every world 2020

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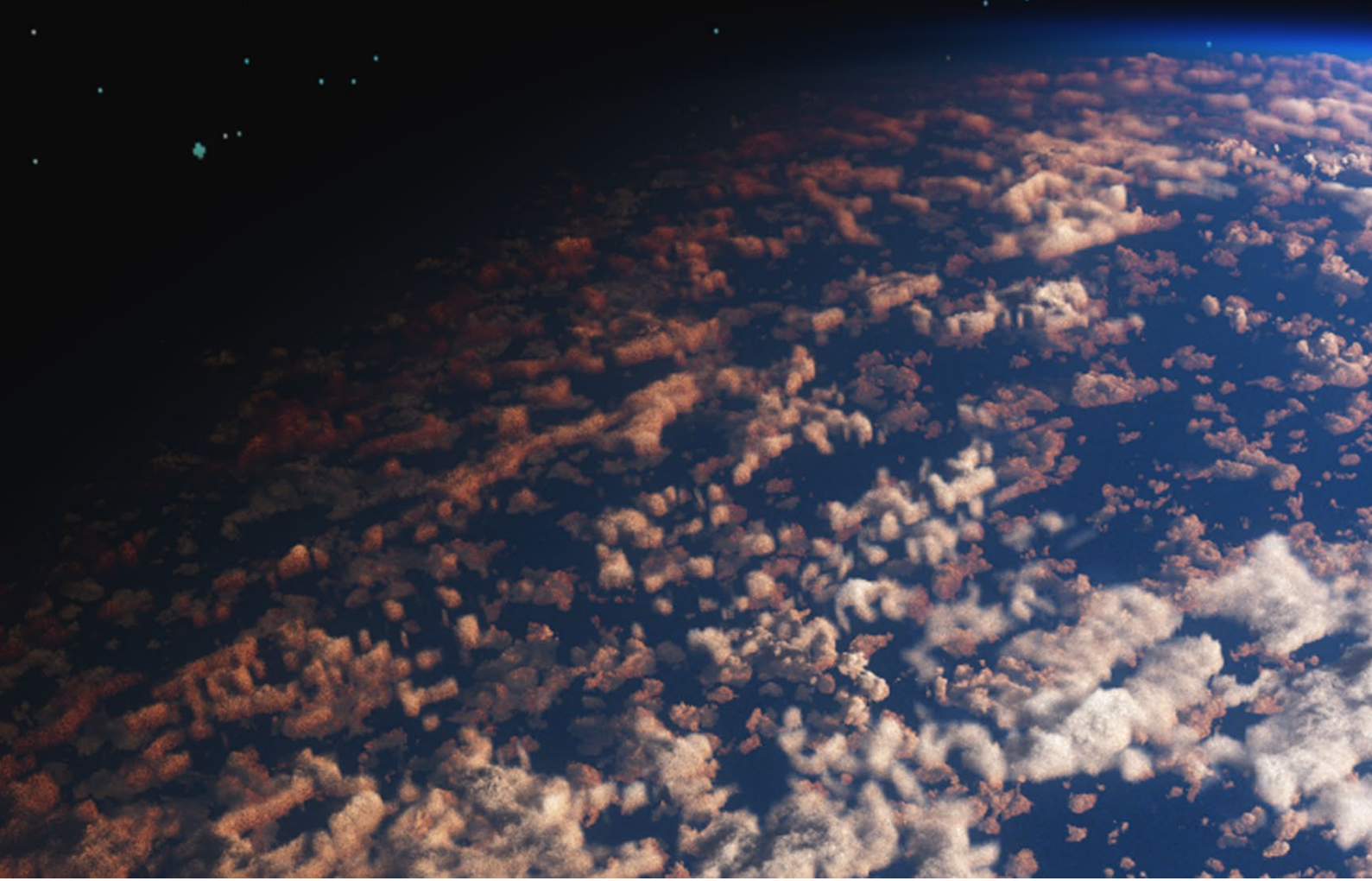
Conference Proceedings



Contents

Welcome

For more than a decade, the AUC has run three wildly successful community conferences:

- /dev/world, focusing on app development for Apple platforms,
- CreateWorld, exploring the intersection of art and education that Apple technology can facilitate, and
- X World, supporting those who deploy and manage Apple devices in education and enterprise

In lieu of these face-to-face events that aren't currently possible due to The Current Situation™, we're bringing the best of the annual events together and online in November as one new event: **EveryWorld**.

Drawing from our existing conferences, EveryWorld's three streams will focus on Development and Frameworks, Arts and Education, and Device Management.

EveryWorld will take place from 25 November to 27 November. Online.

We hope you'll join us for this special event. As the saying goes, we'll try anything once…

(postscript; We tried it, deployed an entire multiconference through discord and it worked!)

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:

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

Program

WED 26 NOVEMBER

	Wednesday 25th Main Track
10:00	Introduction and Welcome
10:30	**Charles Edge** Keynote
11:00	
11:30	**Andrina Kelly** 2020: The Year of Data
12:00	**Jimmy Ti** Flutter: Jumping from iOS to Android
12:30	
13:00	**LUNCH**
13:30	**Matthias Wollnik** Evolution of Endpoint Security on Macs
14:00	**Josh Deprez** Thundering Herds of iPhones
14:30	**Brodan Goepel** Portable VR Systems
15:00	**James White** From skeuo to neuo
15:30	**Andrew Brown** Making Interactive Audio on your Mobile Device
16:00	**Nicole Ronald and Ed Greenaway** Building the next generation of App developers
16:30	**Iain Anderson** The past, present and future of learning
17:00	**Louis Cremen** Dev Sec Oops
17:30	Cup of Tech Podcast

THU 27 NOVEMBER

	Thursday 26th		
	Main Track	**Papers**	**Workshops**
10:00	**MacAdmins Podcast**		**Adobe**
10:30	Big Sur or Bin Chicken		AR Workshop
11:00	**Paul Bowden** Deploying Office vNext on Apple Silicon	**Papers Block 1** David Harris Pamela See Ben Rayment Riley Sheehan	
11:30	**Malin Sundberg** Living on the edge		
12:00	**Katie English** Jamf Pro: Feature Review & Feature Requests		
12:30	**LUNCH**		
13:00			
13:30	**Max Schleser** Keynote		
14:00			
14:30	**MYSTERY** Very Mysterious		
15:00	**Tony Williams** I'll die without admin rights	**Papers Block 2** David Chechelashvili Damian Hills Christopher Ranie Daniel Della-Bosca	
15:30	**Tim Oliver** Running an app on the store for 8 years		
16:00	**Damian Cavanagh** The iPadmin		
16:30	**Nick Moore** Journey onward: the apple II and me		
17:00	**Free time/gather teams for quiz**		
17:30	**Poor, Long Suffering Tony** Quiz		

FRI 30 NOVEMBER

	Friday 27th		
	Main Track	**Workshops**	
10:00		**Tony Williams**	**Anthony Reimer**
10:30			
11:00		Zsh basics	Writing Autopkg Recipes
11:30	**Stu McDonald** Hackuum your vacuum		
12:00	**Adam Saltsman** Creative Production for Remote Studios		
12:30	**LUNCH**		
13:00			
13:30	**Mat X** Inspired by DevOps		
14:00	**SUTU** Keynote		
14:30			
15:00	**Damian Cavanagh** DIY AR on iPad		
15:30	**Bart Reardon** JamJar		
16:00	**Peter Wells** Podcasting in 2020		
16:30	**Richard Gynes** 10 mistakes to avoid in apple business/school manager		
17:00 17:30	**Lightning Talks and Closing**		

Keynote Speaker

10:30 Wednesday 25th

Charles Edge

Charles Edge is the CTO of bootstrappers.mn, the CTO/COO of handrailux.com and a former director at Jamf. He holds 35 years of experience as a developer, administrator, network architect, product manager, entrepreneur, and CTO. He is the author of 21 books and more than 6,000 blog posts on technology, and has served as an editor and author for a number of publications. Charles also serves on the board of directors for a number of companies and non-profits, and frequently speaks at conferences including DefCon, BlackHat, LinuxWorld, the Apple Worldwide Developers Conference, and a number of Apple-focused conferences. Charles is also the author of krypted.com and a cofounder/host of the MacAdmins Podcast and The History Of Computing podcast.

Keynote Speaker

14:00 Friday 27th

Stuart Campbell

Stuart 'Sutu' Campbell uses art and technology in new ways to tell stories. In the last few years, he has garnered an International reputation as a pioneering VR Filmmaker. He has been commissioned by the likes of Marvel, Google and Disney to create Virtual Reality (VR) projects for properties such as Doctor Strange and Ready Player One. He has also written, directed and art directed two VR documentaries: Mind at War for Ryot Films and Future Dreaming for NITV. He has Art Directed and been the principal VR artist on Inside Manus for SBS, The Battle of Hamel for the Australian War Memorial, Jean-Michel Jarre VR Concert for Sony and The Wave XR. He is a Webby, Gold Ledger, award winner and Eisner nominee, His films have been included in the official selections in International Film Festivals such as Tribeca, Sundance, SXSW, IDFA, Raindance and FOST. He is also known for his interactive comics including the Eisner-nominated These Memories Won't Last, the webby award winning Nawlz, The Gold Ledger winning Neomad, and Modern Polaxis. He holds an Honorary Doctorate of Digital Media from Central Queensland University, is a 2017 Sundance Fellow and is the co-founder of EyeJack an Augmented Reality Company

Keynote Speaker

13:30 Thursday 26th

Max Schleser

Max Schleser (B.A. Hons, M.A., Ph.D.) is Senior Lecturer in Film and Television and Researcher in the Centre for Transformative Media Technologies (CTMT) at Swinburne University of Technology (Melbourne, Australia), Adobe Education Leader, Founder of the Mobile Innovation Network & Association (www.mina.pro) and Screening Director of the International Mobile Innovation Screening & Festival. Max's research expertise are Immersive Media and Creative Arts 4.0 with a focus on Cinematic VR and interactive filmmaking. His research explores Screen Production, Emerging Media and Smartphone Filmmaking for community engagement, creative transformation and transmedia storytelling.
Max's experimental films, moving-image arts and cinematic VR projects are screened at film festivals and exhibited in galleries and museums (www.schleser.nz). His community engaged documentaries are broadcasted on TV and online (www.behance.net/maxschleser). Max co-edited the books Mobile Media Making in an Age of Smartphones and Mobile Story Making in an Age of Smartphones, published with Palgrave MacMillan, and edited journals for Ubiquity, the Journal of Pervasive Media and the Journal of Creative Technologies. He conceptualised and conducted digital storytelling workshops for a number of cultural institutes, city councils and government bodies in Australia, New Zealand and the UK. His industry consultancy includes projects for Adobe, BBC, Nokia, Frontier Strategy and Open Lab, among other agencies and production companies.
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Development Track

Josh Deprez: Thundering Herds of iPhones

Does your app talk to the Internet or over a network? Do you want your app to be downloaded and installed a lot? Do you want to be popular, good-looking, rich, and have people shout you drinks? Yes?

Well good news – this talk is for you!

Things you will learn in this talk:

- How to make seemingly benign choices that lead to outages and disasters
- How to crush your servers and network links under excessive client-generated load
- Why you should fail to prepare for unexpected load, and what you shouldn't do about it
- Things to forget when designing both sides of a client-server interaction
- How to lose friends, money, and user trust

Tim Oliver: Running an App on the App Store for 8 Years

On the first morning of /dev/world/2012, iComics v1.0, a DRM-free comic reader was released to the App Store. 8 years later, the app is still on the App Store, and continually ranks in the top paid Entertainment apps category on a weekly basis.
This talk is a reflection on the lessons learned on maintaining an app on the App Store for nearly a decade. This includes how the platforms and technology have evolved over the years, common pitfalls, and tips for upcoming developers looking to do the same

Nicole Ronald and Ed Greenaway
Building the Next Generation of App Developers

This presentation describes how a 12-week university subject aimed at postgraduates was designed to introduce Swift, iOS frameworks and kits, XCode and GitHub tools. The unit has been running for around 8 years, starting out as an elective using Objective-C, and now as a core unit for certain students (some without their own Mac!) and using Swift.
A key aspect of the course has been to instill an interest in the communities for Swift in particular iOS, and to foster ongoing flexible learning practices. Practices and considerations such as target market needs and demographics, mobile solution challenges and opportunities, business testing, UI testing, performance testing, and data integration have been successfully addressed. Like app developers, we are also faced with the challenge of changes to the framework each year, and we will address how this is incorporated into our teaching materials and style.
The results have been gratifying with students pitching to designing and build their own apps, taking on all the designer, builder and leader roles needed on app development projects. Contributions to the Swift community being made on Medium, and also experimented with vlogs and podcasts. Some of our graduates now work as iOS developers, and some have discovered new software development practices and the importance of developer communities.

Katie English, Jamf
Jamf Pro: Feature Review & Feature Requests

Flutter is Google's UI toolkit for building cross-platform native apps. It allows developers to build performant apps while using a declarative and reactive UI programming model, similar to Apple's SwiftUI.
It is challenging for we iOS developers to create Android apps. Learning about Android's system frameworks, understanding the system convention, creating UI layouts that works on all sorts of Android devices, the list goes on and on. Can Flutter help us to develop better Android apps? How do we transfer our iOS development skills to Android via Flutter? How can we leverage the similarity between SwiftUI's and Flutter's UI programming model to create beautiful and adaptive UIs on Android?
This session provides an introduction to the Flutter toolkit, tips and tricks based on the experience of porting an existing iOS app to Android, and demonstrations on some of the new development workflows made possible by various features of the Flutter toolkit

Malin Sundberg:
Living on the Edge: Bringing a SwiftUI macOS App to iOS

SwiftUI is an exciting new UI framework for all of Apple's platforms. This talk is about the journey of building a macOS app, using primarily SwiftUI, and the experience of, and learnings from, bringing this macOS app to iOS and iPadOS.
This talk also runs through some ways of structuring an app and a codebase to make its SwiftUI components reusable for multiple Apple platforms, some pitfalls to be aware of, and some tips and tricks that can be handy when building an app using SwiftUI.

Louis Cremen: Dev Sec Oops

Join Louis (@proxyblue) on a journey into security, why it matters and how deep the rabbit hole really goes. The gap between developers and security is beginning to close as frameworks, tools and automation help developers provide assurance from development teams to security teams. However, security's reach into the organisation is becoming more structured and integrating into nearly all aspects of business – what is a developer's role in this ever-changing structure? How can we evolve and keep pace with the changes our organisation, or other organisations require?

James White
From Skeuo to Neuo: What Should our Apps Look Like Next?

Designers tend to get bored every five years or so. It happened in the early to mid 2010s, when they got tired of fiddling with shadows and textures in Photoshop, and made us start using the word “flat”. Skeuomorphism became a naughty word, and the metaphorical app recycling bin filled up with green felt, Corinthian leather, brushed metal, wood textures, and even some seemingly useful things, like button outlines.
Now it’s 2020 and, presumably bored from being stuck at home, designers are starting to rummage through that same bin, pull out some of those things, and try them on for size. Someone even coined the term “neumorphism” to describe these new trends towards flat depth, or deep flatness, or something.
In this session, James White, designeloper amd long-time /dev/world attendee, will take a brisk walk through recent mobile design trends and attempt to dodge the question, “what should our apps look like next?”

Device Management Track

Katie English, Jamf
Jamf Pro: Feature Review & Feature Requests

A highlight reel of the new things we've brought to Jamf Pro in the past year, and some hints about how to tell us about the things you'd like to see next.

Andrina Kelly, Jamf 2020: The Year of Data

We've all spent a lot of time taking a look at a wide variety of charts and graphs this year, trying to understand what the data means to us, how does it impact us, and what should we be doing based on what we've learnt from that data. We'll take a look at data, what makes it useful, and how we can make data work for us in a way that gives us insights.

Matthias Wollnik, Jamf
The Evolution of Endpoint Security on Macs

Matthias has been spent more than 15 years in product organizations dedicated to Security of users, devices, and data. He came to Jamf from a product role at Code42 and CrowdStrike. Prior to that, Matthias drove a variety of security and storage technologies at Microsoft in their Windows and Windows Server divisions. At Jamf he continues to champion security professionals and the challenges they face as part of the Product Management team.

Paul Bowden: Deploying Office vNext on Apple Silicon

Paul will talk about the very latest advances and best practices for deploying and managing Microsoft Office for Mac. We'll see a lot of changes over the next 12 months including Big Sur, Apple Silicon, and a new generation of Office licenses. Get on the inside track by understanding how Microsoft engineering prepares for these changes, and what knowledge IT admins need to hit the ground running.

Stu McDonald: Hackuum your Vacuum

Having a robot vacuum your home sounds great, but what if the device is reporting your SSID & credentials, router MAC address and RSS value every 30 minutes? And the Lidar maps of your house. That's… less great. Also, the app from the vendor sucks. Let's fix both issues by hacking this linux-based vacuum! I'll talk through the process of obtaining a key from the iOS app, wirelessly rooting the robot vacuum and loading custom firmware so it can integrate with a smart home, automate cleaning, and stop snitching on you.

Creative Track

Adam Saltsman
Creative Production for Remote Studios

We all make assumptions to fill in gaps in our knowledge, but those assumptions can sometimes lead to serious misunderstandings. Working remotely tends to introduce more gaps, and thus more assumptions. Operating as a remote studio for the last 14 years has given us many opportunities to make mistakes, to adapt, and to develop new approaches to the way we communicate as a group to help mitigate these gaps and assumptions. In this talk I will share how we use mockups and a pros-and-cons discussion to help make abstract (lots of gaps) design conversations into something concrete (fewer gaps). I will also talk about a magic phrase we use to ensure that individuals responsible for the labor of any given task get to present their progress without being inadvertently put in a position where they first have to defend their progress, present our process for presenting half-done plans, review what tools we use (and more importantly, why we use them), and talk a little bit about weekly check-ins, peer check-ins, studio-level feedback, and other anti-gap measures.

Brodan Goepel
Portable VR Systems Changing the Interior Design Industry

Brodan will talk about utilising the Oculus Quest virtual reality headset to make changes in real time to interior environments, as well as the benefits a portable system brings to the interior design industry through the design process.

Peter Wells: Podcasting in 2020

Years ago, I created a podcast live on stage (including creating the RSS feed, recording an episode) for CreateWorld. A lot has changed since then – and I've spent the last few months testing the best way to podcast on a Mac.

Nick Moore: Journey Onward: the Apple][and Me

In the mid 80s, Dad brought home an Apple][. This wasn't the *first* computer in the house, but it was the first computer which came with *software*, in the form of a dusty shoebox full of floppy disks.
This is the story of how that machine, and its extraordinary design, came to steer my career into software (from which I've never fully escaped) and how it still informs my understanding and attitudes towards technology to this day.
A light-hearted talk with lots of examples from Apple][games, but also talking about how some of these lessons still apply to hardware and software development.

Iain Anderson: The Past, Present and Future of Learning

Is there a future for university learning now that everyone just googles for answers and finds them on YouTube? How can people attend training or conferences safely, and what are we missing by not being there? Can schools actually learn to deliver remote content well? Will augmented reality help? And are books truly dead?
This talk explores how technology and circumstance are changing in-person teaching, classroom teaching, books, online classes and other forms of learning. It's all about education: how it was, how it is, and how it could be. Some musing, and and some tips and tricks from the trenches.
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Damian Cavanagh: DIY AR on iPad

Create simple, shareable Augmented Reality experiences with your iPad using free apps and zero coding.
Using Apple's Reality Composer, Keynote and Shortcuts apps, learn how to create your own AR scenes for a variety of purposes – virtual signage, interactive photos, device-based scavenger hunts and more.
This presentation is intended for educators looking to apply AR in the classroom, or anyone interested in exploring AR before it really hits the big time!
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Andrew Brown: Making Interactive Audio on your Mobile Device

In times of isolation many people have turned to creative hobbies to occupy their time and stimulate their mind. Such activities include playing the guitar or learning to code. In this presentation we look at how to combine music and coding to produce simple but fun interactive audio apps on your mobile devices, such as the iPhone or iPad, using free development tools.
Mobile computing devices lend themselves to interactive audio, they already contain, microphones, speakers, and motion sensors. The Mobile Music Platform app (MobMuPlat) enables anyone to turn their device into an interactive instrument by connecting the device hardware to bespoke audio software. That software can be coded in the visual programming environment Pure Data which enables sound synthesis, playback and manipulation or recorded audio, and sequencing and timing of audio events. All this along with a graphical user interface toolkit for control and interaction.
The presentation will provide an overview of the creative process to get from scratch to musical instrument using these tools and show examples of the presenter's creative uses of the platform for applications ranging from novelty tasks to professional music performance.

Workshops

Tony Williams: Zsh basics and shell programming

The workshop will first cover a highly opinionated process for setting up zsh. This will be followed by coverage of the basics of shell programming with an eye to scripts that can run under both zsh and bash. Careful attention will be given to regular expressions in both 'grep' and 'sed.
At the completion of the workshop participants will have an understanding of the zsh shell and shell programming.
No prior knowledge is assumed but some prior exposure to programming in any language would be preferred.
Workshop prerequisites: a Mac with a network connection running macOS 10.15 Catalina.

Anthony Reimer: Writing AutoPkg Recipes

You've been using AutoPkg(r) to fetch the latest installers for software you deploy and perhaps even do some post-processing. But there are still a few apps that are not covered by the existing AutoPkg recipes publicly available that you would like to automate.
This workshop is designed to help you fill that gap. We'll cover the basics of how to read an existing recipe and some of the common ways to start building your own recipe. Then we will start building new recipes based on your suggestions. We will conclude with a brief discussion of next steps and how you can then share your creations with the world.
Workshop prerequisites: Attendees who wish to participate in the hands-on portions of the workshop will need a Mac with the current version of AutoPkg (2.2) and a plain text editor installed (e.g. Atom, BBEdit, Sublime Text, or VSCode). Terminal will be used as well. Optionally, the current version of AutoPkgr (1.5.5) can also be installed. It is assumed attendees are familiar with AutoPkg and have run some recipes. For those less experienced or those who have not used AutoPkg at the command line, we recommend watching Greg Neagle's AutoPkg talk from MacSysAdmin 2019 prior to attending the workshop.

