holds new relevance with its recent instalment, and Trevorrow really doesn't hold back on commercial placement either with one of the main locations of the film labelled as the 'Samsung Innovation Centre'. Malcolm's quote speaks volumes within the context of not only spectacle, but the project as a whole as I stand on the shoulders of others to achieve my goals, who in turn also stand on the shoulders of those before them. Consequently these points of relevance to the theoretical framing connect, therefore enabling the project to which I could explore the manufacturing methods in question. This leads to the point as to why the choice was made to develop a sculpture based on an iconic creature from the franchise.

1.2 Capturing Archetype

The initial steps of the project involved developing and capturing the likeness of an on screen creature of science fiction, and building a understanding of the semiotics (the visual signs and cues that build connotation) behind archetype which enable suspension of disbelief and consequently accomplishes spectacle.

Joseph Campbell has many written works regarding myth and archetypes, in particular the 'mono-myth' in his book The Hero with a Thousand faces [7]. Albeit Campbell's works revolve around 'the hero's journey', his views on myth and archetype assist comprehending his deconstruction of character archetypes. These ideals of 'monomyth' have been used in storytelling, and character design for many projects directed towards the general consumers of mass media. Many films, such as the Star Wars Saga, The Matrix trilogy, Batman, and Indiana Jones have all been influenced and shaped by these notions of archetype and the 'heroes journey'. These semiotic foundations have been applied to their character development and design, resulting in extremely successful and iconic franchises that exploit media spectacle and culture.

His inquiry into myth and archetype has been beneficial in constructing an appreciation of what makes stories and films such as these dominant in alluring the masses and exponential amounts of income. George Lucas, the creator of the Star Wars franchise has stated that Campbell was a direct influence on his films and that if he 'hadn't come across' his works, he would 'still be writing Star Wars today' [8]. Statistics of the franchises revenue articulate its success, generating an immense $US27 billion since its inception in 1977 [9]. Most recently, the film Jurassic World was this year's highest grossing film, and third highest ever at a current total of $US1.6 Billion revenue from just theatrical release [10]. Upon analysis of this franchise also, it is evident that Jurassic Park also benefited from such underlying frameworks.

The archetype of the antagonist was immediately formed in the initial opening scene of the original Jurassic Park, we never saw the villain yet felt their aggression, power, and intelligence as it pulled a gatekeeper into its heavily fortified cage. Again later the film hints at the creatures speed and dexterity, yet is never seen. Only the movement of foliage, frightening sounds, and the dialogue exchanged between the films protagonists reinforce this unseen malice audiences could only imagine in their minds.

Finally towards the films climax are we introduced to what was an unfamiliar creature in the context of dinosaurs to audiences at the time, and one of the most suspenseful and iconic scenes in spectacle films to date. Cleverly, each visual aspect of what makes them intimidating antagonists is delivered, piece by piece. The characters snout expelling a jet of steamy air on the window of a door before gazing inwards intently searching for prey, its hand opening the door as it enters the kitchen, the 6 inch retractable claws on its feet tapping the ground in an attempt to lure the children out of hiding [11]. Suddenly the audience is able to grasp the size of these creatures, which appear even larger and domineering from the children's perspectives. If there is one

creature of spectacle from the franchise that the sculptural form could be based upon, the Velociraptor is reasonably justified.

1.3 Co-Operative Inquiry

Within the context of a research methodology this work has primarily utilizing the method of Action research within my investigation. Specifically John Heron's theory of co-operative inquiry, as it communicates to working with participants in research instead of analyzing external subjects [12]. This relates directly to my current approach to studio research, as I am collaborating with other individual's in order to achieve my goals in terms of production and furthering my understanding of industries that seek spectacle. This involved interning and approaching several studios, and contacting experts within both the fields of subtractive and additive manufacturing. Eventually I was able to find myself within a situation as to where this project was achievable.

Examples in relation to the context of the project within this form of research can observed in the processes used by artists and senior designers at WETA Worksop, Andrew Baker, Christian Pearce, and Gus Hunter. They have undertaken projects such as designing the enormous character of Smaug and Godzilla for several feature films as well as many other creatures, characters and environments. Their methodologies provide an insight not only into unique design and research methods, but their most contemporary works have involved primarily designing creatures of immense size. Scale is a significant factor of achieving spectacle within themed environments as it can be used to distort a viewer's perspective, shifting their sense of reality [13]. This was something they endeavored towards in terms of how their creatures appeared on film and in-person (discussed in chapter 2). Their research dynamic relied heavily on a cyclical collaborative and reflective process in which different concepts would be assimilated together to re-enforce a design that embodies the archetypal qualities they were seeking with each form [14].

Application of this method in context to the project has involved working with experts in additive and subtractive manufacturing. I was able to work in a studio based on the Gold Coast which employs the methods of CNC routing to develop characters and themed environments for films, theme parks and other projects. Before work on this project even began, I had already solidified my position there as a primary digital 3D modeler and began gaining experience within the industry itself and learning how the business operates. The cyclical processes involved in co-operative enquiry has allowed my knowledge base to expand in terms of not only the manufacturing processes but learning how to approach conceptual projects, dealing with clients and employees, constant feedback, and requests for modification.

2. Analysis & Exemplars

In terms of critical analysis, there are specific industry exemplars who provide insight into the methods investigated by the project. These exemplars are not only leaders in their field in terms of manufacturing methods, but also in manipulation of media spectacle.

The first text investigated in terms of understanding the successful creation of objects of spectacle was The Winston Effect. The text uncovers Stan Winston studios, one of the most influential effects studios in the film industry over the last few decades (This eventually changed into Legacy Effects after Mr Winston's passing in late 2008). The journey, from its foundation, all the way through to projects being worked on as it was being published. Naturally the project focused on the section that covered the design and creation process for the dinosaurs in Jurassic Park, and The Lost World. Although Winston's processes didn't include additive or subtractive manufacturing, the book provides great insight behind the design processes involved.

The text itself involves heavy documentation of the studios methodologies at the time, and the author Jody Duncan does take some risks to bring to light not only the studios successes' but failures as well. What was achieved with the design and creation of the creatures had never been done before, and was the first time organic creatures were effectively created with not just practical effects but computer generated imagery as well. Examples of the risks and failures involved included Winston expanding his Studio and working on production for a year before he was offered the work, an instance when someone almost died when working on the enormously scaled T-Rex, and a dinosaur prop breaking the night before filming was to take place.

Contrary to general opinion, the design process for the creatures was scientifically based and grounded within palaeontology for the current time. Only two creatures were altered in order to achieve the archetype they were seeking for the story. One of these was the *Velociraptor*. For the film some artistic licence was taken to represent them as the main villains and were made larger. Amusingly the discovery of another dromaeosaur [16] (what is commonly known as 'raptors'), the *Utahraptor* in the same year resembled their design in size and anatomy [10].

In light of this, this illustrated that massive risks are taken in order to achieve goals pertaining the creation of large scale objects of spectacle. However, it also exemplifies that he was able to overcome the tribulations he faced and reaped the rewards, winning an Oscar in 1994. Subsequently, Legacy Effects took advantage of CNC technologies in the creation for the onscreen dinosaurs in some scenes of the latest Jurassic film over CGI in order to allow actors to create a more believable and interactive performance [17].

2.1 Additive & Scale

Printed parts for props within the film industry do look spectacular, and are due their credit. However these are almost always printed in small sections and assembled. There have been attempts at producing large-scale objects with additive methods.

A prime example of this is the 3D printed car built by Local Motors, a total of 48 hours print time is fairly commendable for something the size of a vehicle [18].

Figure 1: 3D Printed Car

Yet aesthetically the vehicle is unsuccessful, the print lines are visible and jagged and there is no sense of spectacle and finesse (Figure 1). This is due to the fact that the printer being used probably has a larger nozzle to achieve larger prints at a lower cost in a shorter amount of time. In a sense of practicality it's great for quickly manufacturing a vehicle frame, however within the scope of aesthetics creating a sense of spectacle that other vehicles it is unsuccessful. These methods however are being combined experimentally with others to produce one of a kind objects that are starting to see success in these areas such as the 3d printed Shelby cobra [19].

China has taken 3D printing to an even larger scale, printing the world's first house, and apartment blocks. The process involves building up layers of concrete in the same method as a traditional 3d printer would, so far this has enabled them to erect walls and flooring for structures at a more cost effective rate. However the method is still experimental and not available for commercial use for a least a few more years, one researcher in California even mentions that "One should realize that initially 3D printing can build the basic shell of the building. There is much more that goes into a house" [20]. The design of these houses remains very simple, and industrial, and they are purposed towards low income or use as emergency shelters. It's important to note that this production process is unable to produce roofing for the structures due to limitations, and arguably restricts the creation of complex forms.

2.2 Fire and Water

Large-scale interactive creatures, and environments are just a few of what WETA Workshop has created and offered to the world. A prime exemplar for the project, Richard Taylor and his team have worked on many fantastic large scale objects of spectacle, as briefly discussed earlier in section on co-operative inquiry.

Though many studios keep their in-depth methodologies to themselves due to the competitive nature of the industry they are within, Weta has showcased some of their methods in regards to the construction of several projects; including the creature installations at Wellington airport in the celebration and marketing of the Hobbit films, and the Scale of War exhibition based upon the realities faced by those who fought at Gallipoli in 1915.

In some short informative videos, pieced together by Weta themselves, we experience their processes, displaying an impressive array of 7 CNC machines all capable of working on 5-axis [21]. A larger than life Gollum, spectacularly enormous great eagles, and the dragon Smaug were all manufactured utilising the subtractive manufacturing methods employed there [22].

Figure 2: Taylor, R. *Gollum (Wellington Airport Installation)* 2013, CNC Machining.

Gollum, a pivotal character from the Hobbit films, reaches out above weary travellers as they eat in the airports food court. His hand sprawling for gargantuan fish, gazing in delight at his next meal as the visitors below enjoy theirs (Figure 2). Accompanying him further down the building, closer to where departures can be observed. Gandalf the Grey wizard, rides upon the great eagles of the Misty Mountains. Their 15 meter long wingspan envelopes the roof, soaring above those who are about to take flight and join them in the skies. Yet a malice lingers close by, watching the comings and goings of those at Wellington International. Smoke rises from the ancient dragon's nose as he peers through debris, ready to devour anyone who comes close at a moment's notice.

Weta has achieved spectacle brilliantly within the space they were commissioned to install these objects within. Not only does the airport set visitors at a tourist point the moment they exit the plane, it successfully alters their reality as they are surrounded by these wondrous sculptures. Coherently this also serves the marketing of commodities advertised through such a franchise that relies heavily on spectacle.

The Scale of War exhibition does very much the same, however is meant to entice a different emotional response. Weta produced several large scale sculptures of actual soldiers from Gallipoli (Figure 3).

Figure 3: Scale of War (Taylor, R. *Jack Dunn- The Scale of Our War*, 2015, CNC Machining

Review of the exhibition have led to statements such as 'Combined with the historical material it adds up to the most powerful and engaging presentation of warfare I've ever seen in a museum. It's obvious the organisers have undertaken a vast amount of historical research. It's not only spectacular, it's intelligent and very moving' [23]. Weta Workshop are a principal example of utilising subtractive manufacturing to achieve spectacle appropriately.