Alwyn Hunt: Adobe Aero

Alwyn Hunt from Adobe's Immersive Division will explore the latest innovations in the AR and VR space. Adobe Aero is Adobe's new, intuitive application for building and deploying content for Augmented Reality, Alwyn will demonstrate how Aero can combine and deploy assets created in Adobe apps as well as 3D modelling software. The Substance suite will also be showcased as a powerful set of texture painting and authoring tools that bridge the divide between Adobe and other modelling applications and game engines such as 3DS Max, Maya, Unity and Unreal engine.

Papers Track

David Harris
Online Implementation of Group Creative Ideation Exercises for Teaching Wearable Technology

Two activities designed for an undergraduate university course in wearable technology provided practical, context-sensitive experience in creative ideation. However, in 2020 these activities needed to be modified for online teaching with little notice.
The activities are 1) a card game that promoted generation of novel concepts using a combinatorial creativity framework to ideate and rapid prototype wearable technologies, and 2) an exploratory and transformational creativity task that encouraged group pursuit of "outlying" unusual ideas deriving from an initial concept.
Both activities were modified for online implementation with success. In both cases, the online form provided some advantages. The first activity was effective in allowing students to ideate in groups but was disconnected from an important physical experience. The second activity was found more effective online than in-person in essentially all ways. Ironically, it was only possible to conduct online due to the availability of new tools that have arisen due to social isolation, the same reason the course needed to be taught online.
Students found the process engaging and achieved unexpected outcomes. Final projects showed innovation and boldness beyond previous cohorts, with evidence for ideas generated in these activities influencing final projects.

Pamela See
Comparing Rapid Tooling Applications for Desktop 3D Printing in Cast Metal Sculpture

Rapid tooling is an application of 3D printing that has been adopted in fine art foundries for investment casting in countries like Australia, China and the United States of America (US). This increased distribution has grown largely unobserved by the museum and gallery sector. This reflects the aesthetic results of the digital intervention being difficult to distinguish from its analog counterpart. This paper was designed to address the growing ubiquity of the technology and the disproportionate number of visual arts practitioners developing the expertise to use it. Through a series of tests undertaken at the Queensland College of Art (QCA), Griffith University, a variety of methods of rapid tooling using desktop 3D printers were examined including fuse deposition modelling (FDM) wax filament, FDM polylactic acid (PLA), stereolithography (SLA) castable wax resin, and SLA tough resin. They were compared in relation to detail, time use and material cost.

Ben Rayment, Reza Ryan
A Soccer Game Simulation using Reinforcement Learning Algorithms

In recent years, video games have become the most popular forms of entertainment around the world. This popularity increase comes with a demand from consumers for reliable and high-quality learning algorithms. One of the applications of this algorithms is a soccer simulation game. This research focuses on investigating how Reinforcement Learning algorithms can apply on soccer game simulation to improve the efficiency. Furthermore, this research comparing efficiency of three algorithms including PPO, SAC and Self Play. Also, this research is looking at increasing the number of players in the game to evaluate the performance. The result confirm that Self Play out performed the other algorithm with the striker, mid-fielder, defender, and goalie.

Riley Sheehan, Samuel Canning, Dale Patterson
Wheelchair Design And Social Experiences of Wheelchair Users: A Thematic Review of Literature

It was the purpose of this thematic review to review the academic literature from the last 10 years surrounding the design and functionality of wheelchairs and the social experience of wheelchair users across both manual and electric wheelchairs. Within this review, the findings of 45 journal articles categorised into two categories are reported and discussed across six subcategories: wheelchairs and social experiences; wheelchairs and social participation; wheelchairs and accessibility; wheelchairs and social perception; wheelchair design; and wheelchair accessories. Three recommendations for future research directions are provided. The first recommendation is implementing recommended improvements to the social experiences of wheelchair users present within the selected articles. The second recommendation is documenting the social impacts of new design of wheelchairs and accessories on wheelchair users. The third and final recommendation is wheelchair customisation should be investigated further to determine how customisation could be used to improve the social experience of wheelchair users.

David Chechelashvili
In Defense of Isolation: An Account of Solitary Creative Practice

The purpose of this paper is to propose an alternative perspective on the meaning of isolation and solitude in the context of creative endeavour. This perspective emerges from my own creative practice as a musician primarily engaged with a modular synthesizer. While much has been written on the negative implications of loneliness and isolation, discussions about its positive aspects are not as plentiful in the literature. Creative collaboration is commonplace in modern music-making but working alone is also valued by many of its practitioners who hold creative autonomy in high regard. Furthermore, the efforts to contain the current global coronavirus pandemic have forced many creative practitioners into forced isolation which makes this discussion timely. My aim is to demonstrate ways in which isolation can be beneficial to creativity and the way in which it re-articulates authorial integrity.

Damian Hills
Online Tuition with Web Tools for WebXR

The paper details experiences in online tuition with web tools associated with the WebXR API, the new standard for 3D rendering of VR/AR immersion through the browser. Web tools and techniques associated with WebXR standard are discussed. These include AFRAME, a framework for building XR experiences with declarative HTML markup; Reveal.js, a framework for HTML based presentation; Mozilla Hubs, an open-sourced VR chat room and finally glitch.com, a project management tool that simplifies setup and online delivery. These tools, techniques and standards together simplify the organisation of delivering coursework materials remotely.

Christopher Ranie, Reza Ryan
AI Assisted Coaching in eSports

This Research Paper outlines a CS:GO skills analysis and training program using Machine Learning algorithms. Data collected on the technical performance of a player is t analyzed by these algorithms and compared to data collected after two weeks of prescribed training against customised bots. For amateur teams who are unable to have a human coach, this could provide valuable information to help climb the ranks and allow existing coaches access to more information with which to guide their players.

Daniel Della-Bosca, Paul Bardini
Augmented and Virtual Reality for Spatial Reasoning

The utilisation of mixed reality technologies in the classroom is proving to be of great pedagogical benefit. It is not just the tools, devices and techniques of Augmented virtual and mixed reality that have an impact on student learning it is the ontological shift in learners that is afforded by these technologies. This paper outlines the procedures of implementing AR and VR in a tertiary course for the express purpose of contributing to an accelerated understanding and application of spatial reasoning. The paper discusses the outcomes of two years of teaching a particular second year University course in 3D modelling.

Partners

We couldn't host EveryWorld without the generous support of a number of people and businesses.

We extend our thanks to Dr. Tim Kitchen and the team from Adobe for their support and for running workshops on Adobe's latest Creative Cloud products.

Thanks to the extraordinary team from The Queensland College of Art (QCA), a specialist arts and design college founded in 1881, and the oldest arts institution in Australia, now part of Griffith University.

And thanks to Griffith University, our long-term event partner. 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.

Conference Chairs

Daniel Della-Bosca is a lecturer in design and immersive 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.

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.

Conference Committee

Tony Gray, Daniel Della-Bosca, Dale Patterson,

Conference Proceedings edited by, Tony Gray, Daniel Della-Bosca.

"The Everyworld 2020 papers contain cutting-edge and insightful research articles in the field of creativity applied through the use of technology. Overall, we had 12 submissions, from which 8 were selected as full papers.

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

International Peer Review Jury:

Dr Jason Nelson, University of Bergen (Department of Linguistic, Literary and Aesthetic Studies)
Dr Dale Patterson, Griffith University (Interactive Media, Immersive Design)
Dr Daniel Della-Bosca, Griffith University (Immersive Design)
Dr Nicole Carroll, University of Newcastle (Creative Industries)

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Online Implementation of Group Creative Ideation Exercises for Teaching Wearable Technology

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Abstract

Two activities designed for an undergraduate university course in wearable technology provided practical, context-sensitive experience in creative ideation. However, in 2020 these activities needed to be modified for online teaching with little notice.

The activities are 1) a card game that promoted generation of novel concepts using a combinatorial creativity framework to ideate and rapid prototype wearable technologies, and 2) an exploratory and transformational creativity task that encouraged group pursuit of "outlying" unusual ideas deriving from an initial concept.

Both activities were modified for online implementation with success. In both cases, the online form provided some advantages. The first activity was effective in allowing students to ideate in groups but was disconnected from an important physical experience. The second activity was found more effective online than in-person in essentially all ways. Ironically, it was only possible to conduct online due to the availability of new tools that have arisen due to social isolation, the same reason the course needed to be taught online.

Students found the process engaging and achieved unexpected outcomes. Final projects showed innovation and boldness beyond previous cohorts, with evidence for ideas generated in these activities influencing final projects.

Keywords

Wearable technology, group creativity, creative ideation, online education.

Introduction

Students in the creative arts are often assumed to come to their courses with a level of inherent creativity that can be applied in their project work. However, this is based on a misconception of creativity as an inherent personal quality. Current understanding of creativity suggests that it can be taught, trained, and is collective (NACCCE 1999).

Professional designers are well-versed in techniques for group creative ideation but beginning students often express suspicion and reluctance about both group work and public expression of their personal ideas.

In recent years, I have developed a range of group-based creative ideation exercises specifically tailored for the course 2703QCA Wearable Technology at Griffith University. The course has been studio-based and organised around assessable group projects. Students come primarily from Design, Interactive Media, and Fine Arts programs. They typically have limited group work experience and a majority of them report not having done any explicit creative ideation exercises in previous coursework.

In 2020, as teaching moved entirely online, the exercises that had previously relied on physical in-person implementation needed to be modified for the new mode of teaching. This paper describes the changes implemented both conceptually and technically and outlines some of the key observations about the impact of those changes.

The two case studies discussed in this paper were designed to engage with the course in a way that supports its process objectives and has potential for creating usable content outcomes. The activities also aim to scaffold students' general growth in creative ideation. A course priority was for students to engage with how wearable technologies can re-form relations in the world, whether interpersonal, identity formation, or autobiographical re-inscription (Tamminen and Holmgren, 2016).

A key goal for the course was to have students conceive of future cultural, personal, and technological scenarios in which wearable technology plays a role, rather than them simply designing for present circumstances. That future thinking requires pushing ideas beyond the familiar and that impetus is built into the design of these activities. The activities were designed to encourage useful mindsets along with challenging common inhibitory modes of thought. Meta-cognitive discussions bookended the activities to enhance their longer-term efficacy.

In making the transition to online development of these activities, I used what is effectively a two-layered version of an action research cycle (Reason and Bradbury, 2001) with multiples cycles being implemented within the frame of one session (where there was a repeated task that could be evaluated and modified easily on the spot). The results of one session were evaluated with more time for reflection and revised to iterate with the next tutorial group, incorporating more substantial changes, with increasing success in the activities. I describe some of those cycles in the narrative of the activities below. The within-session approach can also be seen as an example of "teaching as improvisational performance" (Sawyer 2004), which is apt given the significance of improvisation in group creative ideation.

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In the 2020 version of this course, one weekly session had six groups of four students, and the other weekly session had four groups of four students, for a total of 40 students. The course is nominally for second year undergraduates, but students were in different stages of their programs, from starting their second year through to taking this as a final course before graduation. They were ostensibly spread across two campuses (which affects intra-group relations due to previous acquaintance), but all teaching occurred online.

Wearable Futures Game

The first card game activity occurred early in the course, during nascent group formation and prior to presentation of initial project concepts. The aim of the activity was to push students toward ideas that they would not typically consider, acting primarily through the process of combinatorial creativity (Boden 2004). The goal of the game was to generate new wearable technology project ideas by incorporating a set of prompt words or phrases from a few specified categories, with different coloured cards for each category.

I derived mechanics of the game from future forecasting card games used in professional design circles and applied them to the higher education context. The precursor examples were designed for more generic future forecasting. One used the categories of Strategy, Value, Terrain, and Object (Institute for the Future, 2017), and another used Arc, Terrain, Object, and Mood (Candy and Watson, 2015). To make the ideation activity more concrete and specific to this course, I used the categories of Relation, Form, Material, and Aesthetic, as these reflect the properties, I wanted students to prioritise in project development.

The physical implementation

In previous physical versions, playing in groups, each student was dealt cards randomly from a deck that included 10 relations, 38 forms, 23 materials, and 21 aesthetics. Players took turns playing cards according to some simple rules that allowed limited overrides of other's cards but ended when all four categories were determined (Figure 1). Students then individually came up with an idea for a project, shared their ideas, and the group voted on their favourite.

Figure 1: Physical play of the Wearable Futures game

Groups were then surprised with an instruction to build a low-fidelity prototype of the chosen project on the body using materials from a provided trolley of physical resources. They were only given 10 minutes to complete the task at which point they present the project to the class (Figure 2).

The physical constructions represented projects with a high degree of originality and reflected a variety of conceptual foci of the course by enforcing attention on the aspects of relations, forms, materials, and aesthetics.

Figure 2: A rapid prototype of a glass badge that would break based on a negative emotional response of a person nearby. It was inspired by the set of cards in Figure 1.

The online implementation

For the online version, there was not an easily accessible interface to replicate the gameplay. Specifically, I looked for a tool that did not require signups nor complex websites seeing as this was just a one-time activity and the overhead of having students sign up for services, even free ones, has previously proven prohibitive. If the game were to be used repeatedly, it might have been worth asking students to sign up to use a tabletop simulator site, such as commonly used for online boardgames and roleplaying games, e.g. Roll20.net or tabletopsimulator.com. Instead, I modified the rules of the game to allow for a different flow but retaining key aspects of gameplay.

Each student (there were four in each group) was assigned to make decisions about one of the four categories. Going through one category at a time, the assigned student could either keep a randomly drawn card or draw an alternative, but could not return to a previous option, and could make no more than two rejections. If they got to the third option, they had to keep it. Students could see what cards were decided in each previous category so their decision was informed by the initial ideas they were generating about what projects could potentially be created from the prompts. The idea was to activate their ideation instinct but still keep open the possibility that they would have to come up with entirely different ideas to satisfy future choices by other students.

In the first version, I showed a website which I had loaded with a random generator showing cards from a certain category. The student decided whether to keep or reject a card via voice or text in our virtual classroom (Blackboard Ultra) while the whole class could observe. I had initially elected to only show one category at a time, requiring a webpage refresh to display a new choice, but the clumsiness of sharing a different webpage for each category through our online interface slowed things down to a point of frustration and students often did not take note of the previous choices nor remember them.

For the next session, I remade the website to show all four categories at once, although for ease of rapid programming using easily customisable off-the-shelf tools, all four categories were prepopulated to begin with, even though the initial draws would not be used. A button for each category

allowed me to easily choose a new card for a student based on a simple keep or reject message by text or voice (Figure 3). The rapid response and use of the tool made the card dealing far more enjoyable than the previous iteration and other students enjoyed watching the cards being revealed, as evidenced by their chatter in the text channel while we dealt cards.

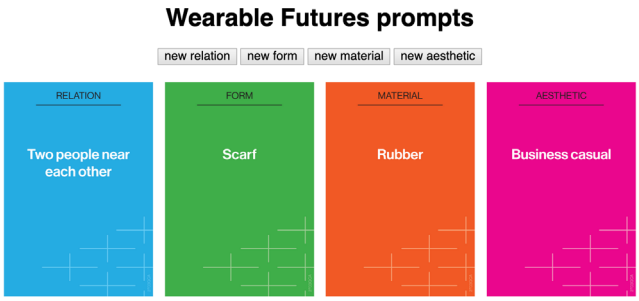

Figure 3: Screenshot of online version of Wearable Futures card game in progress

The webpage for this iteration was coded in a matter of minutes using perchance.org, which allows randomisation and display from various datasets, including images. For this implementation, I had images of the cards already prepared from their use in the physical game, and only needed a dozen lines of html and a minimally structured list of the filenames for images stored, in this case, on my personal server. The code for this activity can be inspected at the website https://perchance.org/wearablescards.

Once all four categories were decided, students were encouraged to take a screenshot for reference. Most groups then shared that image in their group channel in Microsoft Teams, so it was easily accessible.

With the four cards chosen, students were asked to individually come up with an idea for a wearable technology project incorporating all four elements (loosely interpreted) in 3 minutes. The group then chose their favourite (according to whatever criteria they liked) in 2 minutes and then had another 3 minutes to come up with a new evolution of the idea to present.

In the physical game, students would then be asked to construct a rapid prototype of the project. For the online version, they were asked to sketch and briefly describe the idea.

In practice, groups mostly did not sketch by hand or on their own computers as the technological friction for sharing those images was a major disincentive. Upon observing this, I realised that we could get a similar result by having one student draw on the shared whiteboard in Blackboard Ultra in a very rough sketch while another student described the project. The live drawing also allowed students to sketch dynamically to imply motion of the project more effectively than a static finished image might (Figure 4).

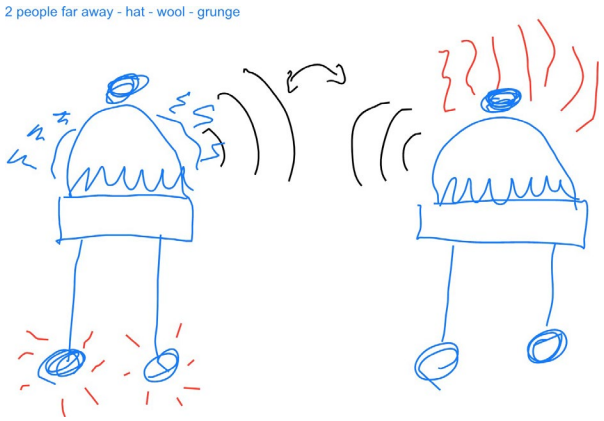

Figure 4: Using the prompt set of "Two people far from each other", "Hat", "Wool", and "Grunge", one group live sketched a pair of woollen hats with tassels that would send signals to each other remotely to respond with motion, sound, and light as a means of enriching relationship at a distance.

Observations

A significant issue for many students is simply coming up with an idea. Although experienced ideators could generate up to a dozen different ideas in three minutes, many students are unable to come up with one, a phenomenon broadly discussed (e.g., Dam and Siang, 2020) but beyond the scope of being fully addressed in this brief trial activity. This anticipated occurrence was partly mitigated by not having a fail state for the task if any particular student was unable to come up with an idea. Other activities in the course would address ideation for those struggling.

As the students were in isolation and attending via online interaction, often solely through a text interface, I had no cues as an instructor to know I should make suggestions and help them along. As a result, I was unable to coach the small but significant fraction of students who were unable to generate a single idea in three minutes. However, their inability to ideate rapidly provided a sign that these students needed further help in learning this skill. Although the lack of ideas generated by some individuals reduced the possibilities for later steps in the process, all groups managed to present an idea within the 8-minute timeframe, although showing a wide variation of elaboration and sophistication.

Branching Ideas Activity

The second activity occurred after groups had determined a project design intent and initial concept. It was aimed at pushing groups beyond their initial (typically unoriginal and obvious) ideas, which students very often cling to tightly unless explicitly pushed further.

The task calls for students to rapidly add brief ideas to an ordered tree of ideas. They are instructed to add new ideas to any node in the tree with a few guiding principles. Examples of the process were shown to them beforehand.

Students were primed with an individual creative warm-up exercise and a discussion of techniques for group creativity and group flow based on Sawyer (2017). One of the aims of this activity was to try to achieve group flow so that students

can experience that state, which could be useful for further group work.

In the physical version of the activity, students wrote short notes on cards that extended or modified other ideas already posted, using the techniques of improvisational theatre such as the "Yes, and..." guideline but in written form (Figure 5).

The activity itself is derived from my experience participating in a forecasting exercise called "Free Space" held by the Institute for the Future (IFTF 2009). It was run as a massively multiplayer online game framed by a particular near future scenario with a goal to explore the best and worst outcomes of that scenario. In that particular case, the game was prefaced by a video introduction to the idea of personal ownership of cheap, small nanosatellites put into orbit. A range of ideas from dystopian to utopian emerged over 72 hours of play by hundreds of participants around the world. Many were quite innovative and drifted far from the more obvious initial ideas.

Figure 5: Participants creating idea trees in a studio class.

This Branching Ideas activity is best framed as a combination of exploratory creativity (as it begins with a single concept and then calls for continuations of the concept) and transformational creativity (as each concept could give rise to a range of variants) (Boden 2004). The tree structure is key to enabling both kinds of creative ideation.

Participants were encouraged to respond spontaneously to any cards that provoked ideas and to not dwell on ideas nor self-censor. During the exercise, the value of an idea is proposed to lie in its ability to prompt further ideas rather than having an inherent value. Ideas that lead interesting places will be built upon while dead ends tend to simply languish without requiring or deserving more attention at that moment. Ideally, the activity will let students arrive at "outlying" ideas rather than circle around the more obvious or immediate ideas, a key limitation of many forms of brainstorming.

The activity itself is designed to be done essentially in silence for a few reasons, some of which are connected with the distinction between brainstorming and brainwriting (Michinov, 2012). One is that more outgoing or vocal members of the group are not able to dominate (e.g., Paulus, et al., 2002). People are not required to wait until one person has finished speaking before, they can make a contribution, as the process is fundamentally non-linear (e.g., Diehl and Strobe, 1987). If people are having ideas, those should be added to the tree of ideas rather than being discussed among participants where those ideas will not be captured.

This is not to say that absolute silence is required. Indeed, the noise that does occur tends to be of a social or expressive nature rather than being about generating or discussing the content of ideas directly. It has been typical to hear and observe laughter, surprise, shock, and indicators of a range of emotions as people see what is added to the tree of ideas.

While the activity is underway, I would model the desired behaviour by wandering among the boards and silently rapidly adding cards to the flow whenever inspired. Many students seemed to catch on and follow that lead, but additional verbal feedback and guidance helped students engage productively.

One significant difference between this activity and many forms of brainstorming or brainwriting is the explicit structuring of ideas. Research in these fields shows that participants generate more and more varied ideas when exposed to a flow of ideas from other participants while ideating rather than just responding to a single initial prompt (e.g., Nijstad & Stroebe, 2006).

Having participants' idea visible to others at all times enables this exposure to ideas, but the structure encourages participants to respond to any particular idea as a source idea and extend it, rather than being tied to the original idea. This is desirable in the exercise as it is intended to search for outlying ideas that are not obvious from the starting point.

Example of a class implementation

In the example shown in Figure 6, a group started with a core concept for a project, "A wearable that relays the sound of your body back to you". Participants explored options and extensions to arrive a number of unexpected ideas. In this particular version of the game, cards had options to extend in the form of "Yes, and…" (an exploratory creativity step), "Yes, but…" (a transformational creativity step), and "What if?" (which can raise tangential questions that are not specifically a variant of the idea).

Some of the first-level ideas are more obvious ones such as "Aids meditation", a fairly natural application of the idea. Others are more abstract, even at the early stage, such as "the hyper-stethoscope", which doesn't have a concrete meaning but is evocative and led to long chains of subsequent ideas. Some of those later stage ideas include "team building in the workplace" and "records your temperature", neither of which are ideas that seem immediately obvious from the starting idea.

Toward the bottom of this tree, one idea reads "A boxing slave will be activated when someone touches you". This is decidedly not obvious from the starting point. At seven steps removed from the initial idea, there has been considerable wandering, but if the goal is to generate outlying ideas rather than necessarily be tied to the starting point too closely, it clearly satisfies that aim.

Some ideas become dead ends early, such as "it enhances the experience of walking", two layers down. But interestingly, the 2020 version of the course had a whole project based on that idea, so it is not necessarily without merit. It just didn't meet the interests of the group participating at that time.

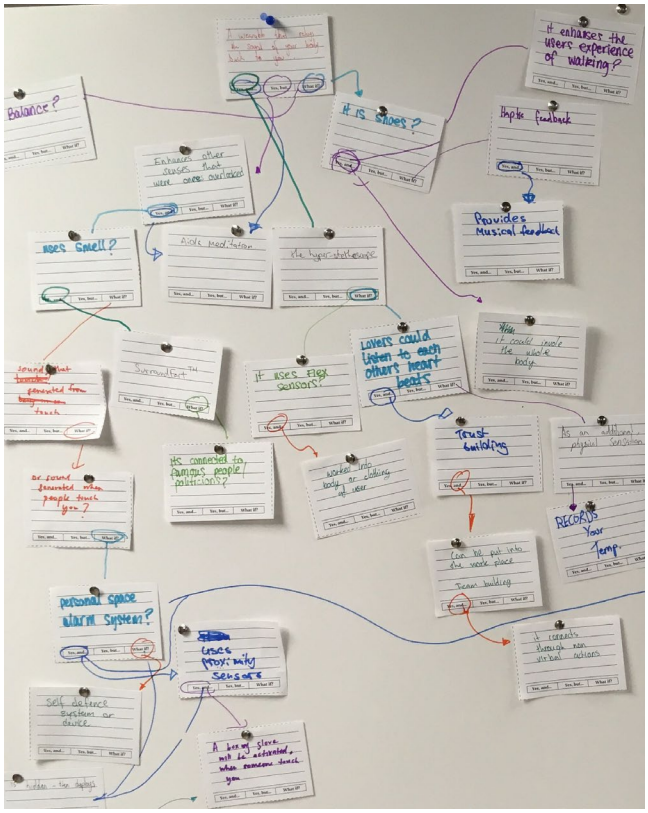

Figure 6: Branching ideas activity example from the first 10 minutes of play with an undergraduate group. (Note: Relevant unclear text is included in discussion.)

This example was shown to students in the 2020 iteration of the course, so it is possible that seeing that card triggered an idea for the group to pursue as their project. If so, the documentation of the process continued to inspire ideation. However, tracing back ideas to their source reliably is difficult at best.

An example tree of ideas developed by the group over about 30 minutes is shown in Figure 7. At this point, the physical limitations of the space are becoming apparent, and the friction of adding cards to the limited space we had available appeared to inhibit easy addition of new cards, which slowed production of ideas.

As time went on, students showed some signs of fatigue with the process, which coincided with more ideas intended as silly or humorous, as evidenced by increasing amounts of laughter. Those ideas weren't necessarily poor, but the quality and quantity of ideas did drop off on average over time, and I used that, as well as class time constraints, as an indicator to cease the activity.

Students were then given time to review the cards, point out any they found particularly interesting to the rest of the class, and were encouraged to photograph the boards for their journals.

Online implementation

The online version of game necessarily takes a different form but tries to capture many of the features of the physical game.

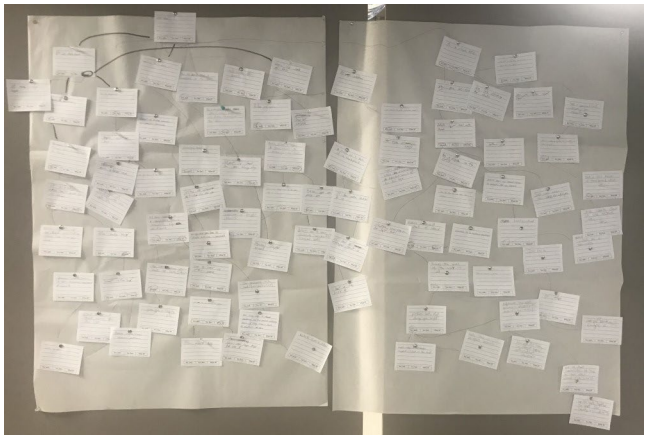

Figure 7: An idea tree after 30 minutes of development by a group of four participants. (Note: Shown for structure. Specific text on cards not essential to read.)

I had previously spent some time building an online tool to allow this activity to be replicated in a browser. However, with the rapid transition to learning and teaching online throughout the world, electronic collaboration tools took big steps forward. I found that some of those obviated my need to build custom tools and I could use new tools in effective ways.

For this particular task, I found that the Miro electronic whiteboard's mind-map tool was well suited to the task. An example from a class activity is shown in Figure 8.

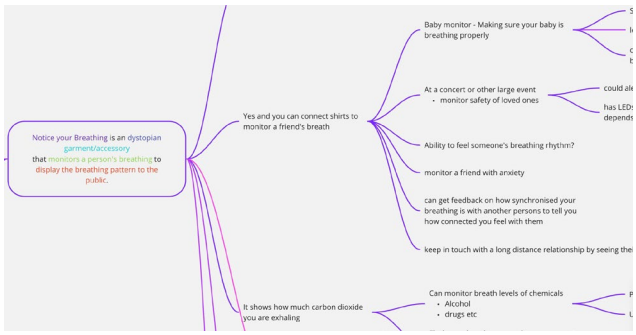

Figure 8: Section of a tree of ideas using Miro's mind-map tools. (Note: Shown for structure. Specific text not essential to read.)

The interface is easy to use to quickly add ideas, so the friction of contributing is minimised. A simple click in the appropriate place will spawn a placeholder for a new idea at a chosen point in the hierarchy and the text can be quickly added. The tree nodes automatically arrange on screen to avoid overlap and remain well organised for scanning. In addition, people can simultaneously add notes without the problem of physically obstructing each other, as happens in the in-person physical version.

The mind-map tool does not allow for the categories of continuation ("Yes, and…" etc.) used in the physical version, but the loss of that specificity was not particularly significant, and I had considered removing those options anyway.

One motivation for the original physical task to be completed on index cards was that participants should add a single idea without too much detail or resolution. The brevity and ambiguity of such ideas can give room for further elaboration

by others. The limited space on cards provided a physical constraint enforcing brevity. Although the online version could in principle lead to entire essays being added as a note, priming of the participants to use brief notes, and the visual style of the mind-map tool encouraged brevity also. Longer notes would scroll off screen and seem unappealing. Line breaks can be added, such as seen in Figure 8, but even the small amount of friction required (the not universally known Shift-Enter keypress) seemed to act somewhat as a deterrent.

After running various versions of this activity, the need to have a good starting prompt has become clear. In this iteration, I ran a structured activity beforehand to help students form their project statement according to the template "[Project name] is an [aesthetic] [form] that [functions] to [influence a relation]." That sentence helps them identify the characteristics of a project that we prioritise in the course. The group's response shown in Figure 8 reads, "Notice your Breathing is a dystopian garment/accessory that monitors a person's breathing to display the breathing pattern to the public."

An experiment with this iteration of the activity included having different groups contribute to each other's idea trees. After a group seeded their mind-map with their project statement, each moved to the next group's Miro board in rotation and had 10 minutes to contribute ideas. The groups then cycled every 10 minutes until all groups had contributed to four boards. The motivation was to present fresh ideas for each board, particularly with new minds responding to ideas many layers down the hierarchy, hoping for even further outlying ideas.

Observations

Once the activity was complete, each group could inspect their own board, mine it for ideas they found interesting, and reflect on those to actively look for interesting ways the new ideas could potentially influence their project. Some groups used a different space on the same board to capture the ideas they found interesting for later reference (Figure 9). In other cases, groups built further on the trees of ideas for their own use, having found the format useful for ideation.

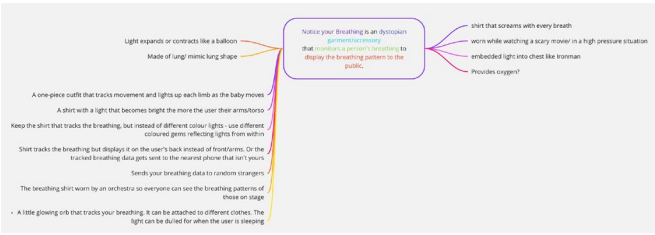

Figure 9: Collection of interesting ideas for one group. (Note: Shown for illustrative purposes. Specific text not essential to read.)

One aspect missing from the activity is the presence of subtle social clues that exist when working in person. However, students implemented their own versions of injecting humour and silliness with the tools in the whiteboard (Figure 10). These took the form of memes, notes written with the pencil tool, and weblinks. That kind of generalised social interaction appears to have been extremely effective in other online-only classes at improving intra-group and student relations.

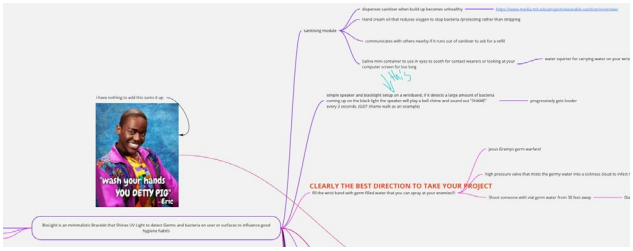

Figure 10: Example of students' meta-commentary using images, graffiti notes, and weblinks. Note only the presence of an image "meme", penciled graffiti, and overlaid commentary.

An additional affordance of these electronic whiteboards is illustrated by the incorporation of images. One criticism of brainwriting in comparison with brainstorming is that some people are more easily able to contribute ideas verbally than in writing. Although this electronic tool does not allow verbal contributions easily, it does provide the possibility for other media including static images, animated gifs, video, and sketches. These possibilities could provide a whole new range of activities that explore creativity in different modes.

One particular challenge in the online environment is that it is difficult for an instructor to help participants course-correct if their contributions to the activity steer in less-than-useful directions. In an in-person version, the instructor can say a couple of words to give an example of useful ways to contribute nodes, particularly in cases where students are tending to add nodes that block or inhibit further elaboration. This did not seem to occur as frequently in the online version as in physical versions, surprisingly. However, as an instructor, I could jump between boards rapidly and would have been able to guide groups if necessary.

Introducing these electronic tools proved to have additional benefits to students as some of them began to expand later from their mind-map activities on the boards to using them for idea collection, inspiration/mood boards, and planning.

Conclusions

These two case studies illustrate some of the issues arising in moving group creative ideation activities from physical space to online forms. It would be a significantly bigger task to try to disentangle the factors associated with the general move to online learning and social changes due to working and living in isolation from the more technical aspects of this format change. However, the online versions seem to have replicated and, in some cases, improved the results of these particular ideation activities.

Tracing the origins of creative ideas is challenging. However, a number of final projects presented in week 13 of the 2020 course appeared to incorporate elements that arose during these ideation activities but had not been present in the original project concepts presented for assessment in week 4 of the course.

There appear to be a few important benefits of conducting these activities online. The first is that there is more concrete and easily retainable documentation for later reference. Despite much urging, it is often quite difficult to have students record the outcomes of in-class activities in a form that they are likely to return to. Although some students retain photos

of their work in their journals (as advised), those records are captured in a form often less amenable to development than being digitally recorded in online tools. The texts written in the online activities can be re-written, extended, copied and pasted, and are easily shared within groups.

The act of working online is self-documenting to an extent. More of this work has shown up in journals in 2020 than in previous years when the activities have been physical.

The persistent, digital, modifiable form of this work has allowed students to return to the results of the activities and make further use of them, sometimes continuing the activities themselves. In previous physical instantiations, some students would replay the Wearable Futures card game or make new Branching Ideas trees but those were relatively few compared with the online implementation.

Students spontaneously reported more enjoyment and satisfaction participating in these activities than they have in previous years.

As a result of these explorations, I am motivated to conduct further experiments and development with the activities.

For the Wearable Futures game, the only significant advantage of playing online rather than in person was that the whole class could easily see other groups rapidly choose their cards, which was entertaining and engaging for them, evidenced by their online text chatter during the activity. In person, that card selection was slower and done entirely within groups so was not visible to others. The rapidity of the web-based choosing of cards appears a viable approach in front of an in-person class with individuals able to make their choices in front of the whole room.

On the downside, the main motivation for doing this activity in class was the physical prototyping that follows the gameplay. The follow-up activity is important because it satisfies a key goal of the course, which is to encourage rapid physical prototyping and experimentation with materials. Online, the drawing of ideas was interesting and entertaining but did not engage some important modes of learning for students.

I anticipate using a blend of these approaches for in-person classes in the future, using the online tool for dealing cards in front of the whole class, and then still having students make physical prototypes in their groups.

The Branching Ideas activity was, in the end, far more effective online than in person. The speed and automatic organisation inherent in online whiteboards are far improved over the physical version of the activity for an activity like this. The physical version of that activity was originally designed in the absence of easily accessible electronic tools that afforded the same gameplay. However, the rapid development of these tools under the conditions of widespread online and isolated learning has provided an option that is better than the physical possibilities in most ways.

One potential implementation of the activity in the classroom would be to have students use their own computers in the room but project the group online whiteboards on the multiple large screens throughout the open plan space this course is usually taught in. The activity has always had substantial value for students, but with the current state of technology, a purely physical version now seems limiting.

Observations of the online version suggest additional future activities, especially in terms of ideating around images, videos, and memes.

Although the move to online teaching was unplanned and rapid, these experiments have demonstrated that ideation activities can be relatively easily adapted for online teaching and that there are now available suitable tools for conducting them quite effectively. It provides an opportunity to rethink how group creative ideation is taught and how that new understanding can be applied not only to online teaching but back in the physical classroom.

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Comparing Rapid Tooling Applications for Desktop 3D Printing in Cast Metal Sculpture

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Abstract

Rapid tooling is an application of 3D printing which has been adopted in fine art foundries for investment casting in countries like Australia, China and the United States of America (US). This increased distribution has grown largely unobserved by the museum and gallery sector. This reflects the aesthetic results of the digital intervention being difficult to distinguish from its analog counterpart. This paper is designed to address the growing ubiquity of the technology in fine art foundries, and the disproportionate number of visual arts practitioners developing the expertise to use it. Through a series of tests undertaken at the Queensland College of Art, Griffith University, a variety of methods of rapid tooling using desktop 3d printers were examined including: fuse deposition modelling (FDM) wax filament, FDM polylactic acid (PLA), stereolithography (SLA) castable wax resin, and SLA tough resin. They will be compared in relation to detail, time use and material cost.

Keywords

Post-digital, additive manufacturing, 3d printing, investment casting and sculpture.

Introduction

Proceeding rapid prototyping and preceding direct manufacturing, rapid tooling is an application of additive manufacturing or 3d printing that emerged during the 1990s.[1] Within the fine arts discipline it is primarily applied in pattern or mould making with an emphasis on investment casting. Unlike direct manufacturing, rapid tooling applications of 3d printing have the capacity to produce aesthetic outcomes difficult to distinguish from its analog counterparts. Subsequently, its ubiquity as a fabrication technique has grown largely unobserved by art writers. Notably few art practitioners are presently using the processes without technical assistance. This paper examines a selection of rapid tooling options available through desktop 3d printing. They will be compared using the variables of detail, time and material costs.

Background of 3d Printing by Artists in Japan and the United States of America (USA)

In 1989, technologist Masaki Fujihata produced the first 3d printed artwork using stereolithography (SLA), titled *Forbidden Fruit*.[2] This was followed by New media artist Michael Reeves, with the *Ajna Spine* series printed using selected laser sintering during the 1990s (SLS).[3] SLA was invented in 1983, by engineer Chuck Hall using a laser, mirror and photosensitive liquid polymer.[4] SLS was invented in 1986, by a team at the University of Texas.[5] It uses a laser to selectively melt particles together. Both artists applied methods regarded, at the time of application, as rapid prototyping in direct manufacturing contexts. A contemporary of Rees, Bathsheba Grossman, is attributed with introducing rapid tooling to the fine arts discipline.[6] Having studied investment casting as part of her Master of Fine Arts at the University of Pennsylvania, Grossman experimented with casting with starch-based prints prior to transitioning into direct metal printing using binder-jetting during the 1990s.[6][7]

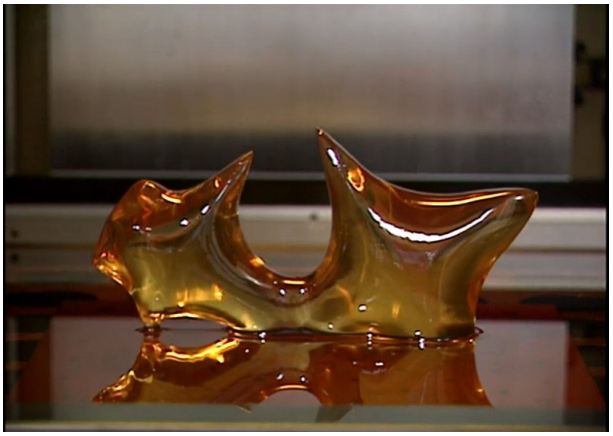

Figure 1. Video still of one of Masaki Fujihata's *Forbidden Fruits* being SLA printed, sourced from "1989 Forbidden Fruits," YouTube video, 2:13, posted by Masaki Fujihata, 18 July, 2019, https://www.youtube.com/watch?v=yygElySiA-E.

Figure 2. Examples of sculptures designed by Bathsheba Grossman. Image sourced from "3d Metal Sculptures by Bathsheba Grossman," *Design Boom*, 3 December, 2008, accessed 26 May, 2019, https://www.designboom.com/science/3d-metal-sculptures-by-bathsheba-grossman/.

Applications of Rapid Tooling in Europe and China

Rapid tooling using 3d printing for investment casting reflects the culmination of four milieu of technological development, which commenced the establishment of lost wax casting during the Akkadian period in Mesopotamia (2900 to 2350 BCE). Over the past decade, the prevalence of rapid tooling in Chinese foundries has led to the supplanting of analog modelling using clay.[8] The primary processes used to scale up designs embrace 3d scanning, 3d modelling and SLA printing. In addition to being the original technique of 3d printing, SLA also offers a high level of resolution with some machines able to capture detail up to 25 microns. 20 microns is the capacity of a computerised tomography (CT) scanner and the diameter of a human hair.[10] In China, it has become common practice for designs to be printed in interlocking sections. The prints are moulded and cast in wax prior to the patterns being cast in bronze or aluminium.

SLA printing to a significant scale presents mechanical challenges such as ensuring the liquid in the centre of the prints are exposed to sufficient UV light to polymerise. In Belgium the first organisation to offer an online printing service in 1997, Materialise, has the capacity to build to a size of 2100 x 700 x 800 mm.[10][11] Between 2011 and 2013, British artist Marc Quinn worked with the organisation to reproduce shells scanned from the Natural History Museum in London, the largest of which stood five metres tall.[6] Using "mammoth resin", they were able to print the pattern for bronze casting in two lengths.[6]

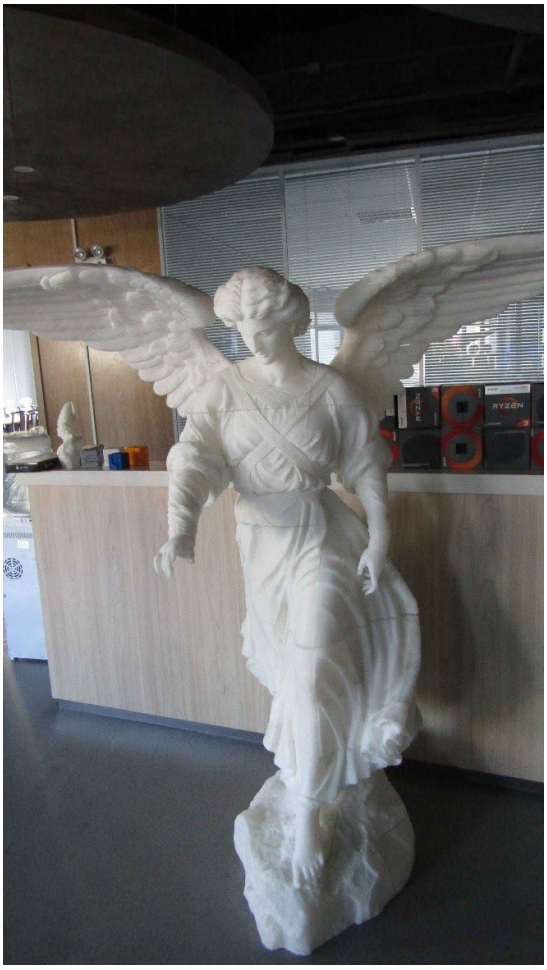

Figure 3. Photograph of SLA prints joined together, taken by the author at the World 3d Printing Technology Industry Association in Beijing in 2018.

Figure 4. Half of a shell sculpture pattern for bronze casting by Marc Quinn SLA printed by Materialise in Belgium. Image sourced from Lucy Johnston, *Digital Handmade: Craftsmanship and the New Industrial Revolution* (London: Thames & Hudson, 2015), 72.