3. DESIGN & CREATION TECHNIQUES

Creating a sculptural artwork that delivers interactive spectacle and advances the suspension of disbelief within the realms of film and theme parks is an extensive process. Initially before beginning a project, concept art and reference imagery is collected before starting a digital sculpting procedure. My personal workflow in terms of producing a digital 3d model consists of interchanging between several 3d applications, each with different strengths and weaknesses.

The process for building a sculptural form like the raptor for this project begins with referring to as many images of the animal's physiology and interpreted designs as possible. The original concept art and proposals by Mark McCreery that were used for

the film Jurassic Park were a fantastic starting point to begin building upon. Once enough information and imagery is congregated, the blocking out process of building the model can begin.

Pixologic's Sculptris is a fantastic tool for creating the base forms of a digital model [24]. Sculptris allows the user to digitally sculpt upon, pull, contort, and twist a sphere into almost any shape desired. Using this tool and working with multiple spheres to create different objects, these objects can be arranged and altered until something that resembles the anatomy of the creature is created. Once the base model captures a strong silhouette and resembles the rudimentary forms of the concept, the model is then imported into Zbrush to fuse the mesh comprised of multiple objects together, and work on the re-topology to enable work on finer details such as skin textures, wrinkles and scarring [25]. Working on these features allows not only to add extra depth to the character, but also breaks up flatter areas so forms aren't lost due to a variety of lighting conditions.

To reach a higher level of engagement with the raptor maquette, it was important to make the sculpture the epitome of a predator. The creatures on film operate akin to pack hunters, similar to wolves or lions. Yet their anatomy is strongly based upon birds and reptiles, particularly as it is a dromaeosaur. The model required scale that ensured it represented the imposing and dominant antagonists discussed in Chapter 1. The large dexterous claws on its hands and feet, scarring across its body and mouth, powerful hind legs used for running at high speeds and jumping great distances, an open maw filled with sharp teeth signifying not only its carnivorous nature but a social intelligence as it calls for others. These were all necessary in facilitating the suspension of disbelief. As a spectator archetype is something that we can relate to, it is the accumulation of fundamental traits in things that allow our brain to instantly associate characters or creatures in particular roles. This is equally true in virtual and real spaces. The use of such “spectacle techniques” can potentially enhance physical experience but may also be able to enhance virtual experience in environments like VR/AR [30-39].

To further enhance these visual cues beyond sculpting, the base model is taken into Mudbox, this then enables the use of its skeletal rigging system to modify the posture and stance of the maquette to imply movement and behavior [26]. Once the posing of the model is completed, it is then sent back into Zbrush for further alterations as the reposing of the model can create some undesired and unrealistic forms warping the mesh [27]. These adjustments are usually made to make sure that details such as muscle shape and textures do not appear unnatural. These aspects enhance the realism of the sculpture, as they ensure small nuances such as stretched skin, weight, muscle shape and compression, all appear naturally. Reference and imagination is used heavily at this stage. This is essentially a creature that no longer exists today and imagery taken from other living animals, and previous interpretations is utilized in order to accomplish a sense of realism (Figure 4).

Figure 4: Digitally Designed Character

Finally a base is created for the model using a similar process, enabling it to be suitable for production and exported as a stereo lithography file [28]. This file creates the path and co-ordinates required for a milling tool such as a CNC Router or a 3D Printer to be able to start its process.

3.1 Investigation Into Additive Techniques

How these themed objects and environments are designed and constructed is a forever evolving process with progressions in available technologies. The subtractive process of CNC Machining plays a large role in building themed environments, effectively cutting away at a block of material to achieve the desired shape and structure based upon a digital 3d model. A newer technology, in the form of 3d printing is looking to surpass the subtractive as a new process that can create objects additively, melting down materials and forming the object layer by layer. Subtractive methods if abused can waste a lot of material. Whereas additive fabrication barley wastes any at all, yet is comparatively more expensive due to material limitations.

Arguably 3d printing is still an incredibly useful technology, being able to prototype smaller objects quite quickly. Observing the methods used by Legacy FX & Sideshow collectibles, these two companies collaborated in order to combine the usefulness of 3d printing to multiple outlets. This involved taking a model used for on screen CGI and 3d printing a maquette at different scales which were then used a reference for lighting so it could fit in seamlessly with the backgrounds used on film. However they also used this maquette as a product which is sold as a collectible statue.

Consequently as part my investigation, 3d printing has essentially allowed me to prototype my model in a much smaller scale before endeavouring to construct the full size version. Limitations in materials is something to keep in mind, for example PLA filaments combine different materials, yet aren’t comparable to pure materials due to its low durability [29].

SLA, and SLS methods offer the largest building envelope so far. This process is unique compared to traditional 3d printing, in which a container of liquid plastic has UV lasers fired into it, curing the plastic, layer by layer. The machine then extracts the objects being created from the container. This allows complex forms to be created accurately, at a faster rate, however is more expensive than desktop 3d printers due to the intricate nature of the machines design and materials required [30].

Within the context of finances, costs were also investigated. Quantitative data in the form of receiving quotes from 3d printing companies enabled an understanding of how expensive additive prototyping is. As an example I uploaded the model to ‘iMaterialise', scaled down to 30cm (1:6 scale) in height printed in resin, and the price was estimated to be within $2775.29 AUD.

Extrapolated to full scale the cost would be around $99,910.44. Granted alterations can be made to the file to save materials, and taking into consideration added costs of services provided it doesn't change the fact that subtractive manufacturing is a more financially viable option. The initial estimations of costs for the full scale sculpture were $1000.00 in materials, and they came to $645.00, with a total of $5770.00 if services were included.

Utilising the 3D printers available at Griffith University, test maquettes of the raptor and areas of interest were printed in ABS plastic to achieve an in-hand physical sense of the model, allowing for any adjustments to the final model in areas that may have been overlooked that aren't as evident on screen as they are physically. This also served as a test to see if the digital file translates well to the physical processes involved as both technologies use similar pathing methods. Then a final test maquette of the full model was printed in different sections, assembled and cleaned up. This model is to serve as a concept piece, displaying what the full scale model would look like if it were completed for a themed environment (Figure 18).

Figure 5: 3D Printed Character

3.2 Investigation into Subtractive Techniques

Once these preliminary steps were taken, the larger version of the model could begin production on a Thermwood 5-axis CNC Router at full scale. As the process is subtractive, it is vital that the model is split up into sections, this way smaller blocks of material can be cut and conserved. Polystyrene was chosen due to its light weight, and speed at which it can be cut. Due to the sculptures large size, splitting it into many parts was also necessary, as the overall piece itself is comprised of complex forms and to save materials. The longest cutting period was approximately 4hrs30mins (the torso section), each process involves a rough cut which engraves the material into the general shape, and then a fine cut which details it.

Preparing the machinery for cutting is also a complex task. Apart from programming as to how the tool cuts the foam, blocks of material have to be cut precisely down to the millimetre, then attached to the direct centre of the routers table to ensure absolute precision. Two blocks have to be cut for each piece, one provides elevation so the cutting tool doesn't come into contact with the table, and the main piece sits on top ready to be shaped.

During the subtractive process, there were a few minor setbacks as expected. Occasional mishaps when programming the machine to cut a section, caused a handful of the cuts to fail, or in some cases damage the foam by having an incorrect toolpath set. These problems were easily rectified as they had been anticipated, and using injection foam to patch areas up was a quick solution. The programming process of setting up a CNC Router is a more time consuming and manual process in comparison to 3d printing, yet if done correctly can be advantageous as it enables optimisation through customisation.

Over two months, I would work in the studio daily for 9 to 11 hours at a time. Splitting the raptor into practical sections, programming each part, cutting the polystyrene required, preparing the machine, operating it, and cleaning up the excess waste. After all 24 sections had been created, the model was then assembled and cleaned up, sharpening any less visible details. Towering at 6 and a half feet, the full scale dromaeosaur and antagonist from one of Spielberg's classics had been realised. (Figure 21).

Figure 6: Realized Large-Scale Spectacle

4. CONCLUSIONS & DISCUSSION

Comparing subtractive and additive methods in terms of large scale projects that seek spectacle is important, as there has recently been a significant amount of attention placed on the fact that 3D printing has enabled us to print large scale objects such as cars and even houses. Yet when observing the results achieved by additive manufacturing within the context of spectacle, the success of these things only goes so far. Observing the results achieved by exemplary studios in terms of subtractive manufacturing within that same context has illustrated the strengths and achievements of such methods. This projects physical investigation into both methods has also strengthened this argument, discovering how large scale objects of spectacle can be achieved with subtractive manufacturing.

Not only did the project run as expected, it was achieved in an incredibly short amount of time. My learning of the industry as a whole, expanded beyond this particular investigation as time went on. By standing on the shoulders of experts who utilise these methods to accomplish something as fast as I could, other aspects of industry methods came to light.

This investigation has the potential to grow further, and even look into how these technologies could be combined to optimise production methods. Envision a machine that could print out the base form and material quickly at a low cost, and simply alternate to a subtractive process which details the result of the initial additive process. Projects mentioned earlier such as the 3d printed cars could definitely benefit from a process such as this. Naturally industry leaders are headed in this direction, with Thermwood recently announcing their own plans to develop such a device [31].

Conclusively this project has justified the superiority of subtractive manufacturing over additive methods, within the context of themed environment's seeking spectacle. Analysis of methods used by exemplary studios, research into financial comparisons, physical investigation of each process, have all lead to the conclusion that additive manufacturing still needs time to develop before becoming a primary and financially viable process for large scale interactive digitally designed projects.

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Digital Disruptions

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Abstract

The exposure of the 'real or alternative' has potential to be disruptive. Social and interactive media allows society to communicate and share ideas that disrupt mainstream culture. Visually, these messages have potentially more power when they entertain and engage with an audience. This mode of creative communication isn't always sustained, progressive or democratic, however it acts as an archive of resistant practices and representations of 'the other'. Practitioners such as Ministry of Agnes are exploring protest design within the context of social media and using interactive digital communication to disseminate visual messages. This process acts as both a springboard for conversation and discussion around this creative process and design methodology. Design as a professional activity, in conjunction with an interdisciplinary approach to image production, has the potential to create ways within which we can work against the stakeholders of commercially orientated mass media.

Keywords

protest design, graphic design, visual communication, culture, disruption, mass media

Introduction

The growing use of social media (Perrin 2015) is occurring parallel to a lack of counterculture and alternatives to mainstream commercialism (Kauffman 2013). There is extensive literature about the impact of mass media and growing critical awareness about its power (Aubrey and Smith 2015, Sterian and Mocanu, n.d., Tsay-Vogel 2015, Geber, Scherer, and Hefner 2016, Ciszek 2016, Shoulette 2011), but continual effort is needed to ensure we maintain and refine our understanding. Within this context, this paper explores design as a form of visual agitation protest, known as Protest Design. A relatively new term, Protest Design describes a stream of designers, who reflect and comment on current social and political events in their theoretical and practical work, using practical design strategies (Brandes 2008).

Background

The perpetual rise of social media (Perrin 2015) provides increasingly diverse opportunities to undermine and disrupt mainstream narratives. (Ciszek 2016, Geber, Scherer, and Hefner 2016) Shoulette (2011) highlights that exposure of the 'real or alternative' has potential to be dangerous. Not because its content is necessarily traumatic, but because it directs our attention towards an ellipsis within the historical record where none is supposed to exist (Shoulette 2011, Moyer 2007).