Applications of Rapid Tooling in Australia

Although the technology is embraced by foundries in Australia, the principle practitioner investigating investment casting in Australia is Louis Pratt. The multi-award-winning sculptor was attributed by the Museum of Applied Arts and Sciences in Sydney for introducing the Open Sourced 3d Printing Movement to Australia.[12] He has contributed 3d prints to international and national surveys, including *Out of Hand: Materialising the Post Digita*l at the Museum of Art and Design in New York in 2013 and *Shapeshifters* which commence a national tour in 2016 at the Australian Design Centre.[13][14] The candidate of the University of Technology Sydney has experimented with small scale lost polylactic acid (PLA) casting, which was fuse deposition modelling (FDM) printed and sanded.

FDM printing was invented in 1989 by Scott Crump who democratised 3d printing technology through founding Stratasys.[15] This style of 3d printer operates by extruding molten material using a nozzle attached to a gantry. Desktop FDM printers use filaments, into which a multitude of partials may be added including ceramic, wood and aluminium. Derived from corn starch, PLA as proved a suitable material for burning out in investment casting on a small scale.

Both investment casting using FDM PLA and SLA resins, without creating a wax pattern, have presented mechanical issues due to the expansion of materials.

Castable filament, like polycast, are available for FDM printers. The technology is being embraced by fabricators like Perides Art Foundry in Brisbane. Despite the considerable time required to remove the layers produced during the printing process, it remains a relatively economical alternative to the labour costs affiliated with scaling using clay and moulding for wax casting. However, their counterparts overseas have abandoned FDM printing in favour of SLA prints which produce smooth surfaces. This is despite the requirement to print large patterns using interlocking sections.

Figure 5. Video still of Louis Pratt sanding an FDM print prior to moulding and casting in wax. The wax pattern is then casting in metal. Image sourced from Louis Pratt, "About", accessed 17 September, 2020, https://www.louispratt.com/about.

Figure 6. An image of Louis Pratt's bronze from 2008 *The Digitised Man* sourced from Nanda Hobbs, "Doppegaenger", Exhibitions, accessed 17 September, 2020, https://nandahobbs.com/exhibition/doppelgaenger/artwork/the-digitised-man.

Figure 7. Image supplied by Perides Art Foundry of a 3d printed pattern and a cast bronze sculpture.

Although castable resins for are regularly employed by jewellers, they lack the strength required for large format SLA printing. In any case, investment casting using large quantities of castable resin is a relatively unsustainable option. Whereas a quantity of the wax used in investment casting is poured out of the ceramic moulds and reused, the option to similarly recycling of castable resin or filament is not presently available. Australian organisations that provide large format SLA printing of patterns for investment casting include 3D Printing Systems in Victoria and 3D Global in Western Australia.

Figure 8. An image supplied by Perides Art Foundry of the ceramic moulds resulting from investment casting.

Comparing SLA and FDM Methods of Rapid Tooling Using Desktop Printers

Presently, there are a very limited number of visual artists able to produce a pattern for investment casting despite the proliferation of desktop FDM and SLA printers. To demonstrate the accessibility of these processes, a series of 3D prints were produced using a variety of 3D printer models. A singular design modelled in Rhinoceros 3D was printed using the following processes in preparation for casting in metal at Perides Fine Art Foundry: FDM Castable Wax, FDM PLA, SLA Photo-polymer Tough Resin (PTR) and SLA Photo-polymer Castable Wax Resin (CWR). The later was also moulded in silicone and cast in wax. The subsequent patterns were immersed in a vat of ceramic and burned out at 600 degrees prior to their moulds being vitrified at 900 degrees and cast in aluminium and bronze. The objects were carefully broken out of their ceramic shells and a minimum of polishing was undertaken. The process took approximately 3 hours and the material cost was $550 AUD. The design of a cotton ball and stem had overhangs, areas of fine detail, planes with limited detail and fine protrusions.

Rapid Tooling using Desktop FDM Printers

Of the FDM prints, the castable wax was trialled on a Wanhao Duplicator i3 plus and a Flashforge Adventurer 3 without success. The filament clogged the extruder and was unable to be fed respectively. The PLA was printed on a Flashforge Adventurer 3 at a layer height of 180 microns or 0.18mm. The design took 8 hours and 7 minutes to print and 11.97m of filament was used. A further 30 minutes was required to remove the support material post-print. No sanding of the surface was undertaken during this exercise. The total material cost was $2.14. The subsequent cast object retained a moderate level of detail however the layers were highly visible. This particularly aesthetically effected the regions of the design which featured planes.

Figure 9. The design was FDM printed using polylactic acid using a Flashforge Adventurer 3.

Rapid Tooling using Desktop SLA Printers

The SLA PTR and CWR were printed using a Formlab 2 at a resolution of 50 microns or 0.05mm. They each took 13 hours to print with a volume of 32.70ml. The PTR required an addition hour to remove the supports and wash in isopropyl alcohol, prior to curing for 20 minutes at 60 degrees in UV light. An additional two hours was required to create a silicone mould and cast it in wax. The total cost was subsequently $148.32. Unfortunately, the protrusions and overhangs broke during the silicone moulding process. Subsequently, the resulting cast aluminum was compromised in detail but had clean planes. The CWR print also took an additional hour to remove the supports and wash in isopropyl alcohol. The print was not cured in UV light prior to casting. This pattern proved to be the most effective from the view of translating both a high level of detail, fine protrusions and clean planes. The material cost of the CWR prints were $137.34.

Figure 10. The design was SLA printed using castable wax resin with a Formlab 2 at the Queensland College of Art, Griffith University.

Figures 11 - 12. After SLA printing a version using photo-polymer tough resin, the object was moulded in silicone and cast in wax. The loss in detail was significant.

Form of Printing	Printed Object	Resolution	Volume	Unit Cost	Time*	Estimated Cost
FDM PLA	Cotton Ball Design	180 microns	3.42m	$59.95 per kg	3 hours 2 minutes	$0.62
	Cotton Stem Design	180 microns	8.5m	$59.95 per kg	5 hours 5 minutes	$1.52
SLA PTR	Cotton Ball Design	50 microns	9.56ml	$354 per l	5 hours 30 minutes	$33.84
	Cotton Stem Design	50 microns	23.14ml	$354 per l	7 hours 30 minutes	$81.92
	Pinkysil Silicone		300g	$39.27 per 500g	1 hour	$26.56
	Modelling Wax		250g	$24.20 per kg	1 hour	$6.00
SLA CWR	Cotton Ball Design	50 microns	9.56ml	$420 per l	5 hours 30 minutes	$40.15
	Cotton Stem Design	50 microns	23.14ml	$420 per l	7 hours 30 minutes	$97.19

Figure13. A table comparing the resolution, time and cost of the different methods of rapid tooling available through using desktop 3d printers.

Figure14. Image supplied by Perides Art Foundry of the cast bronze and aluminum resulting from the rapid tooling tests.

Conclusion

The ubiquity of 3d printing in the art foundry sector has grown over the past decade largely unnoticed by art writers. This reflects its post-digital application as rapid tooling of patterns, which are cast and finished by hand. In Australian, despite the high costs involved in employing the technology they are relative to the labour costs incurred through analog modelling. the In China, scanning and SLA printing have supplanted the scaling up of designs using clay. Few visual artists are able to utilise the technology without technical assistance due to the complexity of the processes of scanning, modelling and 3d printing. The proliferation of desktop 3d printers has created potential for them to access investment casting. This paper compares a number of rapid tooling processes, which can be employed using the equipment. These include FDM PLA, SLA CWR and SLA PTR. The latter was combined with silicone moulding and wax casting. Although the SLA CWR provided the cleanest result with the highest resolution, FDM PLA can be manipulated post-printing to produce high quality results.

Acknowledgements

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A Soccer Game Simulation using Reinforcement Learning Algorithms

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Abstract

In the last decade, video games using artificial intelligent agents have become the most popular forms of tools for coaching and entertainment purposes around the world. This popularity increase comes with a demand from users for reliable and high-quality learning algorithms. One such video game that incorporates coaching intention is a soccer simulation game in which reinforcement learning algorithms are used. This research focuses investigating the efficiency of existing reinforcement learning algorithms which can be applied on soccer game simulations. This research evaluates the performance of different algorithms by increasing the number of players in the simulated soccer game. By having the striker, mid-fielder, defender, and goalie agents in the game, the results confirm that the Proximal Policy Optimisation outperformed both Self Play and Soft Actor Critic. Proximal Policy Optimisation accomplished this, in the simulation, by having a shorter training time with more effective training. The agents trained via Proximal Policy Optimisation for our soccer game simulation were the most efficient overall because of the lower training time and the higher average number of goals scored per game. Although Self Play had the most average number of wins and the least number of average own goals the training time was double the amount of PPO. While PPO did have an even number of wins to loses it was the most efficient algorithm over the other two.

Keywords

Reinforcement Learning, Simulation, Video Games, Artificial Intelligence

Introduction

The demand for artificial intelligence (AI) agents-based video games is ever rising across different disciplines including sport coaching (Li et al., 2004). To create reliable and high-quality AI agent games we need learning algorithms to be used in an efficient way. These algorithms enable an agent to learn in a reward and punishment environment with the aim of maximising the correct actions to cumulate reward and increase performance. These algorithms are known as reinforcement learning (RL), and they can be applied on a wide variety of contexts.

AI agent based video games are among the most popular forms of education and entertainment around the world (Reuters, 2018). However, with this popularity comes a desire for efficient, reliable, and high-quality artificial intelligence agents that can learn. Currently, these agents are being built from the ground up and are being programmed to perform explicit tasks rather than being trained through a learning mechanism. This results in companies hiring professionals to create these AI agents, costing companies time and money with low quality and unscalable outcomes. One of the applications of these algorithms is a simulated soccer game in which coaches can analyse different strategies such as 4-3-3 formation or combination of different roles, for instance, striker, mid-fielder, and defender. However, the quality and reliability of learning AI agents can vary greatly based on the chosen algorithms and context.

Through the continual research and analysis of current RL algorithms used in video games, this research will prototype a soccer game simulation to investigate which existing algorithms are more efficient to simulate a realistic game. This research will adhere to an objectivist standpoint in conjunction with a theoretical vision when collecting data, analysing data, and creating prototypes.

While some soccer game simulations have been created using RL algorithms, they are all built on a small scale. This lacks realism upon the real-life scale of a soccer match including the size of the teams. To combat this problem, this project plans to prototype a soccer game simulation capable of examining various existing RL algorithms built up of all required players such as a goalie, striker, mid-fielder, and defender. The prototype will then be evaluated for performance and efficiency through key factors with rewards and punishments for each agent.

Literature Review

A literature review was constructed to investigate and analyses the current analytical research surrounding reinforcement learning algorithms used in a simulated soccer game to identify research gaps. This literature review investigates which RL algorithms can be applied to multiple agents to generate realistic soccer game simulations and how they can be evaluated. It also aims to investigate how the suitable RL algorithms can be modified to become more efficient for a soccer simulation game between two teams of four key players.

RL is a subset of machine learning where agents learn the optimal route to complete a certain goal through trial and error interactions in a dynamic environment (Shao et al., 2019; Torrado, Bontrager, Togelius, Liu, & Perez-Liebana, 2018). The agent receives positive rewards, based on these actions, which reinforce desirable behaviour whilst negative rewards are issued to discourage unwanted behaviour. The agent will then continue to generate a better policy whilst interacting with the environment to improve its decision-making ability step by step until the policy converges.

Reinforcement learning is being used in many prominent sequential decision making problems such as playing real-time strategy games like Dota (OpenAI, 2018) and StarCraft

(Vinyals et al., 2019), to first person shooters like Doom (Kempka, Wydmuch, Runc, Toczek, & Jaśkowski, 2016), to playing board games (Silver et al., 2018; Xenou, Chalkiadakis, & Afantenos, 2018) and card games (Brown & Sandholm, 2017, 2019). Shao et al. (2019) views these games as excellent progress in RL in games.

Reinforcement learning is commonly derived into two methods, off-policy and on-policy (Shao et al., 2019). Shao et al. (2019) states that off-policy RL algorithms is when the behaviour policy that is used for choosing actions or goals is distinctive to the learning policy utilised. While on-policy RL algorithms utilise the same behaviour policy and learning policy (Shao et al., 2019). Shao et al. (2019) also define two more different methods RL can be derived into, they are value-based and policy-based methods. Value-based methods are algorithms where agents continually update the value function to learn a suitable policy, while policy-based is when RL agents learn the policy directly. In the current state of RL in games, many researchers have been looking towards policy-based algorithms for their research (Vinyals et al., 2019; OpenAI, 2018). Two of these widely used policy-based algorithms are Proximal Policy Optimization (PPO) and Soft Actor Critic (SAC).

Proximal Policy Optimization is an on-policy policy gradient method (Zhang et al., 2019). The algorithm uses a standard advantage-based variance reduction strategy called Generalized Advantage Estimation to stabilize and accelerate training (Berner et al., 2019). The algorithm utilises a balance of sample complexity and ease of tuning, to compute an update at each step that minimizes the cost function while ensuring the deviation from the previous policy is relatively miniscule (Schulman et al., 2017).

Soft Actor Critic utilises an off-policy method while being policy gradient based (Zhang et al., 2019). It is derived from an off-policy maximum entropy actor-critic algorithm (Haarnoja et al., 2018). The algorithm provides for both sample efficient learning and stability. Haarnoja et al. (2018) states the algorithm also avoids the complexity and potential instability associated with approximate inference in other off-policy algorithms.

Zhang et al. (2019) found that applications involving more than one single agent were the most successful, which are known as Multi-Agent Reinforcement Learning (MARL) problems. MARL consists of multiple autonomous agents that learn in a dynamic environment, which aims to return the optimal outcome by interacting with the environment and fellow agents. Zhang et al. (2019) breakdown MARL into three groups, fully cooperative, fully competitive or a mix of both, depending on the settings they address. The cooperative setting consists of agents that collaborate to return an optimal outcome while in the fully competitive setting the agents usually return a sum up to zero (Zhang et al., 2019). While the mixed setting uses both cooperative and competitive agents with general-sum returns (Zhang et al., 2019).

Throughout their project Baker et al. (2020) use transfer and fine-tuning to quantitatively evaluate targeted capabilities through the use of multi agent learning called Self Play. Baker et al. (2020) uses the mixed setting outlined in the previous section along with a physics-based environment in which agents compete in a game of hide-and-seek. They use a visibility-based reward function and competition to teach agents many emergent skills and strategies. These include collaborative tool use, where agents use their environment to their needs. An example of this is when the hiders learned to create a safe area for themselves by blocking off doorways or constructing block structures (Baker et al., 2020). This project is just one that comes from the team at Open AI.

Another successful project from the Open AI team is OpenAI Five, the first AI to defeat a world championship team at an e-sports game. Berner et al. (2019) states that Open AI Five became the first to do this by defeating the Dota 2 world champions (Team OG). This was developed using PPO where each time one of the agents completes an action towards winning the game it receives a reward and receives a penalty if an agent is removed from play.

This literature review identifies that there is a limited research about evaluating which reinforcement learning algorithms are the most suitable and applicable towards game simulations for coaching and educational purposes. A gap was also found about which key factors should be used to evaluate simulations that are based on multiple agents. Many existing algorithms use the number of agents, the number of iterations and time to complete a certain goal as factors for evaluation. Although these factors for evaluation can be used, they do not affect and highlight the efficiency the algorithms have on the agents in a game simulation scenario.

Design of a Soccer Game Simulation

Reinforcement learning (RL) is an area of machine learning focused on how software-based agents must behave in an environment to maximise the notion of cumulative reward. The agents are trained using a virtual development environment, which is what surrounds the agents and what the agent takes rewards from, in our case our simulated soccer environment. The agents take actions, based on their policy outlined by their algorithm, in the environment which can be rewarded or punished. Each RL algorithm works differently and one major constraint in using RL algorithms lies with determining which algorithms are more efficient for their specific application such as a soccer games simulation. This issue is further amplified when you need to use different brains simultaneously within the environment. This is the case in the soccer game simulation where we have various brains for different player positions such as striker, mid-fielder, defender and goalie. In order to find an efficient algorithm we use the training time, the number of goals, number of own goals scored and number of win and losses per round as the evaluation factors. The algorithms being evaluated using these factors are: Proximal Policy Optimization (PPO), Soft Actor Critic (SAC) and Self Play. These algorithms were selected because of their popularity and accessibility in the industry and research literature as well as being compatible with the Unity Machine Learning Agents Toolkit (ML Agents) (Juliani et al., 2018) and the selected game engine for the simulation, Unity.

Proximal Policy Optimization (PPO)

The PPO algorithm was introduced by the OpenAI team in 2017 and quickly became one of the most popular RL methods in the games industry because of its ease of use, good performance and data complexity (Schulman et al., 2017). PPO involves collecting datasets of experiences, or trajectories as stated in Figure 1, interacting with the

environment and utilising that data to update its decision-making policy iteratively. Examples of experiences include agents kicking the soccer ball away from opposing players or the goalie moving in front of the soccer ball to save it

Algorithm 1 PPO with Clipped Objective

Input: initial policy parameters θ_0, clipping threshold ϵ
for $k = 0, 1, 2, \ldots$ **do**
  Collect set of partial trajectories $\mathcal{D}_k$ on policy $\pi_k = \pi(\theta_k)$
  Estimate advantages $\hat{A}_t^{\pi_k}$ using any advantage estimation algorithm
  Compute policy update

$$\theta_{k+1} = \arg\max_{\theta} \mathcal{L}_{\theta_k}^{CLIP}(\theta)$$

  by taking K steps of minibatch SGD (via Adam), where

$$\mathcal{L}_{\theta_k}^{CLIP}(\theta) = \mathop{\mathrm{E}}_{\tau \sim \pi_k}\left[\sum_{t=0}^{T}\left[\min(r_t(\theta)\hat{A}_t^{\pi_k}, \mathrm{clip}\left(r_t(\theta), 1-\epsilon, 1+\epsilon\right)\hat{A}_t^{\pi_k})\right]\right]$$

end for

Figure 1. PPO with Clipped Objective (Achiam, 2017)

from going into their goal. The policy is then updated with this current dataset, the experiences are removed, and a new data set is collected with the newly updated policy. The variant of PPO in which ML Agents utilises is called PPO with Clipped Objective (Schulman et al., 2017), shown below in Figure 1.

This variant has the addition of a Trust Region update, which is a process that iteratively searches for an optimal point within an area determined by the maximum step size allocated to the algorithm (Schulman et al., 2017). In our soccer game simulation this would include a region around the opposing goal of each team as all agents receive a reward when a goal is scored.

Soft Actor Critic (SAC)

The second algorithm utilised in this research is SAC, as shown below in Figure 2. SAC, an off-policy algorithm, incorporates three key elements; an off-policy formulation that enables reuse of past experiences for efficiency, an actor-critic structure with separate policy and value function networks and entropy maximization to enable stability and exploration. Entropy maximization is when the agent aims to maximise the expected reward while acting as randomly as possible such as the random movement and kicking patterns from players training in the soccer simulated environment (Haarnoja et al., 2018).

Algorithm 2 Soft Actor-Critic

Input: θ_1, θ_2, ϕ ▷ Initial parameters
$\bar{\theta}_1 \leftarrow \theta_1, \bar{\theta}_2 \leftarrow \theta_2$ ▷ Initialize target network weights
$\mathcal{D} \leftarrow \emptyset$ ▷ Initialize an empty replay pool
for each iteration **do**
  for each environment step **do**
    $\mathbf{a}_t \sim \pi_\phi(\mathbf{a}_t|\mathbf{s}_t)$ ▷ Sample action from the policy
    $\mathbf{s}_{t+1} \sim p(\mathbf{s}_{t+1}|\mathbf{s}_t, \mathbf{a}_t)$ ▷ Sample transition from the environment
    $\mathcal{D} \leftarrow \mathcal{D} \cup \{(\mathbf{s}_t, \mathbf{a}_t, r(\mathbf{s}_t, \mathbf{a}_t), \mathbf{s}_{t+1})\}$ ▷ Store the transition in the replay pool
  end for
  for each gradient step **do**
    $\theta_i \leftarrow \theta_i - \lambda_Q \hat{\nabla}_{\theta_i} J_Q(\theta_i)$ for $i \in \{1, 2\}$ ▷ Update the Q-function parameters
    $\phi \leftarrow \phi - \lambda_\pi \hat{\nabla}_\phi J_\pi(\phi)$ ▷ Update policy weights
    $\alpha \leftarrow \alpha - \lambda \hat{\nabla}_\alpha J(\alpha)$ ▷ Adjust temperature
    $\bar{\theta}_i \leftarrow \tau\theta_i + (1-\tau)\bar{\theta}_i$ for $i \in \{1, 2\}$ ▷ Update target network weights
  end for
end for
Output: θ_1, θ_2, ϕ ▷ Optimized parameters

Figure 2. Soft Actor Critic (Achiam, 2017)

The advantage that SAC has over other algorithms lies with its dataset efficiency and lack of sensitive hyperparameters (Haarnoja et al., 2018). This is perfect for our research as it minimises the changing of the hyperparameters needed to train the agents while at the same time receiving high quality sample data efficiently for testing and comparisons.

Self Play

The Self Play algorithm, as shown below in Figure 3, is the new algorithm which learns by playing against itself without needing any direct supervision. The algorithm works by developing and learning a policy built up from prior iterations or replay memories from scratch through repeatedly playing the current policies against each other and performing policy

Algorithm 3 Neural Fictitious Self-Play (NFSP) with fitted Q-learning

Initialize game Γ and execute an agent via RUNAGENT for each player in the game
function RUNAGENT(Γ)
  Initialize replay memories $\mathcal{M}_{RL}$ (circular buffer) and $\mathcal{M}_{SL}$ (reservoir)
  Initialize average-policy network $\Pi(s, a \mid \theta^\Pi)$ with random parameters θ^Π
  Initialize action-value network $Q(s, a \mid \theta^Q)$ with random parameters θ^Q
  Initialize target network parameters $\theta^{Q'} \leftarrow \theta^Q$
  Initialize anticipatory parameter η
  for each episode **do**
    Set policy $\sigma \leftarrow \begin{cases} \epsilon\text{-greedy}\,(Q), & \text{with probability } \eta \\ \Pi, & \text{with probability } 1-\eta \end{cases}$
    Observe initial information state s_1 and reward r_1
    for $t = 1, T$ **do**
      Sample action a_t from policy σ
      Execute action a_t in game and observe reward r_{t+1} and next information state s_{t+1}
      Store transition $(s_t, a_t, r_{t+1}, s_{t+1})$ in reinforcement learning memory $\mathcal{M}_{RL}$
      if agent follows best response policy $\sigma = \epsilon$-greedy (Q) **then**
        Store behaviour tuple (s_t, a_t) in supervised learning memory $\mathcal{M}_{SL}$
      end if
      Update θ^Π with stochastic gradient descent on loss
        $\mathcal{L}(\theta^\Pi) = \mathbb{E}_{(s,a)\sim\mathcal{M}_{SL}}\left[-\log \Pi(s, a \mid \theta^\Pi)\right]$
      Update θ^Q with stochastic gradient descent on loss
        $\mathcal{L}\left(\theta^Q\right) = \mathbb{E}_{(s,a,r,s')\sim\mathcal{M}_{RL}}\left[\left(r + \max_{a'} Q(s', a' \mid \theta^{Q'}) - Q(s, a \mid \theta^Q)\right)^2\right]$
      Periodically update target network parameters $\theta^{Q'} \leftarrow \theta^Q$
    end for
  end for
end function

Figure 3. Neural Fictitious Self Play (Heinrich & Silver, 2016)

updates using these self-played game trajectories. In our soccer game simulation this is where the agents repeatedly train against a team of equal skill level and training to increase their mindset on different insights and strategies. These insights and strategies are then collected and used for the next hybrid policy which is then iteratively given to the agents until the max steps is reached. (Bai, 2020)

Experiment, Results and Evaluation

The simulation was constructed using the game engine Unity, an open-source toolkit called ML Agents and a python environment manager called Anaconda (Anaconda Software Distribution, 2020). The simulation was designed to support four key players each with their own brain and position. The teams have the four main positions: striker, mid-fielder, defender and striker. These trained agents are the fundamentals of the project. The team with the most goals at the end of a three minute match would be declared the winner over multiple games.

Rewards were issued to agents when they accomplished a desired behaviour while penalties were issued to agents if an unwanted behaviour was made. Besides the rewards of scoring goals against opponents and punishments for scoring own goals, agents received a reward when they were in possession of the ball. While goalies received a reward if they stayed in their goalie box to simulate being able to use their hands.
Combined with rewards and punishments, adjustments were

made to the raycasts used by each agent. Raycasts are lines that are projected from a point of origin in a certain direction against all colliders in the environment. The number of raycasts used to detect the ball, players, goals and walls of each agent was increased from 14 to 22 to give a more realistic representation of a human's sight. The length of the raycasts was also increased from 20 to 60 so the agents could see the ball regardless of the local position on the field.

The implementation of the aforementioned reinforcement learning algorithms and a rewards and punishments mechanism for a soccer game simulation with four key players is the main focus of this section.

The Unity Machine Learning Agents Toolkit (ML Agents) is used to implement the RL algorithms to simulate the soccer game. The created scenes contain two goals, boundary walls, a soccer ball and two agents per team. Four more agents were added to create a 2-1-1 formation for each team. The soccer field was then scaled to adhere to the new player additions.

The values of Max Ray Degrees and Ray Length were increased from 60 to 90 and 20 to 60 respectively to give a more realistic representation of a human's sight as previously mentioned.

The agent soccer script includes the striker, mid fielder, defender and goalie player positions along with a last player possession variable for own goal calculations in the soccer field area script. The soccer field area script includes statistical variables to track goals and own goals scored by each player so that they could be graphed via a plugin within Anaconda called Tensorflow (Abadi et al., 2015). The rewards and penalties for each agent were also programmed in this script.

The soccer pitch was split into six sections with box colliders. It comprised of two goalies, two defenders and two mid fielder sections.This was implemented to give a reward to agents who were in possession of the ball.

Two invisible walls were added to the front of the goals so that the agents couldn't get stuck in the goals while allowing the soccer ball and the players raycasts to pass through it. This was accomplished using Unity's Layer Collision Matrix.

A new training config file was created to house all the hyperparameters needed for training each agent with PPO, SAC and Self Play. These hyperparameters are specified in Table 1, which provides the initialisation settings that were used within the soccer simulation. Specifically, the batch size and buffer size represent the number of experiences that occur during each gradient descent iteration and the number of experiences to collect before updating the policy model, respectively. While the learning rate is the initial rate for gradient descent, corresponding to the strength of each gradient descent update step.

Parameters	Values	Parameters	Values
batch size	320	beta	1.0e-2
buffer size	2000	hidden units	256
max steps	5.0e6	learning rate	1e-3
normalise	false	num. epoch	3
num. layers	2	time horizon	128

Table 1. Training Parameters

The max steps are the total number of steps (observations collected and actions taken) that must be taken in the simulated environment before ending the training process. Hidden units is the number of units in the hidden layers of the neural network which correspond to the number of units in each fully connected layer to the neural network. Number of layers is the number of layers in the neural network which corresponds to how many hidden layers are present after the observation input. Normalise is whether normalisation is applied to the vector observation inputs. This normalisation is based on the running average and variance of the vector observation. Finally, time horizon is how many steps of experience to collect per agent before adding it to the experience buffer.

To initiate the training process for the agents, a virtual python environment was needed. This was accomplished using the program Anaconda. Training was conducted using PPO, SAC and Self Play until the max steps was reached, as mentioned above and shown in Table 1.

Results

The soccer game simulation was analysed on three main key factors. The time it took to train the agents in real time, the average amount of goals and own goals scored per game and the win / lose ratio. Testing was completed via three different team matchups (PPO vs SAC, PPO vs Self Play and Self Play vs SAC) over a series of ten three minute games per matchup.

Statistics	PPO	SAC	Self Play
Training Time	25 Hours	27 Hours	53 Hours
Average no. of goals scored per game	14.4	3.25	9.8
Average no. of self score	1.05	1.35	0
Average no. of wins	50%	20%	80%
Average no. of loses	3.35	2.80	2.30
Win / Lose Ratio	1.27	2.32	3.15

Table 2. Statistical Analysis of Soccer Game Simulation

As shown in Table 2, the training time difference between PPO and Self Play was 28 hours, while SAC had a difference of 2 hours between itself and PPO. In the world of AI that margin could mean the difference between weeks or months of training. While the average number of goals was similar

for the three algorithms PPO scored the most with an average of 14.4 goals. While the algorithm that had the least number of goals was SAC with 3.25 goals. This shows that PPO is a lot more active near the opponent's goal than the other algorithms. SAC had the highest amount of own goals which means that the goalie and the defender on the team were defending a lot more than other algorithms. Self Play had the highest number of average wins with 80% but did not have the highest average number of goals scored per game.

The results show that PPO is the most efficient algorithm for our soccer game simulation overall because of the lower training time and the higher average number of goals scored per game. Although Self Play had the most average number of wins and the least number of average own goals the training time was double the amount of PPO. While PPO did have an even number of wins to loses it was the most efficient algorithm over the other two.

Conclusion

In this chapter, we will be addressing our research contributions, findings from the research, the answers to our research questions and the potential research problems exposed by our research. Ending with future work that can be done on this topic.

Through this research it has been established that constructing a soccer game simulation requires many considerations to achieve a realistic result. Through the investigation, development and implementation of the three algorithms, we have successfully created a realistic soccer game simulation capable of examining various existing RL algorithms built up of all required players such as goalies, striker, mid-fielder, and defender that can be used for education and coaching purposes.

Research shows that the three algorithms, PPO, SAC and Self Play are readily available and are all open source for researchers to use in their studies. The three algorithms were found to be applicable to generate a realistic soccer game simulation though the use of the ML Agents toolkit along with Unity in the design process of the artefact. All three algorithms are fully integrated into the software making it very user friendly for researchers to use for education and coaching purposes.

What rewards and punishments can be implemented to form a more efficient soccer simulation game between two teams of four key players?

Rewards were issued to agents when they accomplished a desired behaviour while punishments were issued to agents if an unwanted behaviour was made. Besides the rewards of scoring goals against opponents and penalties for scoring own goals, agents received a reward when they were in possession of the ball. While goalies received a reward if they stayed in their goalie box to simulate being able to use their hands.

What are the key evaluation factors to evaluate the efficiency of the algorithms?

The key evaluation factors used to evaluate the efficiency of the algorithms included the number of goals and own goals scored, time taken to train the algorithm and the number of win and losses per round.

Future Work

To complete this research in a timely manner, certain aspects of design were not considered in this research, these areas leave room for future research. They include: (i) a full-scale soccer simulation using eleven key players per team and (ii) using dynamic strategic substitution of players regarding how a team is performing in the simulation.

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Wheelchair Design and Social Experiences of Wheelchair Users: A Thematic Review

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Abstract
It was the purpose of this thematic review to review the academic literature from the last 10 years surrounding the design and functionality of wheelchairs and the social experience of wheelchair users across both manual and electric wheelchairs. Within this review, the findings of 45 journal articles categorised into two categories are reported and discussed across six subcategories: wheelchairs and social experiences; wheelchairs and social participation; wheelchairs and accessibility; wheelchairs and social perception; wheelchair design; and wheelchair accessories. Three recommendations for future research directions are provided. The first recommendation is implementing recommended improvements to the social experiences of wheelchair users present within the selected articles. The second recommendation is documenting the social impacts of new design of wheelchairs and accessories on wheelchair users. The third and final recommendation is wheelchair customisation should be investigated further to determine how customisation could be used to improve the social experience of wheelchair users.

Keywords
Wheelchair, design, social experiences, wheelchair design, thematic review, literature review

Introduction
The earliest well documented example of a wheelchair was one created for King Philip of Spain (1527-98) in 1595 (19). Another early example was invented by paraplegic clockmaker Stephan Farfler (1633-1689) in 1655 (19). Wheelchairs were first advertised for patient transport in the 18th century (18), with the Bath Chair invented by John Dawson being a popular design (19). The modern wheelchair was developed in the early 20th century with manufacturing escalating in the 1930s (19). The electric wheelchair was invented in the early 1950s, by Canadian engineer George Klien, to help war veterans unsatisfied with manual chairs (45). Throughout the remainder of the 20th century the seating, functionality and comfort of both manual and electric wheelchairs improved (18). In the 2016 Australian census, it was estimated around 190,000 people use a wheelchair in Australia (1). Globally, a report by the World Health Organisation in 2017 estimated around 10 percent of people who need wheelchairs have access to one (51). Within the last ten years there have been over 85,000 academic journal articles and books published on various topics surrounding wheelchairs and wheelchair users (50).

Among the journal articles selected, there were four literature reviews. These articles were published from 2016 to 2018. These reviews cover a range of different topics related to wheelchairs. The first review discussed the literature surrounding five different types of manual wheelchairs and the effect each had on the physical health of users (17). The second review discussed the literature surrounding the factors that influence the participation of wheelchair users in community and social activities (41). The third review discussed the literature surrounding the quality of life and psychosocial wellbeing of youth with neuromuscular disorders who use wheelchairs (46). The fourth discussed the literature surrounding the role of the physical environment of a neighbourhood on social participation of mobility assistive technology users (8). The scope of research covered by the four literature reviews leaves scope to cover other topics related to wheelchair users and their wheelchairs, such as the overall social experience of wheelchair users, articles surrounding both manual and electric wheelchairs, and articles surrounding wheelchair design and functionality. It is therefore the purpose of this current paper to review the academic literature from the last 10 years surrounding the design and functionality of wheelchairs and the social experience of wheelchair users across both manual and electric wheelchairs. Following this introduction, the methods used to search for journal articles and books are detailed. This is followed by two sections discussing the selected journal articles and books categorised into one of two categories: the social experience of wheelchair users; and wheelchair design and testing. This paper will conclude by discussing the limitations of this literature review and by recommending future research directions.

Search Phrase	Overall Category	Total Search Results	Initial Selection	Abstract Selection	Introduction and Conclusion Selection Total	Google Scholar	Griffith Library	State Library QLD
						Results **Date of Search**		
Wheelchair AND Social	Social Experiences of Wheelchair Users	82,621	21	19	10	3 **17/03**	4 **1/04**	3 **24/03**
wheelchair AND "social experience"		3,332	18	14	5	3 **17/03**	2 **6/04**	0 **9/04**
wheelchair AND “social participation”		11,054	45	19	8	3 **9/04**	4 **9/04**	1 **9/04**
wheelchair AND "Social interactions"		18,760	15	8	5	3 **20/04**	2 **20/04**	N/A
wheelchair AND “social stigma"		4,943	17	13	4	4 **21/04**	0 **21/04**	N/A
wheelchair AND "design process"	Wheelchair Design and Testing	44,633	16	6	5	3 **22/04**	2 **22/04**	N/A
wheelchair AND customisation		2,714	12	8	3	2 **27/04**	1 **27/04**	N/A
wheelchair AND accessory		5,072	6	4	4	2 **18/08**	2 **18/08**	N/A
Totals		**173,129**	**149**	**99**	**44**	**23**	**17**	**4**

Table 1. Search Result Statistics

Method

In preparing this literature review, a list of search phrases was created (full list in table 1). These phrases were then searched for across three different databases: Google Scholar, Griffith University Library and the State Library of Queensland. The search was limited to journal articles and books from 2010-2020. This search took six months (starting in March and concluding in August 2020) to complete as one additional search phrase (wheelchair AND accessory) was added three months after the other search phrases. In total, there were 173,129 results covering both journal articles and books. It became quickly evident the State Library of Queensland wasn't providing enough relevant results therefore it was decided to stop searching that database. From the results, 149 journal articles were selected based on title. This list was further refined by abstract, narrowing down the list to 99 articles. The list of articles was then refined by the introduction and conclusion for a total of 44. In addition, two articles found prior to the search are also included, bringing the total to 46 articles. After the selection process was complete, each article was double checked to ensure each were peer-reviewed and as such only one articles was found to not meet this criterion and was removed, bringing the final list to 45.

The selected articles came from the following journals. 15 articles came from *Disability and Rehabilitation*. Three articles each came from *Disability and Society* and *Archives of Physical Medicine and Rehabilitation*. Two articles each came from *Applied Ergonomics*, *Assistive Technology*, *Procedia Engineering*, and *Rehabilitation Counselling Bulletin*. The remaining 16 articles came from various other journals. The articles can be categorised into one of two broad categories: social experiences of wheelchair users and wheelchair design and testing. In addition, six other sources are included throughout this paper to add additional context. The following section discusses the social experiences of wheelchair users.

Social Experiences of Wheelchair Users

This section discusses the selected journal articles that were related to the social experiences of wheelchair users. There are a total of 33 journal articles under this category. The search phrases used to find the journal articles related to the social experiences were Wheelchair AND Social; wheelchair AND "social experience"; wheelchair AND “social participation”; wheelchair AND "Social

interactions"; and wheelchair AND “social stigma". The social experiences of wheelchair users is important to discuss as according to the authors of The Social Psychology of Stigma there are social consequences associated with wheelchair use (20) which has an impact on the overall social experience of wheelchair users. The research presented on social experiences falls into four subcategories: wheelchairs and social experiences; wheelchairs and social participation; wheelchairs and accessibility; and wheelchairs and social perception.

Wheelchairs and Social Experiences

There were eight articles selected for this subcategory. These articles were published between 2012 and 2019. The methods used by the majority of the articles were qualitative in nature, primarily consisting of various forms of interviews and questionnaires. The one outlier was a literature review by Travlos, Patman, Wilson, Simcock and Downs which collected peer-reviewed studies with wheelchair users between 12 and 22 years old to assess their quality of life (46). That article found the quality of life was similar between wheelchair users and other people of similar ages (46). The next article by García, González, Rivero, Loureiro, Villoria, and Sierra had a similar focus on the quality of life of wheelchair users, however this article adopts a different approach by directly assessing and surveying the wheelchair users (37). This article concluded ensuring a good match between the user and their chair will increase the likelihood of using their chair (37). The next three articles share a common theme of identity. An article by Rossen, Sørensen, Jochumsen and Wind focused on the everyday life of electric wheelchair users (9). Through the interviews, the authors concluded using a wheelchair influences identity and levels of occupation (9). The next article by Stenburg, Henje, Levi, and Lindström had a similar focus on the daily life of electric wheelchair users, however it concluded the influence of wheelchair use on identity begins during early electric wheelchair use (42). The next article by Ule that focused on students with disabilities disagrees and suggests the identity of the students is formed independently from their disabilities (47). The next article by Papasotiriou and Windle also focused on students with disabilities but at university (34). The article concluded students have weak social attachments at university, but strong attachments outside (34). The next article by MacArthur focused on exploring the results of four projects based on school students (26). The article concluded social participation can be enhanced when exclusion is challenged (26). The final article by Mattie, Aitken-Mundhenk, Bicknell, Mortenson, and Borisoff explored the lived experience of users of manual wheelchairs with on-the-fly adjustable seating (31). The article concluded adjustable seating can have a significant impact on the users, which may help therapists to better understand the benefits of these systems (31). This subcategory focused on how wheelchairs effect social experiences.

Wheelchairs and Social Participation

There were nine articles selected for this subcategory. These articles were published between 2010 and 2019. The methods used by the articles - besides a literature review - were qualitative in nature like the articles on social experiences, however these articles used focus groups and evaluations in addition to the various forms of interviews and questionnaires. The first article by Hjelle and Vik discussed how wheelchair users in Norway experience social participation, concluding the experience consists of constant change both positive and negative over time (21). Next, a literature review by Smith, Sakakibara, and Miller searched four databases to find peer-reviewed papers (41). Unlike the previous article, this article focused on the factors that influence the social participation of wheelchair users (41). The review concluded accessibility, education, finances, pain and skills with wheelchair use are all factors that influence social participation (41). The next article by Sakakibara, Routhier and Miller adds to the factors by discussing the life-space mobility and social participation of wheelchair users aged 50 years or older, concluding occupancy time and distance travelled were significant predictors of life-space mobility and social participation (40). The next article by Inês, João, João, Patrícia, Jeffrey, and Correia reached a similar conclusion, as longer usage of electric wheelchairs leads to lower satisfaction and participation, however this use leads to a higher quality of life (22). The next article by Edwards and McCluskey reached a different conclusion as their study concluded powered mobility devices have some negatives for some users, but the majority surveyed found positives (14). The next article by Fiorilli, Iuliano, Aquino, Battaglia, Giombini, Calcagno, and Cagno discussed the mental health and social participation skills of wheelchair basketball players, concluding players had better psychological well-being and social skills then wheelchair users who didn't play (16). The next article by Magasi, Wong, Miskovic, Tulsky, and Heinemann adds to the previous article by concluding that the quality of mobility devices plays an important role in the social participation of users (28). The next article by Rushton, Kairy, Archambault, Pituch, Torkia, Fathi and Stone discuss the potential benefits of an intelligent power wheelchair on social participation, concluding this type of wheelchair would enhance the social participation of users and should be further developed (39). The final article by Kuter, Eysenbach, Banf, Cheng, Dirks, Routhier, and Mortenson present a method of conducting qualitative interviews with mobility assistive technology users, concluding using a variety of methods to gather data will allow a better understanding of the mobility factors of mobility assistive technology (24). This subcategory focused on how wheelchairs effect social participation.

Wheelchairs and Accessibility

There were seven articles selected for this subcategory. These articles were published between 2014 and 2018. The methods used by the articles were mostly qualitative in nature, with the majority

using surveys and interviews. The first article by Poldma, Labbé, Bertin, Grosbois, Barile, Mazurik, Desjardins, Herbane, and Artis used a different method involving documenting and examining a commercial public space then walking through the space with participants to better understand the needs of people with disabilities in such spaces (36). That article concluded low accessibility, issues with way-finding, and poor contrast are barriers to people with disabilities but social experiences are valuable (36). The next article by Akyuz, Yalcin, Selcuk, and Degirmenci discussed the barriers to social integration faced by wheelchair users in Turkey, concluding architectural barriers resulting in low accessibility are the most important factors limiting social inclusion (4). The next article by Raquel, Catherine, Andrew and Brian discussed the effect of transport accessibility on the social inclusion of wheelchair users (38). That article reached a similar conclusion to the previous articles, however it concluded that proposed solutions to accessibility problems can often generate their own problems (38). The next article by Williams, Hurwitz, Obaga, Onguti, Rivera, Sy, and Kirby documented the perspectives of basic wheelchair users on how their access to wheelchair services could be improved, concluding wheelchair services need to be provided with efficiency in an environment with easy physical access (53). Next, a literature review by Bigonnesse, Mahmood, Chaudhury, Mortenson, Miller, and Ginis investigated the role of the physical environment on mobility and social participation of wheelchair users, concluding environmental features, transit mobility and building accessibility influence social participation and mobility (8). The next article by Borisoff, Ripat, and Chan that discussed seasonal patterns of social participation concluded another influence on social participation and mobility is the seasons as the accessibility of the physical environment changes over time (10). The final article by Amin, Mir-Abolfazl, Hossein, Edwards, and Fougeyrollas investigated the accessibility of segments of a pedestrian network to determine how different policies effect accessibility, concluding further work is needed to refine this approach (5). This subcategory focused on how accessibility effects the social participation of wheelchair users.