The 'real' may include an unattractive or non-commercial aspect of a place, people impacted by inefficient government services, or everyday occurrences that are not presented to a wider audience by mass media. Shoulette further highlights this by telling us that:

"If we were to extend our inventory of heroic defiance to include those many minor, sometimes petty acts of everyday disobedience that Michel De Certeau theorized as tactics of resistance… then it seems suddenly as if an entire realm of shadowy, non-compliant labour has materialised into gloaming visibility about the margins of mainstream social, political, artistic, and economic discourse… Nevertheless, isolated flashes of defiance are disjointed acts of insubordination. They do not necessarily knit together as sustained politics, and they are not inherently progressive or democratic. By and large these are gifts that often "forget themselves" insofar as they are generally not perceived as gifts given or received. Still, insofar as this creative dark activity refuses to be productive for the market, it remains linked, however diffusely and ambiguously, to an archive of resistant practices—past, present, and to come—that Fredric Jameson called a "political unconscious," and that theorists Oskar Negt and Alexander Kluge described in more literal terms as a counter-public sphere made up of dissident affects, re-appropriations, and fantasies." (Shoulette 2011; 187)

Practice & Practitioners

Protest Design and disruption as a creative practice functions to examine and challenge contemporary issues while empowering its practitioners. Not limited to graphic outputs, Stops (2013) identifies craft based practices such as knitting, as a political action and protest of gas mining. An action that facilitates the processing of ideas, it reinforces connections within the community and a tool of social, cultural and ideological influence (Stops 2013). Desai and Darts (2016) also describe the importance of public art, tertiary design education and place within the context of designing disruption. Through the additional lens of pedagogical innovation, they describe 'the constant assault of corporate images (requiring) us as art educators to move out of the classroom into public spaces, where we alter, create and change images, thereby allowing us to see in different ways' (Desai and Darts 2016). Disruption as a creative practice acts by making 'visible what dominant consensus tends to obscure and obliterate' and highlights those who are silenced within the frameworks of the exiting hegemony (Mouffe 2007).

Public art (within the context of Protest Design) also encompasses graffiti. Banksy, the well known (and largely unidentified) graffiti artist and activist is an exemplar of agitational street art and design (Branscome 2011). Subverting the status of public spaces and art galleries and simultaneously occupying the space between cultural criticism and vandalism, his work identifies heavy themes (racism, poverty, consumerism, political authority and terrorism) and results in public interventions. 'Toxic Mary' (2004) and 'Christ with Shopping Bags' (2005) demonstrate how Banksy engages society, while simultaneously allowing viewers to make meaning within the context of a political idea or message.

Figure #. 'Toxic Mary' (2004) Banksy

The disruptive power of image design within the context of mass media is exemplified by the work of Peter Kennard. Instigating debate about politics, society and global themes, Kennard utilises (digital) photomontage to depict a new layer of 'truth' within digitally edited images (Kennard 2001). He says of his own practice '…pummel these pictures into revealing invisible connections, disconnecting them from direct representation into statement and argument' (Kennard 2001). His work reflects a strong emotional reaction to events within our global community and disrupts the idea that art and profit are inseparable describing the process as combining creativity and protest (Kennard 2008).

Figure #. 'Photo Op (2003) Peter Kennard

Commercial graphic design skills, knowledge and resources when applied to a disruptive agenda lead to 'counter-narratives' and mechanisms for producing alternatives within mainstream culture. Moyer's (2007) disruptive practice features agitational propaganda within the context of street art (poster installations), digital publication, lesbian culture and New York. She reclaims public space from commercial dominance and uses this as a mechanism for advocating for gender equality and representation (Moyer 2007). Her work functions as Protest Design in that it exposes the absence of lesbian visual representation in mainstream culture and its implication that an individual is not visible within society unless they belong to the niche market. The image 'Shared Women' represents the culture of both collaboration and exploitation and related themes that need to be shared with an audience wider than the 'alternative community' (Moyer 2007). With over one thousand follower on Instagram, Moyers visual outputs now also include process work and images of private moments in her life. Her work is now also shared and adapted by other users of social media as it adapts to both new and old audiences.

Figure #. 'Shared Women' (2007) Carrie Moyer

Measuring the Impact of Protest Design

Conversations regarding protest, social movements and disruption often lead to the question, "what was the outcome?" Literature provides limited agreement on how to measure the impact or outcome of any social movement or protest (Giugni, M. McAdam, D. Tilly 1999).

Determining a movement's success or failure with respect to their stated goals, assumes that the events, protests or disruptions are homogenous entities and the group or participants maintain agreement as to the desired outcome. In addition, participants and external observers will likely have different perceptions of the success and failure (Giugni, M. McAdam, D. Tilly 1999). Giugni, et al. (1999) identifies that research is often limited to political or institutional impacts, neglecting unintended social or cultural consequences.

Protest Design as a form of activism may be fated to remain a 'movement in itself', not (consciously) for itself. Its success will consist of making democratic communication a nexus, a beacon highlighting different elements of radical democracy (Carroll 2006).

With the awareness of a lack of framework to assess the impact of protest design and related outcomes, this paper views protest design as a valuable creative practice when it:

- Provides the possibility of alternatives to mainstream ideas and culture (Kauffman 2013),
- Reinforces social connections (Stops 2013),
- Creates an archive of evidence of resistance (Shoulette 2011) and,
- Visualises what dominant the consensus often obscures and obliterates (Giugni, M. McAdam, D. Tilly 1999).

More research is required to accurately understand the impact, consequences and complexities of protest and its unintended outcomes, with deeper understanding of the broader social and cultural effects. Ideally, this will occur through appropriate and globally responsive lens, highlighting the impact of time, environmental, social and political conditions.

One New Follower

Ministry of Agnes is a current Protest Design practitioner, utilising disruptive themes and practical processes to investigate mainstream mass media narrative. Her current visual outputs experiment with local identity, economic power versus culture, and focus on the city of Gold Coast, Australia as a case study.

By undermining the mainstream narrative through the exposure of alternative messages, her work aims reveal, record and recode an alternative Gold Coast image. The work currently focuses on the Gold Coast, Queensland and its multiple realities, culture and economic power, all of which are no longer separated (de Oliveira 2009). The images of 'political reality' and 'commercial reality' dominate our physical and psychological environments. Few places represent this statement better than the Gold Coast. It is simultaneously branded by media, advertising and political agendas as many different things:

- The crime capital of Australia (Larkins 2013)
- Family friendly holiday destination (Potts, Dedekorkut-howes, and Bosman 2013)
- Party town with easy access to drugs and sex (Schindeler and Ewart 2014)
- Government moderated Schoolies destination (Pennay and Lubman 2013)
- Prosperous business destination (City of Gold Coast 2015)

As evidenced by the list above, the Gold Coast is not an easily definable place with a singular identity. This indicates a need for exploration of the tension between the imposed identity of the city and the alternative reality (Griffin 1998).

Using a mixed method approach, Ministry of Agnes utilises current literature and statistical data to inform the content of her images, providing a strong theoretical framework. The research process also highlights issues relating to ethical clearance and social media interaction, digital privacy and disruptions within institutional contexts.

Works in the Gold Coast series have been exhibited both locally and internationally in diverse spaces, from commercial art galleries to 'ad hoc' street installations. Social media is also used as an experiment in digital exhibition spaces and Instagram in particular, provides access to real time access to collections of themed images grouped by hash tags. The boundaries of this trans-disciplinary space become increasingly complex as they move and adapt to changes within the environment and also reflect a democratisation of design practice through the inclusion of 'street design' and non commercial applications of the professional design tool kit.

Gold Coast Series; A visual case study.

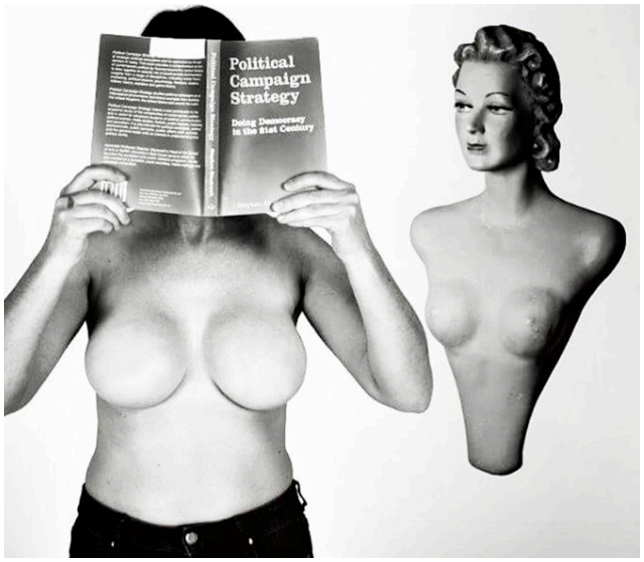
Cop Porn.

Over one hundred stickers have been applied to public spaces around the Gold Coast. As a play on words, Cop

Porn invites viewers to consider the relationship between crime based news media, entertainment and information consumption. Images of the sticker circulation is featured on Instagram.

Surfers Parasites.
Digital editing of an iPhone photo contains a subtle suggestion of an unofficial Gold Coast reputation. Elements of the image reflect research themes such as difference in local and tourist perceptions of the Gold Coast, and what it's like to be a local in a city considered to have a transient population.

Two Girls and a Political Campaign Strategy.
Heavily edited female figures are focused on a book titled 'Political Campaign Strategy', written by Gold Coast based author Stephen Stockwell (Stockwell 2005). Questioning the relationship between the reality of Gold Coast local culture, mass media generated myths and manufactured consent, the image depicts a heavily 'photoshopped' woman and a mannequin head and torso.



Famous for Fun.
Featuring the official Gold Coast Tourism logo on a bag of white power, the image refers to the disparate image of the city as a popular tourist destination and crime capital of Australia.

Impact of the work.
A main effect of Protest Design is its ability to redirect attention of the elite and the public opinion on the issue of protest rights (Giugni, M. McAdam, D. Tilly 1999). Protest Design and other form of media activism challenge the standard conceptions of 'success' in the social-movement literature beyond its absorption into policy and quantifiable data (Carroll 2006).

In the publication 'Why Movements Matter', the authors remind us that work such as the Gold Coast case study by Ministry of Agnes isn't limited to impacting or changing public decisions, but it criticises the ways in which decisions are taken, asking for more citizen participation in decision making. Its impact can be measured in that it creates a visible beacon of resistance and an alternative to the mainstream Gold Coast media and advertising generated image (Giugni, M. McAdam, D. Tilly 1999).

It might seem as only an example of the 'new' in social movements, the emphasis on 'challenging the codes' of media. However through the recontextualisaiton of commercial design processes, Ministry of Agnes challenges the system of symbolic production. It creates a critique of the political economy of mass communication and an effort to build alternatives (Carroll 2006). If new social movements engage in defensive and offensive struggles, its success will not likely bring it a collective identity or a well defined niche within the system or social movement sector. (Carroll 2006).

Carroll (2006) supports this further by stating that social protest may signify a shift from intermittent cycles of protest to a permanently mobilised global society in which movements spread globally inline with the speed of online connections, then Protest Design and media activism will surely play a significant role in the disruption of mainstream media.

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Virtual Reality Rehabilitation for Special Needs

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Abstract

Three-dimensional space in a three-dimensional world using Virtual Reality films and devices can improve learning for children who have special needs undertaking the Year 3 Curriculum.