Wheelchairs and Social Perception

There were nine articles selected for this subcategory. These articles were published between 2010 and 2019. The methods used by the articles were qualitative in nature, consisting primarily of surveys and assessments. However, the first article by Esmail, Darry, Walter and Knupp used focus groups to determine the attitudes and perceptions towards disability and sexuality, concluding there would be benefits for peoples with disabilities if the general public was more educated about sexuality and disability (15). The next article by Vilchinsky, Werner, and Findler discuss the differences between genders in attitudes towards people using wheelchairs, concluding there is a difference in attitudes between genders (49). The next article by Tafoya and Mongeau examined the initial interaction decisions by able-bodied individuals surrounding a partner in a wheelchair, and like the previous article there was a difference in the decisions between genders, with men having a more negative view then women (44). The next article by Marini, Wang, Etzbach and Castillo discusses differences in intimacy attitudes towards wheelchair users between people of different genders and ethnicities (30). This article concluded a majority of people's intimacy attitudes were positive towards people in wheelchairs, but those negative attitudes perceive people in wheelchairs needing more caregiving than other people (30). The next article by Vermillion discussed the self-esteem and body-image of college wheelchair basketball players, finding significant differences between body-image and self-esteem of players of different genders and disabilities (48). The next article by Nario-Redmond, Noel, and Fern investigated if identifying as a person with disability helps self-esteem and provides an effective response to stigma (33). Their results proved that identifying as a person with a disability indeed helps with self-esteem and provides an effective response to stigma (33). The next article by Lund and Seekins discussed the effect of early exposure to people with disabilities on later attitudes towards social interactions and inclusion, concluding positive early experiences have a possible relationship with later attitudes (25). The next article by Asghar, Torrens and Harland investigated if there were any differences in perceptions of people with disabilities between students from different cultures (6). Ultimately the article found there were no differences (6). The final article by Phillips, Fortney and Swafford discussed the social perceptions of people with intellectual disabilities by college students (35). The article found the social perception was mostly positive besides for sensibility and tenderness issues (35). This subcategory focused on the social perception of wheelchair users.

The articles discussed in this section focused on examining what the current overall social experience for wheelchair users is and providing recommendations on how this can be improved. Overall, wheelchair use does improve the social experience of people with disabilities, however social participation doesn't remain consistent over time, especially when there are accessibility issues with the physical environment. The social perception of wheelchair users is consistent across cultures, with there being differences in perception between different genders. There were conflicting views on whether wheelchair use effects the identity of users. Some of the articles indicated that social stigma can be reduced through encouraging inclusion and greater education within the general public. Most of the recommendations made by the articles on how the social experience can be improved have remained recommendations, so it would be interesting to see if these recommendations would indeed improve the experience when implemented. This section discussed the social experience of wheelchair users. The following section discusses wheelchair design and testing.

Wheelchair Design and Testing

This section discusses the selected journal articles that were related to wheelchair design and testing. There is a total of 12 journal articles under this category. The search phrases used to find the journal articles related to wheelchair design and testing were wheelchair AND "design process"; wheelchair AND customisation; and wheelchair AND accessory. The research presented on wheelchair design and testing falls into two subcategories: wheelchair design; and wheelchair accessories.

Wheelchair Design

There were six articles selected for this subcategory. These articles were published between 2010 and 2020. The methods used - besides those for a literature review - were a mix of qualitative and quantitative methods, including design development, testing, interviews, surveys and focus groups. The first article by Burton, Subic, Mazur and Leary used the Taguchi method to assess wheelchair design parameters, concluding this method was superior to previous methods used (12). The next article by Berger, Nieuwenhuizen, Ent, and Zande detailed the design and testing of a new wheelchair for wheelchair basketball players, concluding the new design increased the performance of the players and the chairs (7). The next article by Mahmud, Ismail, Taib, Ramlan, and Ling detailed the prepared product design specifications for a wheelchair, concluding the specifications need to be based on the users of the product (29). Next is a literature review by CL and RC Flemmer discussed the literature surrounding five different types of manual wheelchairs and the effect each had on the physical health of users (17). The review concluded three of the types of manual wheelchairs would increase independence and improve quality of life, however these chairs are heavier than basic manual wheelchairs (17). The next article by Stewart and Watson describes the sociotechnical history of ultralightweight wheelchairs, concluding the emergence of such designs allowed wheelchair users to be included in the design processes to a greater degree (43). The final article by Macul, Antonacio, Tajima, Silva, Cruz, and Zancul described the design and development of a motorised aircraft wheelchair that was then evaluated by a focus group (27). The article concluded the benefits of such a chair would improve the experience of flying for wheelchair users (27). These articles highlighted successful new designs and types of wheelchairs and the methods used to test them.

Wheelchair Accessories

There were six articles selected for this subcategory. These articles were published between 2012 and 2019. The methods were both qualitative and quantitative, consisting of computer modeling, simulation, design development, testing, interviews, focus groups and surveys. The first article by Medola, Orsi, Fortulan, Purquerio, and Elui described the design development of a wheelchair pushrim, concluding the new design was more ergonomic and easier to use then existing pushrims (32). The next article by Jung, Park, Kim and Jung detailed the design and evaluation of a one hand drivable wheelchair against a standard manual chair (23). The article concluded the design was an effective solution to increase mobility and performance for users with one hand (23). The next article by Darcy, Green, and Maxwell described how mobile technology customisation influences supportive call centres for people with disabilities, concluding such technologies increased communication and social participation (13). The next article by Braganca, Castellucci, Gill, Matthias, Carvalho, and Arezes provided insights into the apparel needs of wheelchair athletes to create a set of design recommendations for different body garments and gloves (11). The article concluded disabled athletes need specialised clothes to perform better, while also indicating some of the findings could apply to other manual wheelchair users (11). The last two articles by Abdullah and Mohammed describe the design development, modeling, simulation (2) and testing of a low-cost obstacle pusher for wheelchairs (3). The conclusion of the first article selected an arc shaped obstacle pusher to be further developed (2) then the second article concluded the accessory would potentially improve the quality of life of wheelchair users (3).

The articles discussed in this section focused on the design and testing of new wheelchairs and accessories, with a focus on how well each functioned. Overall, the articles found the new designs of wheelchairs and accessories functioned better than existing designs and any conceptual designs would have benefits for wheelchairs users. There was also a common theme among the articles of wanting to improve the quality of life of wheelchair users. There were also recommendations of how health professionals can use the research presented within the articles to improve the prescription of wheelchairs. The articles also discussed the history of the development of modern manual wheelchairs while highlighting the need for wheelchair users to be involved in the design process. It would be interesting to see the social impact the new designs of wheelchairs and accessories would have on wheelchair users. The search term wheelchairs and customisation only provided three relevant articles and as such those relevant articles were moved to the other subcategories. This section discussed the design and testing of wheelchairs. The following section discusses the limitations of the literature review and recommends future research directions.

Limitations and Future Research Directions

There were some limitations present within this literature review that are important to highlight. The first is the article selection being limited to the last ten years. This helped ensure the articles selected would be relevant and reflect recent research trends. The choice of doing a thematic literature review as this meant comparisons between the selected articles would only be qualitative. The selection of 45 journal articles has meant some of the subcategories are more comprehensive than others. Bias in the

selection of articles and search terms as this meant some potentially relevant articles may have been excluded from this review. Finally, the potential bias present in the articles selected may have affected the conclusions drawn in this review. Taking these limitations into account, there are three primary recommendations for future research. The first recommendation is implementing the recommended improvements to the social experiences of wheelchair users then documenting the results to see if they do improve the social experiences. The second recommendation is documenting the social impacts on wheelchair users of any new designs of wheelchairs and accessories in addition to how well the new designs work. The third and final recommendation is wheelchair customisation should be investigated further to determine how customisation could be used to improve the social experience of wheelchair users. The second recommended research direction will be investigated further in a future paper as it will likely produce interesting results and provide a solid base for subsequent research.

Conclusion

This literature review carried out a thematic review of the academic literature from the last 10 years surrounding the design and functionality of wheelchairs and the social experience of wheelchair users across both manual and electric wheelchairs. The methods of searching for journal articles and books were detailed. The selected articles were categorised into two categories - the social experience of wheelchair users and wheelchair design and testing - before the articles were discussed. This review concluded by discussing the limitations of this review and by recommending future research directions. Overall, the social experience of wheelchair users and wheelchair design and testing remain important and relevant areas of research.

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In defense of isolation: An account of solitary creative practice

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Abstract

The purpose of this paper is to propose an alternative perspective on the meaning of isolation and solitude in the context of creative endeavour. This perspective emerges from my own creative practice as a musician primarily engaged with a modular synthesizer. While much has been written on the negative implications of loneliness and isolation, discussions about its positive aspects are not as plentiful in the literature. My aim is to demonstrate ways in which isolation can be beneficial to creativity and the way in which it rearticulates authorial integrity.

Keywords
Isolation, collaboration, electronic music, modular synthesizer.

Introduction

At the time of writing we find ourselves in the midst of a worldwide coronavirus pandemic which necessitates physical isolation not just for our own sake but also for the benefit of others. Slogans such as "stay home, save lives" are a common occurrence in many countries and especially in densely populated urban and suburban areas. Previous research indicates the rise in solitary living situations precisely in these localities. Census and survey data suggest that there is a historically unprecedented prevalence of people living alone worldwide but especially in more wealthy countries. For example, in some cities of the Scandinavian countries single person households account for more than half of all households (Ortiz-Ospina, 2019). These data form the basis for what the mass media has dubbed *the loneliness epidemic.* We must take care here not to conflate loneliness with solitude as they are not the same. In fact, research suggests that solitude is not a good predictor of the feeling of loneliness (ibid). In some regards, the pandemic and the antisocial measures to contain it has put most of humanity in similar, relatable circumstances. As philosopher Catherine Malabou notes "an epochè, a suspension, a bracketing of sociality, is sometimes the only access to alterity, a way to feel close to all the isolated people on Earth" (2020).

Whether by choice or not, the tendency towards solitude is clearly evident in today's society. It is not within the scope of this article to evaluate the causes of this tendency, nor is it relevant to paint a picture of an alienated, post-industrial society from a politico-economic perspective. Instead, the focus here is on the often unspoken benefits of conducting creative work alone. In a world that privileges collaboration and social embeddedness, it seems counterintuitive if not outright antisocial to place value in solitude and isolation, despite countless anecdotal accounts of artists, inventors and other creatives stressing just this. Examples of this attitude span the breadth of the creative fields. Proclamations from such greats as Mahler, Picasso, Kafka and Einstein (to name a few) indicate the importance of solitude for their respective fields (Choi & Goh, 2016). Mahler wrote most of his nine symphonies in small huts near the Alps during his summertime retreats whilst in near-complete isolation. Picasso spent long periods of time alone in the Spanish countryside and firmly believed that no serious artistic work is possible without the artist experiencing time alone. Kafka strived for hermitic solitude claiming that even this radical isolation was insufficient for his writing, preferring the extreme and rather macabre solitude of a dead man. Einstein similarly spent much of his time on his own. Whether playing the violin, sailing or working on the unified field theory, he preferred to conduct his work alone, away from intrusions and distractions. Although the benefits of isolation for creativity have been broadly established by creative practitioners, our current situation prompts us to reflect on its merits more than ever. While the question of the impact of digitally networked participatory culture on society remains open-ended, the influence of others on creative autonomy was evident in the modern hyperconnected society even before the current pandemic forced us into isolation. Arguably, the manner in which this influence manifests itself can be found in the transformation of social media 'likes' and follower numbers into a currency that serves as a constant evaluative gaze that modern artists must contend with (Vogel et al., 2014) (D'Amato, 2019). In effect, for those creative practitioners seeking radical solitude, it must encompass the virtual domain as well as the physical world. While the virtual influences persist regardless of the pandemic, what has changed is the degree of physical isolation experienced by many artists and musicians and this will be the ongoing focus of this article.

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Creative Collaboration in Music

Historically speaking and with some exceptions, it has been difficult to produce a rich sound complex using only one acoustic instrument that a single human being can operate with precision and confidence. This is especially true of the collection of instruments that are monophonic in nature. But even with polyphonic instruments, the need for timbral variation, rhythmic accompaniment and a wide representation of pitch range has encouraged players of different and somehow compatible musical instruments to play together. A contrasting parallel can be drawn with composers who mainly engage with the classical orchestra for their sound palette; they tend to work alone or at least do not typically collaborate with other composers that write music for the orchestra, perhaps with the exception of film composers who commonly work within larger teams of arrangers and orchestrators. This is in contrast to traditional acoustic Jazz ensembles of the 1950s and 1960s where a high value was placed on individuals who contributed to the overall sound of the compositions within the genre. The notion that the band is greater than the sum of its parts is active here. For example, Miles Davis' Second Great Quintet was comprised of hand-picked musicians selected by Davis himself for specific traits that characterised these players. They went on to perform and record some of the most important music of their individual careers - a feat arguably achievable only as a group (Fordham, 2010). On the other hand, modern automated music-making tools offer the ability to overcome the requirements for social creative collaboration. For example, electronic music producers and computer musicians typically have tools at their disposal that allow for an infinitely broad sonic palette and the ability to combine sounds in multitude of ways, thereby greatly diminishing the need to involve others in their creative work. This also holds true for modular synthesizer artists whose instruments, although in a more limited way, can produce a wide variety of sonic outcomes. Perhaps Edgar Varese's dream of "instruments obedient to my thought and which with their contribution of a whole new world of unsuspected sounds, will lend themselves to the exigencies of my inner rhythm" is closer to reality now than ever before (Varese & Wen-chung, 1966, p. 1).

Creative Autonomy

A similarity in social dynamics between group and individual creativity has been observed by researchers. "In both individual creativity and group creativity, you see a wandering, improvisational process, where creative ideas and creative products emerge, over time, from sustained and deliberate practices" (Patiry, 2014). However, collaborative music-making necessarily demands creative compromises. One could ask, why would a musician compromise the very aspect of their creativity that they have spent time and energy cultivating? The answer to this question can be found in the example of Jazz ensembles given above. It is the hope that one's collaborators will, in a sense, manage the unbridled creative tendencies of one another in such a way that each will act to verify and tacitly approve of the other's tendencies. Keith Sawyer, a psychologist specialising in aspects of creativity notes that in group situations "the measure of whether it's creative or not is also collective…by the group, the members of the ensemble" (Henriksen & Mishra, 2017). While this can be a valuable characteristic of working within ensembles, it can also be limiting. A counter-argument proposed by Susan Cain highlights natural group dynamics where most people try to fit in with the rest of the group; there is a social tendency to instinctively mimic each other, where one may easily abandon their own ideas, a tendency that doesn't occur when working alone (Patiry, 2014). Indeed, creativity itself sometimes results in the creative person's alienation from her group as described by Zhang et al. (2016) and Mohan & Tiwana (1987). Their research showed that creative writers as a group tended to be more introverted and generally more susceptible to neuroticism and social alienation when compared to the general population. These authors spoke of the sense of alienation with the implication that this was a negative in these writers lives. However, what if instead, their relative social isolation actually played a contributory role in their creative capabilities? A perspective from Immanuel Kant addresses this core conflict at play with the phrase "unsocial sociability" which he uses to describe the tendency of humans to come together in a society coupled with the opposite tendency to break up this society. He regards this dialectic propensity as being rooted in human nature. According to Kant, the inclination to live in society allows a person to better develop his natural human potential, through competition and evaluation of himself against others, but simultaneously, the same person also feels the need to live his life as an individual, to isolate from the society in order to organise life according to his own judgements and ideals. He concludes that "through the desire for honour, power or property, it drives him to seek status among his fellows, whom he cannot bear yet cannot bear to leave" (2010, p. 115).

Broadly speaking, research seems to support the notion that autonomy and creativity are at least corelated (Deci et al., 1994), (Sheldon, 1995), as well as the notion that any threat to self-determination greatly diminishes the creative impulse (Hennessey, 2001). Among other factors, Hennessey (2001) identifies the "expectation of evaluation" as the biggest threat to personal motivation and creativity. The study highlights the debilitating consequences on creativity brought on by competitive evaluation, the notion that is further corroborated by the analyses of personal accounts of such notable persons as Sylvia Plath who specifically emphasised the corruptive impact of competition within her own creative field. In collaborative music-making, one's collaborators continuously judge the creative quality of each other's output by acting simultaneously as co-creators and audience, thereby influencing one another's willingness to take creative risks and can thus encourage or discourage the continuous participation in the creative task (Bishop, 2018). A similar sentiment can be felt in my area of technologically mediated music-making with a modular synthesizer.

The Modular Synthesizer

A modular synthesizer is a musical instrument that comprises a variety of distinct electronic units (modules) of specific functions that do not share a fixed architecture. They are instead freely interconnected with patch cords according to the creative-technical needs of the performer-operator. This process and its outcome are commonly referred to as a patch. A smaller subset of interconnected modules

determining some behaviour of one of the sonic elements can be referred to as a sub-patch.

Unlike traditional acoustic or electronic musical instruments, a modular synthesizer's behaviour and the corresponding sonic outcome is to a large extent determined by the choices that the musician makes. Patching a modular synthesizer involves abstract decision-making that relies heavily on the experience and musical intuition of the performer. As a whole, the patching process consists of making a cyclic series of decisions. The real-time feedback from the instrument is constantly evaluated, decisions are made on where to go next, new sub-patches are created and the feedback is again evaluated. The process described above is reminiscent of Dudas' notion of "comprovisation" (2010). A portmanteau of composition and improvisation, it describes various studio activities as inclusive in the category of composed improvisation. Dudas argues that engagement with interactive performance systems (such as a modular synthesizer, in this case) necessitates the composition of the instrument itself upon which the improvisation and ultimately a performance is to take place.

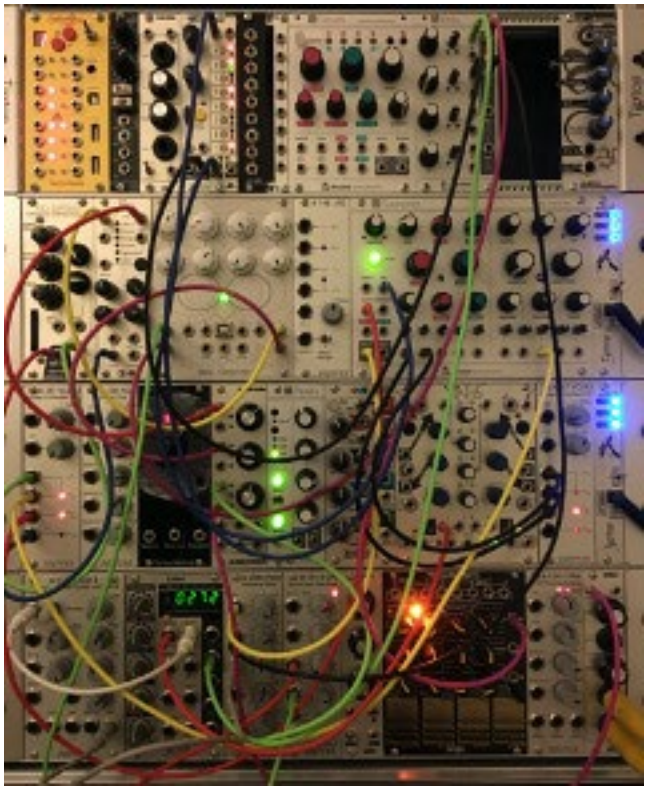

Figure 1. A photograph of my modular synthesizer system

Originally, in the mid 20th century, modular synthesizers were not considered to be suitable live performance instruments, probably due to their physical size and the high cost associated with these early machines along with their tendency to drift out of tune after a time of operation, due to hardware inadequacies (Pinch & Trocco, 1998). However today, having overcome these historical problems, it is considered standard practice within the modular synthesizer community (Holmes, 2008). While live modular performances have become commonplace, the activity that is not practised widely, at least within my genre of ambient electronic music, is that of collaborative 'jamming' among multiple modular artists with the aim of producing repeatable performances. The reason for this lack of collaborative engagement is perhaps twofold. Firstly, the complexity of patches and the subsequent, often unpredictable sonic behaviours doesn't lend itself to real-time responses from a jamming partner. Secondly, the more important factor is that of authorial autonomy and the need for artistic self-determination felt by many modular artists. Literature is sparse regarding collaborative practices within the field of modular synthesis, so here my evidence is autoethnographic at best and anecdotal at worst. Nevertheless, the lack of modular synthesizer ensembles within the community seems to corroborate this notion. While modular artists do feature as members of ensembles, these are usually made up of more traditional musicians playing various acoustic and electronic instruments alongside a modular synthesizer.

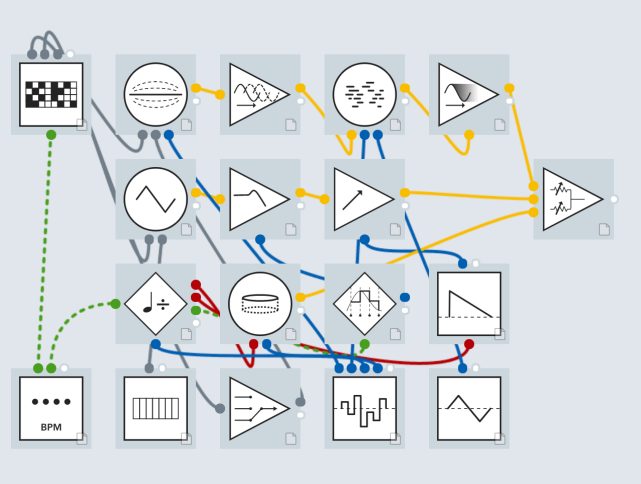

Figure 2. A simplified signal flow diagram for a modular synthesizer patch

My own experience supports the mode of engagement with the modular synthesizer to be largely solitary. I have collaborated with other musicians on occasion but only with ones that play non-modular instruments such as the electric guitar or keyboard. I have also played at public concerts with other modular artists performing on the same bill where several times we have attempted to perform together during the soundcheck or after completing our individual performances. These attempts proved somewhat unsuccessful as we quickly realised that without significant planning it is difficult to organise who is doing what in the moment. We all have instruments capable of producing complete musical works, so to play together, each of the performers would have to do less than what they are capable of doing. For instance, we would have to designate one performer, to play the percussion part, someone else the bass part, another the lead and so on. This runs contrary to the ethos of most modular synthesizer artists who prize creative freedom and self-determination highly. Once again I draw on the parallel with composers of orchestral music (as stated earlier, perhaps with the exception of commercial film or game score composers) who similarly would find it absurd to assign one composer to compose for the brass section,

another for the strings, another for the percussion, etc. Solitude in this sense affords a modular artist creative independence and time to compose, improvise and evaluate on their own terms without being beholden to the ideas and pace of others. For example, it is not uncommon for me to set up an initial patch on my modular system and leave it running for extended periods of time to allow the musical idea to develop in time through perhaps a generative process of some sort, and for me to then try various new sub-patches to evaluate their suitability for the particular piece being composed.

Figure 3. Dome-shaped performance venue at MOTAT in Auckland, New Zealand where I performed during the Night Lights event in June 2019

Canadian philosopher Brendan Myers frames the poietic musical experience in somewhat more existential terms. He writes "... the Word of Being is spoken in the hope of hearing an answering call from another being. Thus the Revelation in music asserts the statement 'I am here!', and at the same time asserts the question: 'Is anyone else out there?'". But what happens if the performance is without an audience or collaborators? He goes on: "Music is no less a performative art when the same person is both performer and listener. The singer asserts her own presence to herself" (Myers, 2010, pp. 123-124). While this may be true in some situations, it doesn't accurately describe my experience of solitary music-making. Rather than the need to assert my own presence to myself, it often seems that both I and my instrument make this assertion to one another. In this way, the instrument is anthropomorphised in becoming my 'jamming' partner as it displays some agency through its capabilities and unpredictability. Here, I am of course not referring to any kind of intelligence on the part of the modular synthesizer or any kind of panpsychism within its electrical circuits, rather I am alluding to the sense of resistance, the capacity to surprise and the feeling of being steered by the instrument. A notion that comes to mind is that of *imagined agency* as described by Ferguson (2013). He writes: "What I mean by this is that imagined agency, as I perceive it, is a useful notion to articulate the ambiguous, and sometimes irrational processes, within a practice that seeks out resistance and agency in a variety of forms, and attempts to interact with it." Additionally, in Brown (2016), creative practice is seen through the lens of agency networks, a distributed view of influences between not only human and technological musical agents but inclusive of broader culture and the physical environment where complex networks of mutual influence lead to creative outcomes. While boarder questions regarding creative agency and technological creativity persist, the agency network view does resonate with my own creative practice with modular synthesizers, where generative processes are ascribed agency but where the evaluation of quality still lies within the domain of human judgement and subjectivity.

Conclusion

For now, social isolation and solitude seem to be the new normal for great many people. In many ways it is a moment of shared experience due to the universality of this pandemic. Though, however oppressive this experience may be, it may at the same time offer opportunities for creative self-reflection. I have found my engagement with the modular synthesizer to have benefitted from recent periods of enforced isolation that the response to the pandemic has required. Despite the overall atmosphere of general anxiety that has endured throughout these periods, creativity has not suffered as a result. In some sense the opposite is true. Time spent working on music in solitude, away from the gaze and opinions of others has proved to be fruitful and has served as an anchor in otherwise turbulent times.

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Online Tuition with Tools for WebXR

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Abstract
The paper details experiences in online tuition with web tools associated with the WebXR API, the new standard for 3D rendering of VR/AR immersion through the browser. Web tools and techniques associated with WebXR standard are discussed. These include AFRAME, a framework for building XR experiences with declarative HTML markup; Reveal.js, a framework for HTML based presentation; Mozilla Hubs, an open-sourced VR chat room and finally glitch.com, a project management tool that simplifies setup and online delivery. These tools, techniques and standards together simplify the organisation of delivering coursework materials remotely.

Keywords
augmented reality, virtual reality, educational applications, WebXR, web standards

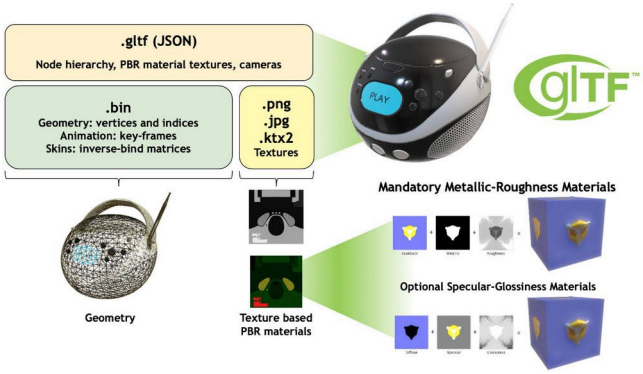
Introduction
The instruction of programming, computer graphics and 3D are already difficult subjects to deliver in person and this is further exacerbated when combined with online delivery. Teaching remotely does not allow the instructor to be able to work directly with the student to solve problems. This might be a programming issue that requires access to the student's viewpoint, or it could be related to a hardware or software configuration that is particular to the student's setup.

With a growing list of online tools and standards, the web stack provides a fundamental set of tools and approaches that make it highly suitable to online course delivery. New immersive standards such as WebXR [1] allow for these concepts to be conveyed. Additionally, the web brings a suite of tools that assist with delivery. These include AFRAME [2], a framework for building XR experiences with declarative HTML markup; Reveal.js [3], a framework for HTML based presentation; Mozilla Hubs [4], an open-sourced VR chat room and glitch.com [5], a project management tool that simplifies setup and online delivery. These tools, techniques and standards together simplify the organisation of delivering coursework materials remotely.

In general, the web stack builds upon a set of standards that applies to all user contexts and device configurations as such there is a general consistency. This allows for these tools to be used in new and applicable ways when a new technique is developed. For example, this could be applied to programming languages, HTML or javascript or any other technique that was developed elsewhere. As such the interoperability of online tools allow for interesting combinations of techniques that are favourable to social engagement through long established networking protocols and highly applicable to online delivery. Traditional online tools in the education space such as Blackboard Collaborate [6] allow for the numerous hardware and software configuration issues to be bypassed, as such any browser that supports the standards should operate equally on both the student and instructor's devices. This paper will discuss the advantages of each of the tools listed and how they can both enhance presentation remotely and also simplify student problem solving.

WebXR, AFRAME & GLTF format
The WebXR is the new web standard for 3D immersive environments online for both VR and AR. It builds upon a set of browser-based technologies that include the WebGL standard that supports 3D rendering in browser environments. WebXR supports a range of devices including many user inputs such as speech and gesture. In conjunction with AFRAME, a framework for building XR experiences with declarative HTML markup, make these technologies suitable for students to learn the fundamental principles of computer graphics and user interaction.

AFRAME has an extensive list of examples for students to work with and produces immediate results without complicated setups, as the student only requires a browser to see the results. While the features increase with complexity, the base examples are very simple and only require an understanding of HTML markup language to get started. As an open-source software, it also supports all other open technologies including the GLTF 3D [7] file format. The file format is the new initiative from the Kronos [8] group, a consortium of companies working with 3D file formats. This is especially useful for 3D artists wanting to showcase their work as they can choose from either developing their own XR website or using any 3D format hosting service such as Sketchfab [9] to showcase their portfolio. Open file formats such as GLTF along with AFRAME allows students to work directly with all other web services and any 3D created is interchangeable.

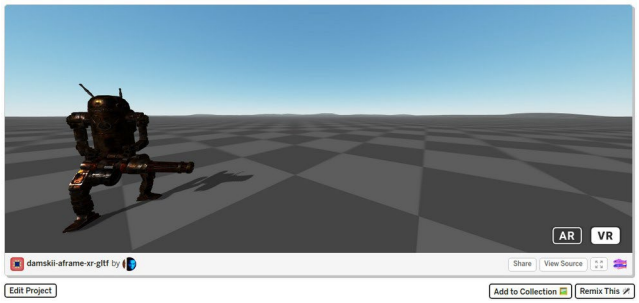


Mozilla Hubs

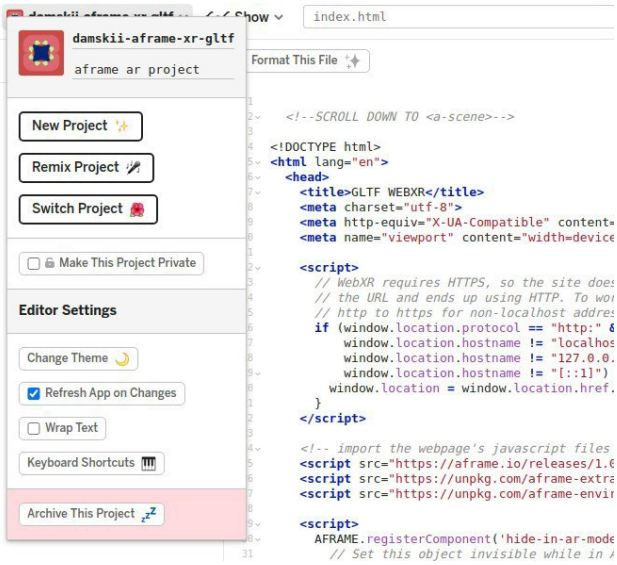
Mozilla Hubs is an open-source browser-based VR chat room that allows students to showcase their 3D work in a public VR space with their peers and the public. It has particular support for the GLTF standard by including a basic 3D editor Spoke [10]. This tool allows for testing if an environment is suitable for social VR. Students once they have developed their 3D and tested through other browser-based technologies such as AFRAME or Sketchfab can then test their models in Spoke. This allows them to understand the viewpoint of the user in VR and the limits of scale in social VR. Once this is done, their peers can then be invited through any device to interact with the space. Hubs allows for 3D designers to quickly understand how their models work in a social context, with implications for how exploration/gameplay is performed in the space including appropriate designs for online social environments.

Glitch Project Management

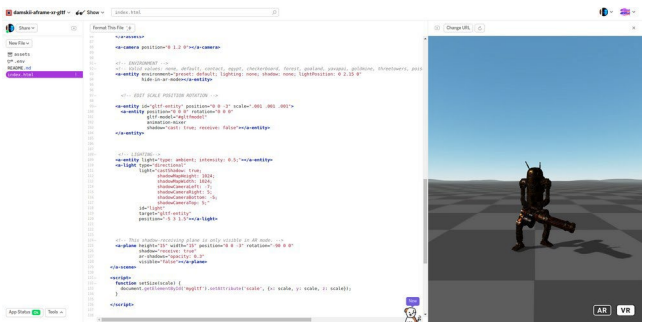
Glitch.com is a browser-based project management tool that simplifies setups for students to create and extend projects within an open community. Students use a simplified web interface to present projects publicly online including source code or full web URLs containing the running program.



Glitch bases itself on being an open community of developers, so all projects may be easily shared with others. While shared projects are owned by their creators, students of the project can 'remix' or fork the program and create their own version. The forked project can then be edited allowing for study and experimentation of the example. This is especially useful in online education contexts where problems may be resolved by remixing a version of the student's work, fixing an issue, then sharing the program back with them. They can either adopt the solution or attempt to modify their own solution. In either case, learning is done by experimentation, breaking things or going back to the solution to understand how it works.



Students when presented with the sandbox example are able to work through and understand the patterns and procedural contexts for how the program executes and produces its visual result. With design students, they are able to both equally view source code and show the result next to the code window, modify and experiment to see the output.

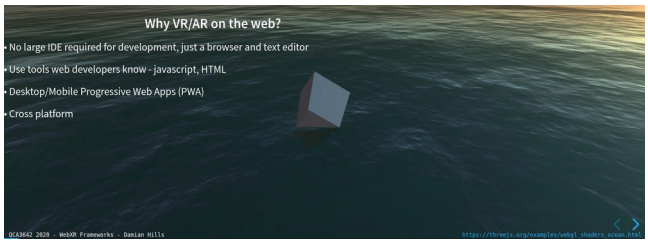


The glitch.com environment has been widely adopted by the AFRAME community to showcase the possibilities with WebXR and has shown to be an ideal playground to host online coursework and student projects.

Reveal.js

Reveal.js is an open-source HTML presentation framework that allows teachers with some HTML markup experience to develop presentations and utilise any existing browser based features including WebGL [11] and any associated web stack technology such as WebXR.

The advantages for remote and online instruction is the ability for students to have their own playback setup while the lecture is ongoing. Typically, a student may be viewing a shared screen during a remote lecture. With a reveal.js lecture, the link may be publicly shared and experienced independently of the shared context, so the student could be running a separate window with the actual fully rendered experience while listening to the live or recorded delivery.



Discussion

This paper has presented a set of web technologies that support open standards with a focus on WebXR related tools including AFRAME, the GLTF 3D format and glitch.com project management. Together these tools form a convenient presentation architecture for online learning some of the fundamentals of 3D computer graphics.

This coursework was first presented as a standard in-class tutorial with hands on support, with the following year being fully online. Developing coursework around web-enabled tools will allow the flexibility to present in either context, given that the future might be a combination of both. Between these two semesters not much had to be adapted in terms of providing support. Providing student support often involves analysing the problem as it relates their current device setup and configuration. This could be any number of operating systems or devices and these problems can often be resolved best in person. However, since browser-based solutions standardise this environment, remote support becomes easier to accomplish. Project management solutions like glitch.com become easier to predict and resolve through project sharing.

Glitch simplifies this process by containing each example within the browser separate from the complexity of the student's local device configuration. From this reasoning, web enabled tools might be a necessity to remain relevant in online coursework. For a specialised course in WebXR for example, vendors interested in providing hardware solutions for education would do well to support these open standards or potentially lose out in the marketplace. In previous years, the ChromeBook has gained traction as an education device capable and up to date with supporting these standards. While it could be argued that creative applications [12] have more scope with iPad devices, lagging behind on standards such as WebXR will only allow competitors further space within the market.

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Developing eSports Coaching Bots Using K-Means Clustering Techniques

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Abstract
Traditional sports have heavily adopted AI data analysis techniques to develop unique training plans tailored for individual players. However, this has not yet extended enough to eSports despite the ease of access to large datasets that come with the digital profession. Existing researches either focus on AI opponents used to out-perform human players, or do not outline an implementation of their AI data analysis for coaching purposes. This research focus is on developing a training environment for eSports competitors using bots, AI and data analysis techniques such as k-means clustering. A pilot study is undertaken to investigate the performance of the developed bots to understand if they could improve the player experience. The results show participants who show have more aggressive playstyles improve the most when training against bots tailored to their playstyle when compared to passive players. These players after training tended to show more thought into their actions, reducing the number of shots fired while maintaining the number of shots hit to lead to an overall increase in accuracy. Regular use of an AI training bot when used as a supplement for regular gameplay can help to improve player accuracy for developing players faster than regular gameplay.

Keywords
Artificial Intelligence, eSports, KMeans Clustering, Bots.

Introduction
eSports is an emerging area for games researchers, with an abundance of clean, pre-defined data to process and complex environments to navigate (Lam, 2017). Current research into the applications of AI analysis in eSports is limited compared to its counterpart in traditional sporting. Traditional sports have heavily adopted AI data analysis techniques to develop unique training plans tailored for individual players, however this has not yet extended to eSports despite the ease of access to large datasets that come with the digital profession. Existing works either focus on AI opponents used to out-perform human players, or do not outline an implementation of their AI data analysis in a meaningful way.

Through the continual research and analysis of current eSport coaching, this research will analysis of existing individual player performance data using machine learning techniques. The analysis results will be used to prototype required bots for players coaching. This project will adhere to an objectivist standpoint in conjunction with a theoretical vision when collecting data, analysing data and creating bots.

Training environments available to players of popular competitive video games are heavily restricted to either the developers in game matchmaking tools, or private training matches organised by individual players or team coaches at the professional level. To overcome this problem, this research plans to use machine learning analysis of individual player performance data to come up with customised training bots to improve the players training experience.

Literature Review
This section looks at the existing work in the field of eSport coaching in order to identify research gaps. eSports is an undisputed playground for AI researchers, with an abundance of clean, pre-defined data to process and complex environments to navigate (Lam, 2017). There are many areas being explored within eSports and AI, including player Role Identification, Tactical Team Analysis, Adversarial AI and a few attempts at coaching tools and services. The importance of knowing the types of players on a team and playing to those strengths and weaknesses is the key method of avoid giving an advantage to the opposing team.

For AI, the ability to identify and define different roles within a game is extremely valuable in estimating the chances of victory for a given team and the performance of an individual player. As such, researchers at the University of York have developed an AI algorithm to determine a player's role in the popular eSports Multiplayer Online Battle Arena (MOBA) Dota 2 by analyzing resource priority, map movement and player choice of abilities (Demediuk et al., 2019). This detailed analysis of Dota 2 role classification lays the groundwork for much of the AI-driven tools that may be developed, with the ability to determine what major functions a player serves within a team being pivotal to determining what skills may need to be developed to achieve an ideal outcome for the individual player, and their team.

In Belarus, researchers have used AI analysis to determine the winning factors for a team in the First-Person Shooter game Counter Strike: Global Offensive (Kadan et al., 2018). By collating basic information such as movement, health and shots fired, the team identified the fa-

vorable conditions for each team to achieve victory. Neither does the paper assess technical factors such as player accuracy or map awareness that inform the tactical choices made throughout any given game.

As literature review identified, there is a clear gap in existing research on how player technical skills within eSports can be improved to affect the outcome of a game. Moreover, there is a research interest in how AI analysis of individual player performance can assist in the training and coaching of eSports players. The analysis of player data can help to provide players and coaches with more tools and meaningful information to identify weaknesses and improve a player's performance.

To achieve this goal, this research will collect, process and analyse the performance data of individual players in CounterStrike: Global Offensive using K-Means clustering algorithms to identify their playstyle, and develop an AI opponent to help improve the development of their skills more efficiently than going through normal play.

Data Driven Design of eSports Coaching Bots

To fill this research gap, three tasks need to be completed, Data Collection and Preparation, Data Clustering using K-Means Clustering and Training Environment Creation. Data Collection and Preparation looks at the collection of data to use in the creation of K-Means Cluster models in the following section. After this model is completed, the information gathered about player behaviours relating to individual performance at a technical level can be used to inform the design of AI opponents used in the players customised training.

Data Collection and Preparation

The data that is used in the program will be collected from the popular eSport Counterstrike: Global Offensive. Data will be gathered by downloading professional level match data from HLTV.org and processing the files using DemoInfo, a C# library developed at MIT that allows access to the information that passed through the match servers during the recorded game.

The initial data collection will track a number of key events, outlined below, that occur throughout the match tracking what event occurred, and which players were in- volved. This data is collected from a public resource and processed into an easily readable format. These events are stored in an encrypted .demo file and are read chron- ologically in game ticks where each tick is a server up- date.

```
Input .demo files
For each .demo File
        Check players listed in the game
        Initialise current tick to zero
        While current tick is less than the total number of
        ticks in the game
                Check for key events (Shots Fired, Kills,
                Deaths, etc.)
                Record which players were involved in
                each event
                Move to next game tick
        If all .demo files have not been read
                Move to next .demo file
        Else
                Save recorded data to .xlsx file
```

Implementation of K-Means Clustering

For this project, the number of clusters will be set to two (2). This decision was made to reduce the potential workload for processing and determines the number of training environments that would be required for the Demonstration and Evaluation stages of the research project.

As looked at in the Literature Review, there are 2 distance algorithms being looked at in this research, Euclidean Distance, and Cosine Similarity. When processing the data gathered in the previous section, the implementation of Euclidean Distance when clustering grouped the players based on the number of shots fired by each player. The players who tended to shoot more throughout the game, and as a result score more kills against the enemy team are labelled “aggressive” players. The remaining players, who engage with the opposing team less often were labelled “passive” players.

Training Environment Creation

The next stage of development is the creation of the training environments that the players will be training in to improve on any identified weaknesses. Each cluster would be assigned its own training environment based on the prioritized list of skills that the cluster needs to improve. This environment would take the form of customised AI bots for the player to train against.

The primary implementation of these training environments come in the form of custom AI opponents adjusted to suit the performance of a given cluster. These AI opponents would be created to give players a many opportunities to improve the identified skills as possible by acting in a way that 1) exposes the AI to the player often, and 2) acts in a way that gives the player an opportunity to practice the specific skills identified as requiring improvement during the clustering phase. For example, bots designed for high activity or aggressive players have higher levels of communication with their team to identify the players position and move towards the player as fast as possible.

Cluster Identities and Player Types

Euclidean Distance

Clustering based on Euclidean distance was primarily based on the number of shots fired by a given player. Comparing this to other core metrics such as player deaths, number of kills, times flanked and weapon usage all show clear delineations between aggressive players with high kill counts, and more passive players with a lower number of kills. An aggressive player is defined as a player who is more active in a game, engaging in more firefights than their teammates and as such, getting into a higher number of dangerous situations. Figure 3 shows the difference between these two clusters, where aggressive players shown in orange achiever more kills at the expense of dying more to the enemy team. Passive players tend towards the opposite.

With a clear difference in player aggression, the average player in each cluster plays quite differently. The average player in the more passive of the two clusters, here on called Player E1, fires around 620 shots throughout the game, and successfully hits an enemy 17% of the time. With an average kill count of 27 through the course of the game, 23 shots would be fired for every kill Player E1 achieved. The more aggressive player, Player E2, fired nearly 3 times as many shots over the course of a game at 1576 and killing 74 enemy players with an accuracy of just above 18% or 21 shots per kill. With both players are achieving a similar level of accuracy, the key difference

comes in how many shots are fired by each player and consequently, the number of kills they can secure. Additionally, the justification of the players being clustered by how aggressive they are is shown in the increase in player deaths and flanks. The more passive Player E1 died 26 times compared to Player E2 who died 70 times throughout the game. This discrepancy can be attributed to the close-range gameplay of the aggressive players leaving them more open to being flanked by the enemy team.

Cosine Similarity

In contrast to the Euclidean Distance Algorithm, clustering based on Cosine similarity provided groups based on player weapon preferences rather than any clear performance metric. Specifically, the Cosine clusters show a player's tendency to use the M4A4 weapon as opposed to the AK47. Important to note, these weapons are team restricted, meaning only one team have immediate access to the M4A4 at the start of a round, while the other team can only purchase the AK47. The only way for a player to access the other team's weapon is to wait until halfway through the game when the teams switch, or to pick up the other teams weapon from the ground after killing an enemy who is holding it. Further, while each cluster shows a preference for a certain weapon, most players from both clusters used the AK47 at some point throughout the game, while just over 21% of players from the AK47 preferred cluster never used the M4A4. This indicates that players, no matter which team they are on, have a tendency to use the AK47 over the similar M4A4 and may go out of their way to take one from the enemy team.

For the performance of players within these clusters, while there is a difference between the aggression of a player within these clusters, it is not nearly as exaggerated as that shown in the Euclidean clusters. A player who prefers the AK47, Player C1, averages 823 shots throughout the game, with an accuracy of 17% and 37 kills on average. By comparison, the M4A4 player, Player C2, is slightly more aggressive with 923 shots fired, 18% accuracy and 42 kills.