Keywords

Special Needs, Virtual Reality, Improvement, Rehabilitation

Introduction

Virtual Reality is new, up and coming and is now available on any persons' smart phone. With the use of a 360 degree display, viewers can immerse themselves into a virtual world. As studies are formed, the Virtual Reality device is producing outstanding results when it comes to the involvement of being in a virtual world whilst learning, giving game developers and even scientists a reason to create amazing programs for people to use on these immersive devices. Whilst consulting with my peers, I believe it would be fair to create a film, an immersive film to assist with helping children with special needs learn in a unique and creative way.

Contextual Relevance

This topic is important because the research that I have studied so far has been mostly inconclusive. I have recognized that this topic is challenging when it comes to working with children with disabilities because they are realistically unpredictable, this shows in some of the articles responses. In two out of the four sources I have researched, two have concluded with inconclusive results, although have found other interesting aspects they may not of thought of when completing their test. Since I am using different children to other tests that have been conducted, I feel this topic could be forever on going, however the more results, the more this project is going to be noticed and may eventually implemented as an official rehabilitation or learning tool for children with special needs.

Social Value

As my topic revolves around children who have special needs, who may not be considered in their own minds the same as others, they strive to be participants within the community. The children may have specific goals they want to achieve in their life which may not be possible due to their disability, however if virtual reality devices were able to make an impact on their learning and rehabilitation needs, they may be able to do something similar to achieve their goals in their lives. As humans, we always want to make an impact and to contribute to other peoples lives. The children's values would want to be the same as ours, and conducting this research survey and participating with other people will go a long way in helping them be one with the community.

Methodologies

To test if the theory would be successful, these were the methodologies used.

• *Qualitative Response* With the qualitative responses – keywords – for example when the child recognizes a certain shape that will be documented and the results will be compared and an analysis will begin. The benefits of using a qualitative response is that it goes into behavior exploration. This is key to what I want to find a response to in my test.

• *Survey Questions* To conduct this test, I have created a short survey for the kids to respond to after they finish watching the video. The idea of it was to see how much the child could remember from certain parts of the video. I have also included the emotional aspect of the survey, which asks the children how they felt while watching the video. The benefits of using a survey in my test is that anything can be said and the responses can vary from each child.

• *Blind Testing* To ensure the testing is fair I have created an eye witness account survey, where person unrelated to the test will answer questions based on what the child is experiencing. The benefits of blind testing are there are no chances of any bias coming into the test, giving more accurate information and having it being easier to compare to.

• *Descriptive Analysis* To collect the data and compile it, a series of other subparts like the test being observed by another person and recording the information is crucial to gaining enough information to compile into a research project.

• *Comparative research* To ensure I have a good amount of information, I have chosen to go with comparative research. The aim of comparative research is to compare my results with an eye witness account and with other articles I have researched.

• *Environment* The environment the test will be conducted in will be quiet so the child can focus on what is in front of them, however this may vary due to the kids being unpredictable sometimes and I may have to follow them around to get the survey completed. Mostly I will have a set position where the children can safely watch the video then conduct the survey. The benefits of conducting a survey where it is quiet is so the child can focus clearly on the video and the test. It is also good for the eye witness so he/she is not disturbed by other things around them.

Preliminary Theoretical Investigation

Source 1: Reference: Article **Author:** Tremblay **Year:** 2014 **Publisher:** ProQuest Library. - ***Learning disabilities and visual motor skills; comparing assessment from Hapto-Virtual reality tool and Bender –Gestalt test.***

The authors of this article conducted a test on people who suffer learning disabilities and people who do not to see if the virtual reality tests were more successful to either group than the bender-gestalt test. The subjects were tested first with the bender-gestalt visual motor test to evaluate the visual motor maturity and to search for disorders or damage to the brain. Subjects were then tested using the virtual reality tool. The conductor's hypothesis suggested the subjects with learning disabilities results would be lower on the Virtual Reality test. This theory turned out to be correct as the participants without a learning disability exceeded much higher than the subjects who had a learning disability. The bender-gestalt test however did not return significant results to prove who did best out of the two groups. The authors suggest the use of the Virtual Reality tool distinguishes motor functions for people with and without learning disabilities, although they had to account the Learning disability participants found it harder to attempt problem solving. This research article is useful to my topic as it is in favour that the VR device did not increase any motor skills in the subjects with learning disabilities. The research does not specify which type of Virtual Reality device was used to undertake these tests so the information may not be accurate as to what I am studying. This article opens up the thought to Virtual Reality devices not benefitting the Children with Special needs, however providing decent information for ongoing tests that may occur.

Source 2: Reference: Article/Research Test **Author:** Dean Inman **Year:** 2011 **Publisher:** ProQuest Library ***Learning to drive a wheelchair in Virtual Reality*** This article is based on a research project which enabled children with disabilities to test driving a wheelchair in a realistic virtual reality world. These studies were conducted to examine whether the children greatly improved in the real world after testing in virtual reality. The test included different scenarios including exploration, discovery, visual memory and even relationships. Results proved in the real world the children were much more improved. The children were more likely to spend time in the first and second levels, familiarizing themselves with the virtual reality space and handling the controls, then clearly exceeded into the third round which included street crossing and hazards. The results clearly showed all of the test subjects gained skills in driving. The use of virtual reality was able to help children with orthopaedic disabilities to drive a wheelchair without the risks of learning in the real world.

This research article is useful to my topic as it explains Virtual Reality was providing a safe and a non cost effective way for children to learn how to drive a wheelchair. This topic goes in favour of VR devices helping make the experience of learning for special needs children fun and safe. The research does not cover in specific detail the age of the children however it does state that since the children are growing and need to start looking for ways to get a job or study, they need to efficiently learn how to drive a wheelchair without assistance. This information will add generous input to helping answer the research question.

Source 3: Reference: Article/Research Test **Author:** Emilie Loup-Escande, Oliver Christmann, Romain Daminano, Franck Hernoux and Simon Richir. **Year:** 2014 **Publisher:** ProQuest Library **– *Virtual Reality Learning Software for Individuals with Intellectual Disabilities: Comparison between Touchscreen and Mouse Interactions.***

The aim of this test is to analyse the results from a computer interface with a mouse and a virtual reality tool in a virtual environment allowing self-learning tasks (Touchscreen). The task they focused on was dishwashing. Methods they used was the experiment itself, a questioner and afterwards, an interview. The practiced all of these on a few people who all had disabilities. The results concluded the interest of a virtual reality tool linked with a computer interface of tasks by workers with mental deficiencies. In this process, a touchscreen device was given to the group as well as the test of VR on the computer. Four out of the six that were given the touchscreen device said they had preferred it in the long run as it is more portable and is perceived as easier to use then a mouse. In all the tests run, the touchscreen proved faster than the mouse.

The test conducted in this article was to see if a touchscreen with a learning scenario was faster than a computer virtual reality scenario. This article is quite similar to the way I will conduct my test without using a computer. Although this test mainly focuses on timing, they did not put any information based on how the person was feeling and whether the test subjects were comfortable or not. This article is useful to my research because it focuses on

different aspects I probably would not have thought of for my own test, which brings hope that I will have conclusive answers. This topic goes in favor that VR devices will most likely help people with disabilities, which will assist my research as it goes forth to help others.

Source 4: Reference: Article/Research Test **Author:** Denise Reid and Kent Campbell. **Year:** 2006 **Publisher:** ProQuest Library - ***The use of Virtual Reality with Children with Cerebral Palsy: A Pilot Randomized Trial.***

This article focuses on testing a child with cerebral palsy with the use of a virtual reality device. The study was to capture information and examine changes in upper extremity movement and in self perceived self efficiency as a result of Virtual reality intervention. The aim conclusion of this study was to show the use of emerging technology such as the VR device will help in the field of pediatric rehabilitation. Their research question was; "Does the use of virtual reality with children who have cereal palsy have an effect on their self-competence and quality of upper-extremity movement?"

Their results were non-significant except with a social acceptance sub scale, which showed a large improvement in the treatment group. The kids felt more accepted because they were making new friends, they were more comfortable with people who were non-disabled and they liked it a lot more because they were doing things with other kids. The conclusive result was to allow VR devices to be put into the health care environment to help the children who are disabled who are essentially at risk of self-esteem issues.

This article is very useful to me as I feel the testing situation could be quite similar to mine. This is because the results found an increase in social development. This is not because my answers are the same, but because they were able to find a conclusion for something that was tested mannerly. It gives hope and insight into searching further for an accurate conclusion in my own test. This article gives thought into VR devices not being able to help, but find possible conclusions which may be tested again in the future.

Practitioner Exemplars

Practitioner 1: Creator: Morton Heilig. Year Created: 1962. Location: America. *Origin of VR: Sensorama.*

The father of virtual reality and inventor Morton Heilig, was most famous for his invention of the Sensorama. The Sensorama machine was a simulator designed for one to four people that involved the impression of reality using a 3D motion picture which also included sensory involvements such as smell, vibrations, stereo sound and wind to create an illusion of reality. The Sensorama motion picture projector

projected images such as a motorbike scene or a plane scene. The Sensorama was created in the 1960's but was patented in 1962. Morton Heilig was a cinematographer who was fascinated with studying human sensory signals and illusions as well as Cinerama and 3D movies. He designed the Sensorama to "stimulate the senses of an individual to stimulate an actual experience realistically." Since the Sensorama is well out of date, it has inspired programmers and businesses to create portable and effective devices such as the Oculus rift.

This practitioner is useful to my topic because it focuses on one point in time when the world of virtual reality was being created. Pointing out who created the first VR device opens up a world of possibilities for new creators to invent devices like Heilig's. This research does not provide initial direct influence to this device helping children with disabilities however this is what started the craze of experiencing motion pictures in a different way for the first time. This information contributes to my research as I will be able to compare multiple devices that have been created to show if they can assist children with special needs.

Practitioner 2: Creator: Palmer Luckey. Year: 2012. Location: USA. *VR Today: Oculus Rift.*

Palmer Luckey was 21 years old when he first created the oculus rift. What started out as dismembering old technology in his parent's garage turned into a multi-million-dollar invention over the course of a couple of years. Luckey strived to experiment with headpieces to create something he wanted to use and he wanted other people to use. The Oculus rift was created to make something effective and something different from what was on the market and "inexpensive for gamers". Luckey dismembered and remodelled old training devices that were used for training soldiers to try and create a new device that had clear vision and corresponded easily to move with people's vision. By early 2012, Luckey was approached by well known video programmer John Carmack, who presented 'The Rift' at an E3 convention. Luckey then partnered with three other video programmers and started a kick-starter campaign that raised nearly $2.5 million dollars. Soon after Facebook got involved and named it the coolest thing they had ever seen. Facebook then bought

Oculus for $2.2 billion dollars. The Oculus rift is now used for gaming and is available to most people. Although the

Oculus is a gaming virtual reality device, it has sparked ideas for other companies to create devices that may assist people. This practitioner is useful to my research as this is the device that is helping shape the future of technology and gaming. It is also sparking ideas for people to create similar devices to help aid people with learning disabilities or physical disabilities. This research does not identify any correlation to children with special needs however the article did mention a section on how they tested the device – being placed in a circular room with a treadmill to walk around and experience being outside when they were confined in this room. This opens up opportunities for in home therapy to become interactive and helpful to people who may have suffer from a physical disability. This information contributes to the project because it is now one of the biggest VR devices on the market and although it is only specifically for computer gaming use, it should open up other opportunities for disabled people to experience new things.

Practitioner 3: Creator: Jaron Lanier **Year:** 2013. **Location:** USA. ***"Who Owns the Future?" The Journal of Social, Political, and Economic Studies"***

Jaron Lanier - Computer Scientist, Popularized the term "Virtual Reality".

This article talks about the influence Jaron Lanier has on the future of Virtual Reality. Others such as Morton Helig are referred to as the "Father of Virtual Reality", it seems Jaron Lanier has undertaken the same name. Lanier is a computer scientist and a musician and is highly known from his research into virtual reality. He popularized the term Virtual Reality and has received multiple PhDs and other awards. In 1987, Lanier and his company (VPL) developed a range of virtual reality gear, such as the Dataglove - which he partnered with Tom Zimmerman and the EyePhone head mounted display. His company was the first to sell VR goggles. In 1992, a movie called The Lawnmower Man was based on Lanier and his early laboratory days. Lanier was played by Pierce Brosnan, a scientist testing out virtual reality therapy on a disabled patient. Real equipment from the research company was used in this movie. Other than his countless amounts of research, Lanier wrote many books, such as You are not a Gadget, where he specifically states to readers that someday super intelligent computers will dominate or absorb human beings. There are other important topics this article covers such as the jobs technology has taken over, the use of 3D printing, all the way to Self-driving vehicles. It is clear that Lanier's research has gone a long way in the field of Virtual Reality.

This article is useful to my research as it touches on some topics I may not have thought of such as comparing what technology we have today to something that could happen in the future. His research would be interesting to read as his virtual reality devices have gone a long way to inspire others. It is also interested to know that a movie, The Lawnmower Man, is a true story that is based on Lanier's early laboratory days. This article will add generous input into my research as it is inspiring and will ultimately help with my test.

Practitioner 4: Creator: Ivan Sutherland **Year:** 2000 **Location:** USA ***"Virtual Reality, Combat, and Communication." Journal of Business and Technical Communication***

Ivan Sutherland is known universally for creating computer based VR in 1966. This document talks about the head mounted display (HMD) currently being the most common form of equipment projecting Virtual Reality. The article explains the way Virtual reality is used in gaming and how the device works with people. Sutherland is mentioned throughout as he worked with the Head mounted displays introduction to Virtual Reality. Sutherland started experimenting with different computer inputs, using a light pen in a computer display and a computer output. This created the ultimate display, users could now see a virtual world. Sutherland worked with was originally a military experiment that worked with a Helicopter company. Their HMD used an infrared camera that allowed the pilots to fly safer at night. Sutherland is also known for creating the sketchpad, a human and computer interaction program which was a breakthrough for computer graphics and the computer industry itself. Sutherland's concept has certainly drawn a path for people all over the world to delve into the world of Virtual Reality.

This article is interesting as the information goes into depth about how VR was actually created and formed. It is quite interesting to learn about how VR is being used in training such as in the Military and for other simulations like flying a plane. I believe this is a gateway to allowing full use of Virtual Reality devices in helping assist children with disabilities.

Survey Results

To summarize, for this test I had two documents printed, one in relation to the child recognizing objects/colours/shapes on a 360 YouTube video and the other for an eye witness account to recognize and describe what the child was seeing. 3 children were tested.

The analysis of the findings concluded indifferent. Most of the children found it amusing, whilst some found it quite boring or not amused by the situation. Factors to contribute is the attention span of the child as well as the disability the child may have.

Three children were picked random and were asked to undertake the survey. The first a high functioning child on

the ASD Spectrum, The child was accurately able to identify all things involved in the video. The child was comfortable with the device and was intrigued by the movement.

The second child had Downs Syndrome, The child was not too cooperative and didn't give full answers unlike the first child. The child seemed to understand the concept of the device, although was not too interested, this however I feel was disrupted by the environment. The third child interviewed had ASD, this child was able to identify a few things in the video, but not all of them. This child was excited about the process, but found it a little confusing. In beginning this research, the aim was to ultimately find that the children would be quite ecstatic with the fact that they have a moving video in front of them and want to interact, and it did for 2 out of the 3. Whilst conducting my research on other practitioners and researchers, I found that not all of their information went in favor of the device being a capable learning device.

I discovered this whilst conducting my own test. Each child interviewed was completely different, some taking the test great and some not being interested at all. To further my testing, I would like to interview another range of children, to see if the device would have similar effects for people with the same disability.

Overall the children thought it was fun to experience virtual reality on a regular phone, each child interacted and managed to recognize most of the items on the screen, however became shy and less outspoken when it came to how they felt out it.

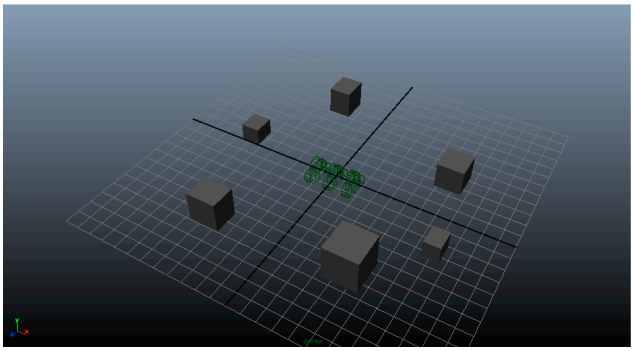
Reflection

There is a strong possibility that if a specific video was made for their particular age bracket, the odds of them being able to recognize particular objects and have lots of time to do so, are more than likely. For the main assignment, I plan to create a short video, completely animated with different types of objects, sounds, words and sentences optimized for their school year. Based on the age of he children, I have estimated their school year to be in Grade 3. With this I have done some extensive research on what they learn, such as sentence structure, multiplication and addition, reading, picture books, rhyming, film, multimodal texts and more. Now having VR available on everyday devices and having tools such as google cardboard, and knowing how to create different scenes, I will be able to create a video where the children are more likely to interact and learn as if they were in their own class environment, but except in a Virtual World.

Implementation

I have been intensively studying and researching how to create a 360 Video. The first thing I needed to do was to make sure I could successfully set up a stereo-spherical image in the 3D software and render it available for YouTube, which is the player for 360 Videos.

This image here was the first stereo-spherical or 360 image I was able to create. For this I used Maya and Domemaster 3D, a plugin to make images or animations 360.



In this Maya screenshot, you can see I simply placed cubes in a circle and placed the 3 LatLong Stereo Cameras in the center. After a series of settings and a batch render, you get this image.

Next, I put this image into premiere to make it a film, because this was a test, no animation was involved so it was rendered as one image. Lastly, the film was then injected with metadata and was uploaded to YouTube to become a 360 Video. https://www.youtube.com/watch?v=1PhIEoaVgk8

After many basic tests, I was inspired by the earth and our solar system to create the video SOLAR 9.
This VR (360 Video) is optimized for YouTube and to be experienced on your very own smart phone. This can make it accessible for children and parents where ever they go.

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I have strayed away from the learning techniques because I believe facts, animations and an empowering voice will hopefully allow the kids to open up and remember what they are being taught.

The film consists of 10 scenes, an opening scene to the planets with the planets revolving around you and one scene for each planet. Each planet scene contains multiple facts about that specific planet. The film is accompanied by a voice over and calm music.

Conclusion

Through the creation of this project, I have learnt a lot about the thoroughness of researching, demonstrating how something was made and how it can effortlessly change the future. I have learnt how to successfully create a 360 Video with the help of software and online resources.

This project has achieved its purpose, to provide a learning source to children with special needs, however I have focused this more on a “anyone can view” project as it is suitable for anyone. I would hope that potentially in the future I could make a series of 360 films like SOLAR 9 and even have them being interactive as well to be more immersive.

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3D Scanning of Heritage Artifacts as an Interactive Experience - Creating a Window into the Past

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ABSTRACT
This paper looks at innovative methods in the capture of high quality 3D detail from historical artifacts. These forensically accurate details are then applied for use in building engaging interactive entertainment outcomes. The Mephisto, the only remaining German tank from the First World War, was used a case study to examine the methods available to accurately record a large and iconic piece of war history. This paper introduces 3D scanning workflows as a method to create an accurate three dimensional model of Mephisto, and also addresses how the high quality information from the tank can preserve, and also allow for analysis and presentation of Mephisto in ways that have never been seen before. Combining 3D scanning workflows with forensic analysis and historical war records, this paper explores the possibilities of how to best communicate and present this 3D information through interactive and virtual realities. It describes how augmented and virtual realities can create a window into the past, possibly answering some of the questions surrounding the tank, its story, and allowing visitors an interactive user experience bringing realism and truth to a historically accurate digital tank. Thus building a powerful mechanism for communicating history through innovative capture and presentation techniques.

Categories and Subject Descriptors
• Human-centered computing ~ Human computer interaction (HCI) • Human-centered computing ~ Virtual reality • Human-centered computing ~ Visualization

Keywords
3-Dimensional; 3D Scanning; Heritage Preservation; Forensics; War History; Virtual Reality; Augmented Reality; Interactive Experience; Interactive Realities.
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1. INTRODUCTION
What happened to the German tank known as Mephisto has been scrutinized for almost 100 years, but research may help put an end to the speculation and take the public inside the tank, for an interactive digital experience, for the first time.
The Mephisto was immobilized in the area close to Villers-Bretonneux called Monument Wood in France when it became lodged in a shell crater during the First World War. The Germans were unable to recover Mephisto, so it remained stranded until July 1918 when Australian troops of the 26th Battalion AIF, which was composed mainly of Queenslanders, eventually regained the lost ground and pushed the Allied front line past Mephisto's position [1].

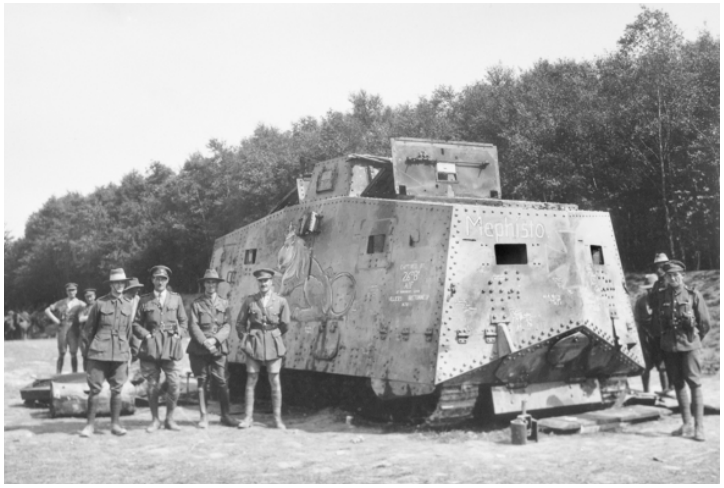

Figure 1. Mephisto after its retrieval during WWI [2]

As a result the battalion's commander ordered the retrieval of Mephisto (Figure 1.) and it was sent to Australia as a war souvenir. It is currently the sole surviving A7V tank in the world and many people have a memory of the Mephisto from seeing it on display at the Queensland Museum, where it was housed, in open air, for many years. However, due to its historical significance, it now sits in an air tight preservation bubble (Figure 2.) and very few people are allowed to get close and personal with Mephisto, and even less have had the opportunity to experience the tank from the inside. The potential for digital capture and display, through interactive augmented or virtual reality systems offers potential to enable this historically important item to become more accessible.