Bot Design

As a result of these clusters, a total of 6 bots were designed to accommodate the player types identified. These bots are primarily designed around the aggression categorization of the Euclidean Clustered data, with 2 types of bots, each with 3 difficulty levels for adaptive training based on the players proficiency in the game. This allows access to this type of training to anyone regardless of their level of experience in the game.

The larger group of passive players have bots designed around fighting at mid to long range, a decision made by the low number of times a passive player was flanked by the enemy. Short range weapons such as shotguns and SMG's were removed from the passive bot's weapon list, and the bots were given a lower aggression value to discourage close combat to reflect the types of mid to long range combat engaged in by passive players.

The more aggressive bots by comparison, have full access to all the weapons on their team allowing the use of close-range weapons such as shotguns and SMG's. Access to the extended list of weapons allows for much closer combat to take place as a direct result of the AI

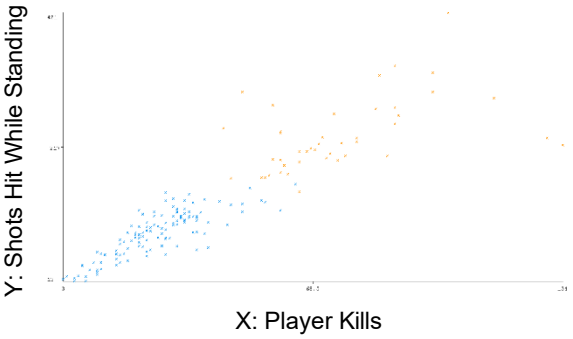

Figure 2: Kills / Shots Hit Standing data, coloured by cluster
Orange – Aggressive, Blue - Passive

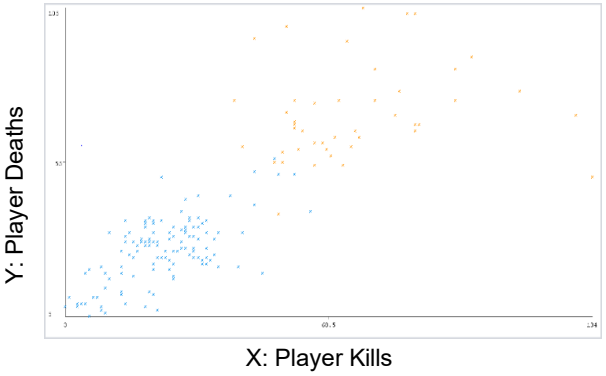

Figure 1: Kills / Deaths data, coloured by cluster
Orange – Aggressive, Blue - Passive

opponents' ability to use close range weapons. Additionally, these bots are highly aggressive and communicate the players position to the entire team, allowing the player to improve their reaction time and aim under pressure, as well as movement to take cover from flanking bots. These decisions are made to simulate the aggressive playstyle of these players by outnumbering and surrounding them, forcing a more calculated approach to the aggressive plays these players make.

Both of these bots have varying difficulty levels that effect the bot's accuracy, reaction time and communication. At the lower difficulties, bots have performance similar to humans, however the higher difficulties have reaction times and accuracy above that of professional level players. These adverse environments encourage players to flank their opponents to get an advantage against the bots, as well as improving their accuracy and reaction time to increase their odds in a head-to-head fight.

Testing and Analysis

Testing took place over 5 days, with days 1 and 5 being assessment days and a total of 10 participants, the equivalent of 2 full CS:GO teams. For assessment days, participants played 15 minutes against Aggressive bots to measure their performance before and after the training period. Over the 3 days in between, participants were asked to play 30 minutes per day (equivalent to 1 average length competitive round of CS:GO) either in the standard competitive mode, or against the training bots with half of participants assigned to each option.

Initial data shows a participant average hit accuracy of 32% across the 930 average shots fired. Players in this initial test, unlike the training data used to develop the

bots, tended to be more aggressive with 60% of participants firing over 1050 shots in the initial trial. While this does not reflect the cluster sizes found in in the training data, it has no effect on the outcome of this trial as players are tested individually to prevent situations where a team of aggressive players are all tested at once. This discrepancy is likely a result of the number of participants and further testing with larger group may reflect more accurately compared to the original test dataset.

	Aggressive	Passive
AI Training	+6.2%	-2%
Standard Training	TBC	TBC

Table 1. Change in Player Accuracy

After the second assessment, it was found participants who practiced against the bots increased their accuracy by 4.7% compared to the 3.2% decrease in accuracy shown by the participants practicing in standard game modes. Aggressive players training against bots improved accuracy the most averaging 6.2% higher than initial testing, while passive players decreased by 2%. As a result of this increase in accuracy in aggressive players, the number of kills achieved also increased, while at the same time decreasing their number of deaths. All players showed a decrease in aggression with up to 30% drops in kills and shots fired. From this, it can be determined that aggressive players tend to benefit the most from this bot training, increasing accuracy significantly despite firing less shots overall. The increase in performance for aggressive players while seeing a decrease in performance from passive players may point to a flaw in the design of the passive bots used, and more experimentation of the passive bots behaviours could lead to an AI bot design suitable for improving the performance of passive players.

Conclusions

This research has implemented machine learning analysis through K-Means clustering of individual player performance data to come up with customised training bots to improve the players training experience and outcomes.

This analysis and testing that through the proper implementation of AI opponents customised to the player, these players can show a greater in increase in accuracy when compared to players who practice solely in regular gameplay. This application of player customised training bots notably improved the accuracy of aggressive players, while proving to be a detriment to passive players.

Further research could include application of different clustering techniques to reveal new behavioural patterns in players, and development of a training environment tailored to improve the performance of passive players.

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Augmented and Virtual Reality for Spatial Reasoning

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Abstract
The utilisation of mixed reality technologies in the classroom is proving to be of great pedagogical benefit. It is not just the tools, devices and techniques of Augmented virtual and mixed reality that have an impact on student learning it is the ontological shift in learners that is afforded by these technologies. This paper outlines the procedures of implementing AR and VR in a tertiary course for the express purpose of contributing to an accelerated understanding and application of spatial reasoning. The paper discusses the outcomes of two years of teaching a particular second year University course in 3D modelling.

Keywords
Augmented Reality, Virtual Reality, Spatial Reasoning, Learning and Teaching, iPad

Introduction

As an educator and educational designer for a range for courses in computer aided design, a frequent challenge is implementing strategies to build and strengthen the capacity for spatial reasoning. Thinking spatially is a capacity that is essential for a student to exercise in product, interior, immersive, games and interaction design.

One of the courses I convene and teach is called *3D Modelling for Interaction*. It is a second year course in the Bachelor of Creative and Interactive Media at the Queensland College of Art/ Griffith University. The protocols for the course are to build skills in Three Dimensional Modelling, particularly in parametric modelling and polygonal or mesh based modelling. Conventionally one single course would not teach two markedly different software platforms. This course however is unique in that the theoretical foundations for it are introduced in a first year course where students are exposed to the ontological implications of the technologies and processes of design using computers. The affordances and constraints of design using computers are explored in other subjects within the degree, but in this course the ontological positions are directly negotiated whilst training in two markedly different applications for three-dimensional modelling, namely Autodesk Fusion 360 and Autodesk 3DS Max.

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Mathematically speaking the differences are that Fusion 360 is a solid modeller and 3DS Max uses boundary representation (Requicha 1980) (Requicha and Voelcker 1983). Both software platforms will permit objects and environments to be created through multi variant processes, but those processes can vary fundamentally in their mathematical origins. Conventionally a product design student would follow the conventions of the engineering paradigm and learn solid/ parametric modelling, whereas a games design student would learn boundary representation or mesh-based modelling. This course is not bound by convention and strives to introduce students to the different strategies for three-dimensional modelling as afforded by the different platforms, for the express purpose of challenging constraints imposed by insulation. Descriptive Geometry as an ontological constraint is also discarded in this course. That is not to say however, that it has no use. Descriptive geometry in the form of protocols and techniques for orthographic projection is a necessary and relevant form of communication to others (González 2018) (Huang, Chen, and Lin 2017). The parametric interface of solid modellers however were based upon the rules of descriptive geometry and in turn these rules constrained the ways in which the user interpreted and manipulated form.
Terry Winograd and Fernando Flores write of this concern using the standpoint of design. 'In the act of design, we bring forth the objects and regularities in the world of our concern. We are engaged in an activity of interpretation that creates both possibilities and blindness (Winograd and Flores 1987). Descriptive Geometry although powerful in building the capacity for spatial reasoning also suffers the constraints of reasoning within a Euclidean paradigm, that is describing the three dimensional interpolation of two dimensional forms through processes such as extrusions, revolutions, and Boolean operations. Solid modellers are wonderful tools for designing, but they can reveal the blindness of the descriptive process. Similarly, polygon modelling software can reveal new possibilities at the expense of accurate and easily repeatable methods of description.

Course Structure

The goal of the course is to expose students to the technical and theoretical potential and pitfalls of two somewhat contradictory computer aided design processes. This is achieved not by burying the students in theory that they don't understand yet but by experiential learning through problem-based projects. If the course began with reiterating the rules of descriptive geometry very little would be achieved as the constraints placed on the modelling process would limit the outcomes.

In terms of course objectives, *3D modelling for Interaction,* comprises two components, six weeks of individual projects using solid modelling and six weeks of group projects using polygonal modelling. Students are provided with a set of assignment options for both projects and given the opportunity to deviate from or add to that list. It is imperative that individual students and groups work on projects that motivate them[i]. As student motivation is a complex but necessarily personal set of issues, a suite of options to draw from has proved effective in previous courses. A secondary factor in allowing students to choose and help define their projects is that the time involved in one course is not enough to encompass the breadth of the software taught. It is imperative that students seek deeper learning of the components of the applications that they are learning and apply those components to solve problems that are meaningful for themselves. It is easy to become complacent as teacher in what is usually a pragmatic set of technical tasks in other institutions. Retaining a focus on problem based learning provides an opportunity for the otherwise mundane tasks of leaning software parameters to be enjoyable and challenging.

In 2018 and 2019, 126 students had completed in 3D modelling for interaction, divided amongst two campuses, serviced by two lecturers, Paul Bardini, specialising in solid modelling and myself, specialising in polygonal modelling. This offering was the second time in which a course had been split into two modules, so although the successes had been made in another course, this was the first time in which a computer aided design course had been so radically changed. From an external observer's position, this course may seem to exhibit novelty in many respects, but it is as a result of a long experience of teaching computer aided design that from our point of view the newly implemented elements of course design are logical decisions based upon student need. The decisions to implement somewhat contradictory modelling platforms in one course were in response to the diverse set of potentials we need to offer to our students in the newly formed Bachelor of Creative and interactive media. The graduate outcomes of the student contingent are diverse and not explicitly constrained to one discipline. One student, for example may graduate and require product design skills, and so skills in solid modelling will be of benefit. Whereas another student may build skills in projection mapping so polygonal modelling skills would be necessary. A course such as this is necessarily written to allow for a diverse set of experiences to be undertaken so that a great many opportunities be revealed to students. What is of importance, as well as course structure is the flexibility of delivery and the adaptability and guidance of the lecturers, a framework that could be construed as a Cognitive Apprenticeship (Brown, Collins, and Duguid 1989) (Huang, Chen, and Lin 2017) (Wu et al. 2012). The learning framework is firmly entrenched in Constructionist philosophies as espoused by Seymour Papert (Papert 1993), as building on Jean Piaget's theories of Constructivism. In regard to this course a guided tutorial is delivered at the commencement of each class to negotiate key technical and conceptual issues pertaining to the task and the rest of the class is devoted to guidance and problem solving whilst students applied newly learnt procedure to their individual or group project. The crucial test of modelling abilities in a technical and conceptual sense is for students to realise their solutions to project problems in a tangible sense. Papert's ideas of experiential learning are crucial to how this course functions as the entire course is concerned with building the students skills and confidence not just in using software effectively but applying it to tangible problems.

The key concern of a course such as this is how students can experience a tangible solution to two diverse problem based assignments, within a short period of time. A previous solution to providing tangible solutions to problems incorporated the use of additive fabrication or 3D Printing. This occurred in a course entitled *advanced fabrication*. It was necessary in this present course to have faster solutions as 3D printing firstly can still take significant time to acquire the requisite skills, and secondly 3d printing is much more time consuming to adapt to modelled forms of larger scale and intricacy.

Virtual Prototyping

Augmented and Virtual solutions offer viable and seemingly tangible outcomes to a three dimensionally modelled product and particularly a modelled environment filled with furnishings and artefacts and mapped in materials. The decision to implement the use of augmented technologies in the classroom were based purely on purpose and not novelty, as it has been noted by other researchers that the use of AR by educators can be ad hoc (Billinghurst and Dünser 2012). Having spent research time experimenting with various AR frameworks, it was a calculated decision to use *Sketchfab* as the platform to experience and test 3D modelled outcomes (https://sketchfab.com). A professional *Sketchfab* account was procured for the University and in the classroom, students were guided in the creation of personal accounts so that as they worked towards resolved outcomes, they could effectively export and upload models to *Sketchfab* for experience and testing using a suite of the latest *iPads* using *ARKit*. *Sketchfab* is an ideal platform for experiencing modelled objects as it is multiplatform, using web, iOS and android platforms effectively to view objects and scenes in AR and VR.

Figure 1 Chair Modelled in 3DS Max by Cam Scott

Simple singular objects such as the chair in figure 1 were the first to be tested in AR as these types of objects could be tested for scale against a backdrop of real world proportions. Furniture items could first be tested for scale and secondly for application for material and texture. The impact on experiential learning is almost immediate not because the object in AR appears real but because it is believable, and it is believable because the barriers to disbelief are stripped away. The objects and environments modelled do not just reside within the computer in an abstract sense, they appear tangible as they can now be experienced at human scale against the backdrop of the real world. The experience of the object or environment in AR becomes, ontologically speaking, not just a visual representation, but a sensorial representation.

The object, in this case the chair can be experienced visually and haptically, it can be experienced and assessed in relation to the body that experiences it. It may seem like a novelty to a newcomer to these technologies but for students learning the procedures of three dimensional modelling and applying these procedures to seemingly tangible outcomes it provides a leap in spatial reasoning. In turn the AR frameworks simply become the new tools to model and test in increasingly swift design iterations. The successes of 3D modelling for interaction are not in the resolved and polished outcomes but in the flaws unveiled by testing quickly in AR.

There are multiple sets of interrelated procedures for modelling valid forms using solid and polygonal modellers, but little tolerance for error is acceptable for export for use in additive and subtractive manufacturing processes. The use of *Sketchfab* to import FBX files from *Autodesk Fusion and 3DS Max* helps reveal errors and inefficiencies within the design process, in terms of scale, proportion, modelling procedure and operands using boolean union, intersection and subtraction to name but a few. Figure two demonstrates a well modelled replica of a Roman stool which in *3DS Max* is quite convincing and shows careful attention to procedure and detail. Import to *Sketchfab* however reveals issues with the polygon mesh for the fabric that is then transferred to the UVW map for the material. If the teaching and learning experiences remain fixed to one software application the students would experience what is possible and what is blinding within that software application (Winograd and Flores 1987). Translating to other platforms and experiencing forms in AR helps to expose that blindness.

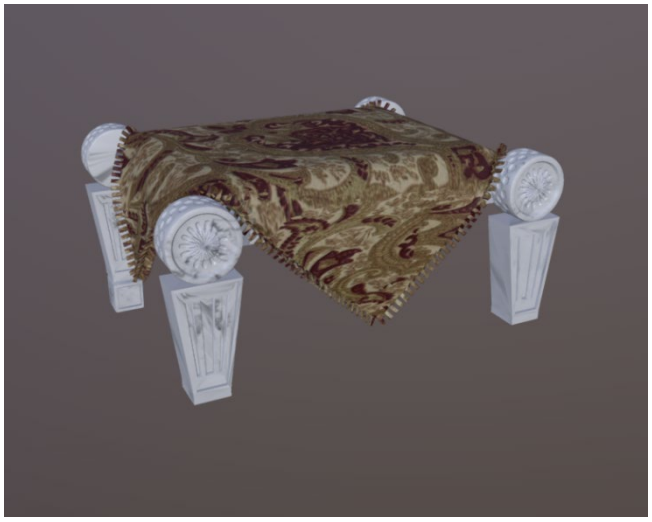

Figure 2 Roman Stool Modelled in 3DS Max by Emily Zamattia

Contextually modelling a roman era stool and situating it within a contemporary environment also enables a correlation between ergonomic principles applied to furniture from differing eras. Hannah Schraffenberger and Edwin van der Heide write of the relationships between the virtual and the real, inclusive of spatial relationships and content-based relationships (Schraffenberger and van der Heide 2014) (Schraffenberger and van der Heide 2013).

Emily Zamattia's Roman stool demonstrates the potential for coexistence of the virtual object in physical space, both in terms of spatial relationships and content-based relationships, of the physiological correlation to form and of the tactile associations to materials and textures. Such an unravelling of potential is not easily possible in a conventional computer aided design course, but the immediacy of negotiating the relationships of virtual content in physical space permits this possibility.

A directly haptic association of virtual object and the human body is demonstrated in figure 3. This example was carefully crafted in *Autodesk Fusion* and exported as an FBX file to *Sketchfab.* The modelled set of objects demonstrate proportional structures relative to the human body designed and modelled quite accurately. Accessing the *Sketchfab* file using the *iPad* and *ARKit* help reveal and validate the relationship between the model and the body

Figure 3 Gauntlet modelled in Autodesk Fusion by Emily Zamattia

As Schraffenberger and van der Heide accurately state. 'The virtual not only relates to the real, the real also relates to the virtual. The spatial and /or content based relationships are *between* them (Schraffenberger and van der Heide 2014). Emily Zamattia's gauntlet evidences what the interactions between real and virtual can offer. It is in this liminal space that rapid advances can be made in the acquisition of new skills by their examination and verification using AR platforms.

The interactions of the object modelled in computer and the physical body is a very difficult and time consuming task particularly for novices just beginning to learn the software. The gauntlet is on of our best examples of rapid acquisition of technical skills in modelling, and conceptual skills in spatial reasoning that we have witnessed.

Figure 4 Gauntlet by Emily Zamattia captured using ARKit.

Some of the outcomes from the 3D Modelling for Interaction class, particularly environments modelled in *3DS Max* were best accessed in VR devices, for that purpose the entire models were exported prior to resolution to *Sketchfab* and navigated via Browser with the *HTC Vive* headset. The environments were the most difficult assignment of the course as it requires careful adherence to modelling protocols and the appropriate sharing of files inclusive of models and materials within groups. The environments are a real test of modelling ability and export to VR is certainly not designed to penalise students for error but rather to reveal problems through navigation in VR so that they could be amended by returning to the modelling process.

The Villa as shown in figure 5 is not perfect but is easily navigable in VR so that modifications can be made to the Max file and retested.

Navigation of the *Sketchfab* file is quite straightforward in VR using the *HTC Vive* and its teleport function. The immediacy of navigation affords almost instantaneous feedback as to the validity of the file, particularly its spatial connection to the viewer. Scale and proportion are the first to be tested as the students navigate their created space for the first time.

Figure 5 Roman Villa by Sarah Bidlake, Eva Chan, Jeffrey Handebo, Ning Yi Yeoh and Emily Zamattia

Many students reported that they knew instantly what to fix as soon as they could view their environment in VR, and student groups were eager to return immediately to their files to modify their models and return to navigating and testing the environment in the next class. As an educator it was inspirational to witness such remarkable advances in spatial reasoning. I have taught polygon modelling for many years and know from experience how difficult it is for most students to grasp the essentials of computer aided design let alone achieve mastery.

Future iterations of this course will begin translation of objects and scenes into virtual spaces earlier. More *iPad* and portable VR headsets have been purchased for class use and will be available for continuous experience and testing. This being the first run of this particular course some of the outcomes can be introduced early to discuss the potential of the use of AR and VR. It is also expected that many more

student users enrolled in this course from next year will have personal devices able to utilise *ARKit* or *ARCore* thus rendering the technologies further into the background of learning activities whilst permitting more time for experiential learning.

The Ontology of Prototyping

Students were informally surveyed in 2019.

Many students reported that they knew instantly what to fix as soon as they could view their environment in VR, and student groups were eager to return immediately to their files to modify their models and return to navigating and testing the environment in the next class.

In 2020 students were formally surveyed with ethics approval GU ref no: 2020/375. The results, although impacted by the rapid shift to fully online classes, showed that

1. Students reported that using augmented reality had helped with spatial thinking
2. Students reported a small improvement in understanding the 3D modelling process by using Sketchfab and AR.

Students noted in the survey that they wish that they had access to VR devices in the first half of 2020 to better understand their models and environments. But interestingly those that commented still presumed that only a high-end viewer is capable of VR and had not tried their own mobile devices.

Apart from the technical challenges of 3D Modelling and subsequent translation to Sketchfab, all students in the course have a set of journal tasks to complete that are critical and contextual. There are two theory readings to comment on. One concerns affordance and the second is a paper by Udo Kannengeisser, called 'The Ontology of Computer Aided Design'. Students are not required to read Kannengeisser's paper, but those who do take up the significant challenge that it is, fare better in their technical tasks.

Students are asked to reflect twice on the readings at different stages, and perhaps the best acknowledgement of learning comes from students such as this who recognised what went wrong by evaluating it with Kannengeisser's 'Three world structure'

'In my works, my focus is more Object-centred then Process-centred. I focus on the object as it is and forget about the rest of the environment as a whole. this became apparent when I changed the size of the environment. I might have gotten more space but I failed to take into account how that would effect the other objects. My interpreted world was far different from my expected world'. (Journal extract from a student in 2019)

The best outcome one could ask for is a continued and considered use of mixed reality platforms to test and communicate 3D models. What we now see after the conclusion of this course is the continued and refined use of Sketchfab by our students. The technologies themselves, (Autodesk software and Sketchfab) afford the depth in learning. but the student's critical analysis of theory, object and process influences ontological position. There are student outcomes from this course that evidence the growing awareness of an individual's stake in the construction of their reality. Spatial thinking is part of that ontological position. The modelling, testing and evaluation of computer designed objects and environments helps in the understanding that reality is not separate from knowledge.

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