1.2 Recent Conservation Efforts

Over the past thirty years the Queensland Museum has made considerable effort to analyze and preserve Mephisto. A number of laboratory investigations including metallurgical analysis, paint colour testing and composition sampling have been undertaken.

Mark Clayton, Senior Curator of Social History at Queensland Museum suggests "In more recent years the Museum's scientific focus has shifted more towards conservation and archaeology, both of which remain central preoccupations. While the former has always been an overriding interest, the 2011 Brisbane Flood led us to dramatically increase our efforts in this direction" [2]

Figure 2. Mephisto on display at Queensland Museum [2]

2. Digital Revolution in Capture

Chris Little explains 3D scanning as a non-contact method of "digitally importing the physical shape of an object as three-dimensional information. This accurately defines the size, shape and colour of a real world surface as a computer generated model." Whether time of flight or phase based, a vertical strip of laser leaves the scanner, hits the object and returns to the scanner. This information is recorded as three-dimensional points known as point-cloud [3,7]. He also suggests 3D scanning began "in the 1960's, where lights, cameras and projectors were used to create the first 3D scanning technology. Originally used as a measuring tool by surveyors and engineers, this was replaced with white light and lasers in the late 1980's and Cyra Technologies [now known as Leica Geosystems] was founded in 1993 and produced one of the first commercial scanning systems." [3].

2.1 Digital Heritage Preservation

No longer is 3D scanning used only for reverse engineering and quality assurance. The 3D design and innovation space is constantly developing and improving with technology becoming smaller, more affordable and easier to use. This has introduced digital 3D scanning systems to several emerging fields where traditional methods of data recording may soon become obsolete. One of particular interest is the area of Archaeology and Digital Heritage Preservation where the application of 3D scanning and digital photogrammetry are being used to capture irreplaceable items from the past. The capture alone is a valuable piece in the preservation of this knowledge, but the potential to extend beyond capture, to create interactive experience, could bring these historical relics to life for a much larger audience.

2.2 Smithsonian Institute Digitization Program Office

As part of the Smithsonian Institute, the Digitization Program Office carries out digital preservation activities for significant artifacts of differing scales. This office "uses a variety of 3D scanning tools and techniques to capture the geometric and colour information of Smithsonian objects and scientific research sites and is an integral process for their archiving and presentation of 3D information." [4]. The Digitization Program Office provides information from completed 3D models through their X3D web based viewing platform [www.3d.si.edu] to enable a broader audience to access these valuable pieces of history [8]. The key objectives of this capture and online delivery system are to:

- Allow schools to freely download and 3D print iconic Smithsonian objects in the classroom
- Provide new measurement tools for research
- Provide conservators a condition report for Smithsonian objects

The Smithsonian Institute also explains how "the Digitization Program Office is also involved with advanced 3D scanning and modelling techniques for the future, such as the "Next Generation 3D Portraiture: A Digital Life Mask of President Obama" (Figure 3.) where Barak Obama is the first presidential portrait created from 3D scan data. Using two hand held structured light scanners, 8 DSLR's and 50 light sources mounted on a frame, the president sat still for 90 seconds of data capture producing a 3D model and 80 high resolution images." [4]

Figure 3. Next Generation 3D Portraiture: A Digital Life Mask of President Obama 3D printed model [4]

2.4 The CyArk 500 Challenge

CyArk is a not for profit organization involved in the conservation of valuable world history through digital technologies. Their main concern is in the preservation and capture of the world's heritage sites and they state that:

> *"heritage sites are a significant part of our collective memory and we are losing them at an alarming rate. The stories they tell are at risk" [5].*

With the help of scanning experts around the world and collaboration with industry giants such as Google and Leica Geosystems, Cyark's vision is to 3D scan 500 heritage sites within 5 years.

CyArk has already completed 40 projects toward its goal of 500. These sites, called the Exemplar Projects include Pompeii, Babylon, Mt. Rushmore (Figure 4 & 5), the Leaning Tower of Pisa, the Titanic, the Sydney Opera House and, most recently, the Tower of London [5].

2.3 The Historical Scotland Digital Documentation Team

The Scottish Ten is a 3D scanning project to digitally document Scotland's five World Heritage Sites and also five international World Heritage Sites. These sites include:

- New Lanark
- Orkney
- Antoine Wall
- St Kilda
- Edinburgh
- Mount Rushmore
- Rani ki Vav
- Eastern Qing Tombs
- Sydney Opera House
- Nagasaki

In partnership with Cyark, the Scottish Government has provided critically important support through a mix of heritage, survey and visualization experts. To ensure the best possible results these teams have come together (and continue to do so) using a variety of mid-range and long range scanners combined with digital photogrammetry to deliver accurate terrain and building models to a very high level of detail. The 3D data sets for these large environment based projects are extremely large, and the need for smart file management and efficient data post-processing workflows are critical to the final outcome.

To achieve this the project has had 2 key phases. In phase 1 the data capture and acquisition is the focus, where in phase 2 data visualization and dissemination of knowledge, through engaging interactive experience, is the focus. As outlined in the project:

> *"Phase 1 of the Scottish Ten projects has focused on fieldwork for each of the ten sites, and production of basic deliverables including geo-referenced registered pointcloud, 3D images and animations. The main objective of this phase has been data acquisition to create an accurate 3D record of information." [6].*

> *"Phase 2 of the Scottish Ten project will focus on re-purposing of Scottish Ten digital assets to be used for research, dissemination, learning and engagement. This will involve the use of mobile apps, augmented reality and virtual reality viewers." [6]*

Figure 4. Practically scanning Mt Rushmore [7]

Figure 5. 3D Scans of Mount Rushmore [7]

2.4 Interactivity - Bringing Life to History

The potential to apply technology based interaction techniques, including online interactions, games and VR/AR systems, to deliver access to these historical datasets for a broad audience is evident. From the earliest days of computer games and virtual reality, the ability to place the user in an artificial space built or modeled on real world history has been actively pursued. In fact the use of "iconic" historical sites is common in both early and modern computer games [9,10]. The ability for an immersive computer game, or VR environment, to place the user in an unreal, yet believable space is potentially a powerful tool to address the loss of our historic sites, and more importantly their stories, as outlined in the Cyark quote (see section 2.4).

Virtual Archaelogy or Virtual Heritage, is a well established field with many examples of visualizations of history going back to the earliest computer graphics based systems. As computing, and particularly rendering power, has increased, examples of highly realistic immersive historical environments, contained within interactive games has also increased. Interactive games range from those directly based on the history and its interactive visualization [11,12,13,16] through to many others that simply utilize environments that are rich in history (or historical references, such as the gothic or medieval styles of many role-playing games (RPGs). Such games utilize our human understanding of history to help place players in a believable virtual story, the historic elements accuracy helps to make this experience more immersive and engaging for a range of (perhaps not based in true history) forms of play [14,15,16,17].

As developers of rich interactive systems, the value of realistic and engaging environments is critical. Photorealistic, or close to, virtual worlds are becoming more common, yet the time required to digitally design and construct these more and more complex worlds, and the props/items within those worlds, presents a challenge for modern game developers. Automated content creation tools, such as l-systems, shape grammars, fractal and other rule-based techniques allow for the quick, automated creation of rich content [18,19,20,21]. These tools are effective in building realistic and rich content, yet these automated items/spaces lack reference to identifiable real world entities and their history, which we as humans often value. There is a clear need for systems that enable developers to more quickly obtain "real-world" items/environments to enrich virtual spaces, yet current systems for capture and workflow are complex and comparatively slow (note how the Scottish Ten project (involving many highly skilled members) has only targeted 10 sites).

2.5 Interactive Engagement

Virtual archaeology and history have evolved from 2 slightly different perspectives [22]. The first, based in information capture and presentation, involving obtaining, documenting and at the highest quality, recording and preserving the key information and data. In simple terms, this perspective involves getting and recording the artifacts accurately for future use. The second perspective, based in entertainment and distribution of knowledge, involved the development of interactive ways of enabling users to experience the history. The work of the teams from the Smithsonian, Cyark and Scottish Ten are all good examples of the capture oriented approach, where the computer games and VR simulations (such as historical strategy or RPG) are all good examples of the entertainment based approach. One of the challenges for virtual archaeology is bringing these two fields together. Enabling interactive entertainment to be able to utilize the historical data, including both the raw scan information as well as other related knowledge (which plays a key role in telling the stories of what happened). This research project looked at workflow processes to enable highly accurate data to be captured and analyzed, to help tell the story of how specific historic events unfolded, then extending into the use of that information for interactive experience, utilizing virtual systems to make best use of interactive and play based systems to engage users [23,24].

3. WORKFLOW METHODOLOGY

At the heart of developing effective mechanisms to enable these "real world" sites and items to be captured, and delivered to an audience, is the core workflow of accurately capturing both the data and the related information that builds the full story. Then using that full set of information to create engaging and interactive visualizations, like those described previously.

3.1 Planning The Workflow

There are four main steps in the 3D scanning process:

Capture => Processing => Analysis => Presentation

Understanding how to 3D scan these objects is only the first step in producing an accurate, workable deliverable to a client and the point cloud always looks beautiful in its native scanning software. [3]. To "Plan the Scan", in helping determine the best type of scanner and workflow required before 3D scanning the following needs to be considered:

1) What it is that being scanned (and are their restrictions on what can be used)
2) What information are we wanting the extract from the 3D scan data or what is the end deliverable
3) What is the accuracy required
4) How to best communicate the 3D scan to others

3.2 Capture - 3D Scanning The Mephisto

To commemorate the WWI centenary, the Mephisto was temporarily relocated to the Australian War Memorial. As part of Queensland Museum's ongoing effort to preserve the tank, while away from its resting place 3D scans were taken of Mephisto before and after its journey to Canberra. These 3D scans of Mephisto were in order to assess any possible damage to the tank during transit.

Upon examination of this original 3D scan data it was agreed that the data captured, while taken for a specific purpose, and while fulfilling their original brief, was incomplete and did not contain sufficient information as a basis for a complete, and archaeologically useful three-dimensional model of Mephisto. The initial 3D information scanned from the tank did not include the level of detail required for such a significant piece of war history, however the initial scan data did become the topic of conversation. This lead to discussion on how to best utilize these 3D scanning workflows for the tank to become a digital heritage piece for the Queensland Museum. Through these discussions exciting new possibilities were able to be developed for the virtual version of Mephisto.

3.2.1 Mephisto - What was being scanned?

Mephisto is the remains, post WW1 war damage, of an A7V tank (the last of its kind in existence) and measures 7.3 metres long, 3 metres wide, with a height of 3.3 metres. Because of its overall size, shape and material type, the tank was best suited to 3D scanning with a mid-range, phase based laser scanner. The tanks exterior including all sides, the roof and undercarriage are scanned using this method. This would create the base geometry with an accuracy of approximately 2mm (good for many uses eg. in game but perhaps not detailed enough for preservation of detaiailed damage). A hand-held structured light scanner is a very portable system and is used to also 3D scan the inside of Mephisto and any blind spots or missing information not included in the base model scan data (including high detail areas).

3.3 Processing - Scan data & Deliverables

Through conversation with Senior Curators at Queensland Museum there were a range of possible outcomes that they targeted relating to the 3D scanning of Mephisto:

- Accurate information vaulted, recorded and documented
- Interactive augmented reality experience at Queensland Museum
- Interactive virtual reality experience at Queensland Museum
- Web based viewing and schools access for teaching
- Deterioration comparisons for condition reporting
- As built information
- 3D printing
- Forensic analysis of the explosion to the roof
- Bullet trajectory analysis

These target outcomes very closely align with many virtual archaeology projects, with accurate capture and recording playing a key role, but also interactive entertainment (through VR/AR and related systems) and its use in better presenting and understanding the story of what occurred.

The forensic analysis plays an interesting role in the later, particularly from the entertainment perspective. Through the 3D scanning/capture element very high quality data is obtained. Such data, through the analysis of bullet holes and related physical damage, can be used to forensically analyze the trajectory of indvidual bullets and through this information, when placed in a VR simulation, to help replay the scenario (the story) of what occurred to the Mephisto in its final battle.

3.3.1 How much accuracy is required?

The end deliverables and the amount of information they require (for example the VR system may not require super high accuracy, but the forensic analysis does require extremely high accuracy to enable trajectories to be established) plays a critical role in determining the accuracy required for the 3D scan data. Scan data accuracy is critical, in capturing most historically significant

items. Not only because of extremely limited access to the item (in this case the tank (see Figure 2)) but also the 3D scans of Mephisto will be vaulted, recorded and documented for heritage preservation and war history. While the mid-range laser scanner provides the Queensland Museum with a sufficient data set for an interactive display, it does not have the level of accuracy required to capture fine detail for forensics such as bullet markings (Figure 6.) and the explosion to the roof of the tank (Figure 7.). This required scanning with a high-resolution hand held scanner with 0.1 millimetre accuracy.

Figure 6. Bullet and shell fragment scars to side of the tank [2]

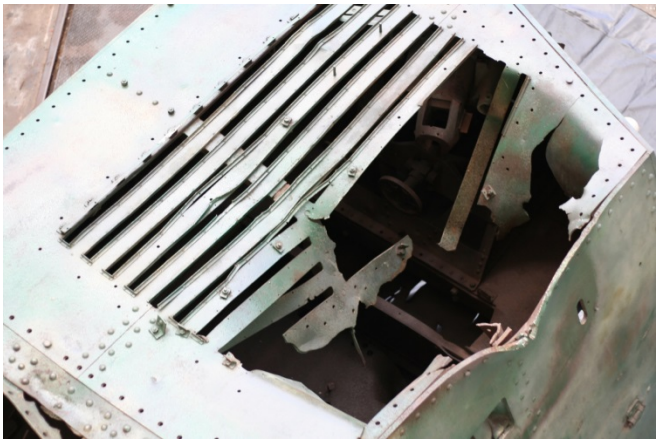

Figure 7. Major impact that tore the tanks roof apart [2]

Once captured, at the correct level of accuracy, the digital information can be used for further forensic measurement to research bullet trajectory and explosion analysis to help bridge the gap surrounding questions of what caused the Mephisto's battle scars during its last days at Villers-Bretonneux.

3.4 Analysis – Turning Data Into Story

Developing story, based in truth and established from captured information involves a complex set of analytical tasks. Research deliverables from the analysis of the 3D scan data of the tank may be divided into two main technology paths; Interactive Experience and Forensics. Both require new innovative processes for analyzing and communicating point-cloud information from the captured 3D scan data. Scans of large-scale items, such as Mephisto, generate large data-sets. Managing the data and enabling its use at an appropriate level-of-detail for the differing tasks is critical. The size, accuracy and complexity of the raw information, when registering and post-processing 3D scan data, needs to be considered. The workflows undertaken in this area by Smithsonian Institutes Digitization Program Office, CyArk and Historical Scotland's Digital Documentation team for digital heritage preservation and management of large data sets provided existing methods for this task and outlining them is beyond the scope of this paper (see [4,5,6] for details.

3.4.1 Story – Map, Scan, Forensics, Diary Accounts

With support by Mark Clayton, Senior Curator of Social History with Queensland Museum, imagery from the battle field has been imported into Google Earth to find "the exact location and position of Mephisto when it came to rest in Villers-Bretonneux." [2]. This important piece of information is the building block allowing us to 3D scan the area of interest and digitally place Mephisto back in its original position. Combining this terrain model, with diary accounts from Australian, British and German commanders of WWI and forensic analysis of bullets and damage we are able to reconstruct, in an immersive virtual sense, an accurate story of Mephisto's last days in battle at Villers-Bretonneux (Figure 8).

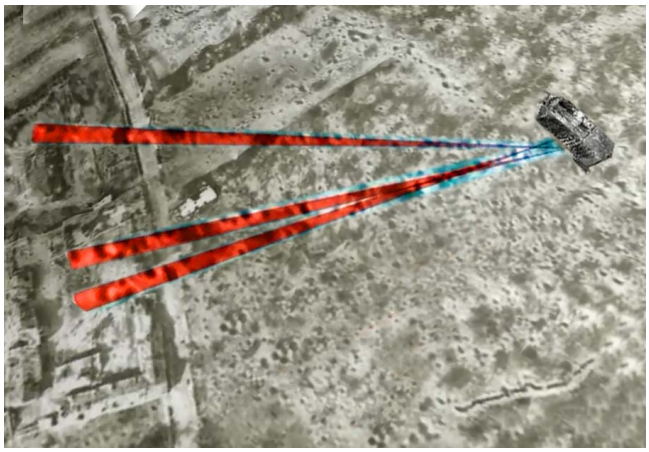

Figure 8. Proof of concept – 3D reconstruction of Mephisto on the battlefield in Villers-Bretonneux.

This finished 3D reconstruction of the tank on the battlefield needs to be easily accessible to those visiting the Queensland Museum. Through the use of the 3D scan data, and its interactive display (augmented and virtual realities using mobile devices and hologram models are all possible). These methods for accurately highlighting points of interest will greatly improve the user experience and provide increased understanding of "the Last Days of Mephisto." [2]. The use of advanced, and immersive 3D interaction techniques will assist in placing the user in the experience [25,26,27,28,29]. Linking this with effective social media tools and interactions aims to enhance the users immersion and experience while also building a larger community for the experience itself and those engaged with it [30,31].

4. CONCLUSION

The aim of this research is to develop 3D scanning and post-processing workflows for Interactive Realities to provide people a truly accurate and realistic user experience with Mephisto and its captivating tale. Whether a war enthusiast seeking answers, someone who remembers Mephisto from their childhood or a visitor to Queensland Museum for the first time, it will allow

people to involve themselves with its history and follow its story while trying to solve the mystery behind what happened leading up to its retrieval in those last days at Villers-Bretonneux.

While it is a privilege to work with Queensland Museum on the Mephisto project, it is the development of these workflows required for museum artifacts and heritage sites, and the techniques involved with analysing and presenting this information that must be considered of special importance.
Methods for manipulation of large point-cloud data sets are still inadequate. Until this is properly addressed, communication and presentation of heritage items requiring measurement and detail accuracy cannot be achieved. The rapidly evolving technologies in Interactive Realities can provide 3D scanning for heritage preservation an opportunity to create a window into the past and present history in ways that users have never experienced before.

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Dancers & Technology, a collaboration celebrating "corporeal difference"

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Abstract

This paper examines the role of dancers who extend beyond the paradigm of age and their contribution to current dialogues in the field of dance through film documentation. This project aims to make visible the older dancer through film giving new materiality and value by celebrating the older body on screen. The research seeks to investigate which is the preferred performing body, the youthful or the mature? These older dancers choose to ignore the rationale and perform which In turn could be considered inappropriate behaviour by the western dance world. There is a need for the mature dancer to be acknowledged not only for their 'corporeal difference' but recognition that their practice rather than their age defines them.

Keywords: mature dancers, value, embodiment corporeal difference, visibility, digital technology

Introduction

Dance is a body-based dominion, unlike most other careers where retirement so early would be incredulous[1].

The relationship between the dancing body and the camera combine as process under the heading of practice-led research for the creative element of the PhD: Ageism and the mature dancer. There is an inner subjectivity and honouring of experience that can only be perceived or embodied by the mature dancer. This shift is motivated by dancers who chose to defy the stigma of ageism by questioning and elongating their presence on the stage and screen in the western dance world. Today's emphasis on a youth culture weighs heavily in the current dance world and for those who are approaching forty years of age, there has been long held prejudice, towards the mature performer. There has always been taboo in and around the question of retirement. For generations dance has long been a discriminatory industry but a flux is challenging the presumed domain of the youthful dancer. Current research indicates there is increasing interest in this phenomenon – the mature dancer. Performer Betsy Gregory, former Artistic Director of Dance Umbrella (2007-2013) and The Elders Project, echoed similar thoughts regarding this shift.

In recent years we have been living in a culture that is so youth orientated that people have forgotten that older people can dance. Or maybe, they thought they never could! I don't know, maybe people never really realized that older people could.[2]

This paper investigates ageism and longevity of performance in today's contemporary ballet culture through film documentation, which highlights the craft and embodiment of the eight dancers featured in the film, *Interprete/Inappropriate Behaviour* filmed and edited by myself. To see older dancers on screen is an important step to keeping them visible in the current ageist dance world. Their collaboration with the project has been central to both the primary and the creative research.

The primary research has gathered qualitative data via a questionnaire from prominent dancers in Australia, UK, Canada, Holland, Sweden, Germany and the USA; where they address their ageing, physicality, injuries and process in the dance world they inhabit. Investigation of the dancer's performative value as a mature practitioner and their corporeal value will be a focal point. The creative research has invited eight mature dancers to collaborate on a project using a dance motif of mine first choreographed when I was a student at the Laban School of Movement & Dance in London in 1987. The motif is a group of dance movements that have now been re-enacted and filmed then assembled as a guide for the dancers to view and then recreate as their own individual motif. The concept is based on an appropriation of French artist Sophie Calle's work; *Take care of yourself* (2007)

To interpret this to analyse it, comment on it, dance it, sing it. Dissect it. Exhaust it. Understand it for me. Answer for me. [3]

Approach

Youth, agility and athleticism are essential ingredients in an art form that demands dancers aspire to an aesthetic that has remained unchanged for over a century.[4]

To capture these moments through video footage and/or the digital camera is the creative element of my PhD investigation into exhibiting the ingenuity of the mature dancer in motion. I have had the opportunity to collaborate with two groups of mature dancers, the Australian Dance Artists who are based in Sydney and four British dancers based in London. The dancers ages range from 57 – 69 years of age. All are professional trained classical or contemporary dancers.

In January 2015 I flew to London to meet with and film the four British dancers who I knew either as colleagues or by reputation. The first session included dancers: Jennifer Jackson, former soloist with the Royal Ballet Company & Dancing the Invisible, Nicholas Minns, former Les Grands Ballets de Canadiens and Susie Crow, former soloist with the Sadler's Wells Royal Ballet Company. The filming took place at the University of Surrey, at The Ivy Studio, which was kindly, co-ordinated by dancer/lecturer Jennifer Jackson. Before we commenced filming the dancers sat

and viewed my Motif video again to reacquaint themselves with the content: https://vimeo.com/112907186
From here the dancers began a short period of 'warming-up' their bodies before they commenced rehearsing in the studio space. This procedure took about an hour. Whilst the dancers rehearsed I positioned the video and Nikon cameras on two separate tripods. I used no additional lights other than the daylight streaming through the studio skylights. I filmed each dancer in turn, allowing them only one attempt of their individual motif. By using this method the new interpretations were fresh and hopefully gave the dancers the opportunity to produce their best effort. Technically, I filmed using my JVC video camera on a tripod to capture the dancer 'in close-up' which gave me more opportunity to capture movement whilst my Nikon SLR was positioned as a secondary fixed video recorder which displayed the full image plus background. With this process I gained two versions of each individual motif giving me six blocks of film to later edit. These three performers were all classically trained ballet dancers and each battled with the idea of only one 'take' as they would have preferred to improve on the first performance.

The second session with contemporary dancer Ann Dickie was filmed at the Siobhan Davies studios in Vauxhall, London. Ann was unable to join us in Guildford for the first shoot so by hiring the studio in London I was able to film her motif. Technically, I repeated the same approach with the previous dancers; two cameras, one stable on a tripod and the second manned by myself on a separate tripod for close-ups. Ann works very swiftly and chose not to rehearse but allowed me to film her immediately. As opposed to the other dancers she insisted I film her motif several times so she could change her costume to suit. This was permitted even though I had not extended the same criteria for the previous dancers but an element of artistic licence was necessary in order to gain the footage.
Both sessions provided some excellent recording. I found using two cameras most beneficial, although producing double the amount of film; it created endless imagery that was most favourable. I had never before attempted this process, which proved to be a great learning curve as well as giving me new expertise to edit accordingly. As a dancer I considered this new method as choreographing with film.
The time spent editing, as any filmmaker would appreciate, is long, especially when dealing with two separate but similar blocks of film. As each dancer filmed produced two films to edit it was a period of intense learning through the iMovie application on my Mac Laptop which when completed were all uploaded to www.vimeo.com for the dancers to view.
Featured here are the four dancers and their individual motifs. Please go to these links:

Interprete – Chapter One – Inappropriate Behaviour
Featuring Nicholas Minns
https://vimeo.com/131616011

Interprete – Chapter Two – Inappropriate Behaviour
Featuring Jennifer Jackson
https://vimeo.com/131639723

Interprete – Chapter Three – Inappropriate Behaviour
Featuring Susie Crow
https://vimeo.com/131751942

Interprete – chapter Four – Inappropriate Behaviour
Featuring Ann Dickie
https://vimeo.com/136408093

As an experiment, I later edited the four dancer's motifs to produce a trial film, which created some interesting visuals.

Ist Edit - The merging of the four British dancers
https://vimeo.com/119615078

In April 2015 I flew to Sydney to film the Australian Dance Artists: Anca Frankenhaeuser, former London Contemporary Dance Theatre, Patrick Harding-Irmer, former London Contemporary Dance Theatre, Ross Philip, former Sydney Dance Company and Susan Barling, former Sydney Dance Company. The filming took place at the studio of the artist Ken Unsworth in Alexandria. For this shoot, I again used the natural light in the studio accompanied by limited lighting on the stage. The dancers were currently rehearsing for their next production so time was very limited due to their busy rehearsal schedule. I continued with the same regime as in London, filming with two cameras, one JVC video recorder and one SLR, Nikon 5100 to film each dancer accordingly. One of the dancers, Ross Philip, was recovering form recent hip surgery. His improvisation was performed with him lying horizontally on the stage floor moving with a large piece of fabric. Ken Unsworth suggested I film this motif from the ceiling above the stage, giving a unique view of Ross's performance. This process was managed by tying a rope around my waist whilst Ken Unsworth acted as an anchor and support; which proved quite demanding but the visuals produced were interesting and unique.
Again, this process of filming produced double the amount of editing necessary for exact detail required for each of the dancer's interpretation. Two cameras were positioned to capture close-ups and wide-angle shots of the dancers except in the case of Ross, where I filmed using a handheld camera for close-ups only. The only complication was sound, the musical accompaniment I had selected for the film had not been passed on to the dancers. Two of the dancers had chosen their own music and this will be documented in the thesis but for the film I had to edit, avoiding possible copyright issues. This glitch was my mistake, as I had not communicated thoroughly with the dancers. The composer Bill Ryan gave me permission to use his music for the soundtrack of the film.

Featured here are the four Sydney dancers and their individual motifs. Please go to these links:

Interprete – chapter Five – Inappropriate Behaviour
Featuring Susan Barling
https://vimeo.com/136364135

Interprete – chapter six – Inappropriate Behaviour
Featuring Anca Frankenhaeuser
https://vimeo.com/136420754

Interprete – chapter seven – Inappropriate Behaviour
Featuring Patrick Harding-Irmer
https://vimeo.com/136418016

Interprete – chapter eight – Inappropriate Behaviour
Featuring Ross Philip
https://vimeo.com/136368317

The *Interprete* films could they be seen as eight chapters, whre the four British dancers and the four Australian dancers respond to my motif. The use of social media has been integral in the research as a mode of attracting an audience to view and critique the works before they enter the exhibition space.

The intention is to screen the films in an exhibition space projecting them directly onto the walls of the gallery where I anticipate a dance dialogue to ensue. The images would be shown life-size to give the work a more personal edge.

Creative Works

For the first exhibition in July 2015 I experimented with screening the eight films in a gallery space, projected onto three gallery walls. By screening the films 'life-size' the dancers will appear to engage in a dance dialogue with each other. The arrangement of three data projectors on the floor as opposed to the ceiling by a rig was experimental and not without issues. By uploading the films to three separate hard drives and adding them to the data projector the films were then projected onto three of the gallery walls. The visuals with the accompanying soundtrack proved very effective and feedback from viewers was positive. Indeed, there were virtually no comments discussing the age of the dancers but more of how beautifully they moved in the space and who these dancers were. By screening the dancers larger than life it highlighted their movements and gestures which was most engaging to the audience.

From this point I decided to investigate amalgamating the eight dancers into one new film. This experiment proved most positive though having to choose which pieces to edit was challenging but the final cut was not unlike choreographing a dance except the material at hand was film. This work is titled: *Interprete/Inappropriate Behaviour*

Please go to this link: https://vimeo.com/136466421

This film later won a gold award in the UK.
http://www.pdsw.org.uk/dance-development/dance-for-health/dance-for-older-people/joie-de-vivre-dance-film-competition-2/joie-de-vivre-dance-film-competition-2015/

This prize enabled me to showcase the work and ensure the visibility of the mature dancer through the lens of film.

Research Aims

That dancers 'speak' with their bodies is a given as they dance but the opportunity to hear them voice their thoughts is rare. The questionnaire sent to numerous dancers across the globe has given great insight and validity to their process. British dancer Jennifer Jackson, who featuress in creative element of the PhD, observes:

> *As an old practitioner I observe profound shifts in the balance between the athletic and artistic dimensions of my own dance. I am interested in how this plays out in the choreography, plus how mature dance challenges the aesthetics of established dance performance, especially in ballet, which is closely associated with youthful beauty and athletic virtuosity and as a means of purely technical rather than creative development.*[5]

Susan Barling, (Australian Dance Artists) who also features in the films states:

> *Maturity helps my performance, I'm not trying to pull off a triple turn – I'm aware of the infinite possibilities I have to express myself within the dance. Before I thought it was more about perfection, now I feel it is more about connection.* [6]

Nicholas Minns, also featured in the film discussed his thoughts regarding the mature dancer:

> *These are not older dancers strutting their stuff past their virtuosic prime – as some older dancers have been know to do – but offering us the rich territory of individual and shared dance experience.*[7]

In 1986, dancer and choreographer Siobhan Davies was creating a new choreographic work: *Bridge the Distance.* Her chosen dancer was former London Contemporary Dance Theatre, Patrick Harding-Irmer, and then considered a veteran dancer aged forty. Davies stated:

> *That dance then was seen as a physical manifestation of youth, vibrancy, high jumps and technical expertise and I loved it when I see something that is as thoughtful as Patrick's one simple move*.[8]

It seems incredulous now that Harding-Irmer could have been considered old at that time when his physicality and form seemed ambiguous. He is now nearing seventy and his collaboration with both the primary and creative research has been pivotal.

Analysis

In today's Internet world the importance of social media is essential in the promotion of film and the issue of mature dance featuring on the platforms of Facebook, Twitter and Instagram have been essential ingredients to indorsing the visibility of the older dancer. There is a growing industry in dance films globally and this assists in opening further dialogue around value and validation of these mature performers. Undoubtedly, dancers carry a lifetime of embodiment, a history of dance vocabulary within them, but recognition that they carry a chronicle of movement within their limbs has been slow to materialise. Many dancers are challenging the concept that being older does not necessitate the end of a career, emphasising the significance of being mature carries a specialised embodiment that can only be attributed to life experience and should be viewed as a positive.[9] The mature dancer's body is the instrument of their physicality. British dancer Wendy Houstoun, fifty-five, acknowledges that she feels somewhat strange being a mature dancer, and questions her relevance and visibility when perceived by younger contemporary onlookers.[10] As she notes, 'It becomes an odder and odder thing to do, to exhibit age through movement.'[11]

Individual reflection

My personal embodied experience of this journey, from the young performer through to the mature dancer has also been intrinsic to this research. To have this project discussed within the wider dance community would potentially enlighten and encourage all dancers, whether they are young or mature-aged, to acknowledge, that the '*dancing does not have to stop'* at a set time of life. Ageing dancers have demonstrated that performance need not end. Support from choreographers and audiences alike are indicating this to be true. It is not a case of older dancers performing past their corporeal ability but their performance skills are a sharing of their accumulated individual dance

knowledge and this can only be the case because they are mature. The opportunity to address the older dancer through the practice of digital technology has enabled me to discuss my research at conferences in England, Sweden and Australia and screening of the film *Interprete/Inappropriate Behaviour* is opening a much needed dialogue in the western dance world concerning value, validation and visibility of the mature dancer.

Conclusion

Years of knowledge and wisdom stored within these older bodies go to waste and audiences lose transformative experiences as we, as a society, revel in the virtuosity of youth and fail to see physical feats as merely one aspect of an artistic investigation.[12]

Through digital technology showcasing dance on film is a great platform for exhibiting the mature dancer and getting the message across that 'the dance by date' is no longer applicable. "The one that hits dance hardest is ageism and it is the last to be explicitly addressed." [13] Could it be that these words are now being given the spotlight and ageism in dance could be a thing of the past?

Endnotes

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[7] Nicholas Minns, 'Dancing the Invisible,' *Writing about Dance* (blog), May 5, 2012, accessed March 25, 2013, http://writingaboutdance.com/?s=invisible.
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[9] Schwaiger, *Ageing, Gender, Embodiment and Dance*, 4, 79.
[10] Judith Mackrell, 'Wendy Houstoun: The Death that Made Me Question Everything,' *The Guardian*, May 26, 2014, http://www.the guardian.com/stage/2014/may/26/wendy-houstoun-interview-dance-flame-nigel-charnock-pact.
[11] Ibid.
[12] Jillian Harris, 'Dancing into the Twilight,' *Dance Chronicle* 36, no. 2 (2013): 278, accessed April 20, 2014, doi: 10.1080/01472526.2013.792374 .
[13] Jacky Lansley, Fergus Early, 'The Wise Body' (Bristol: Intellect. 2011) p.12

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