College of Engineering

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Te Whare Wānanga o Waitaha
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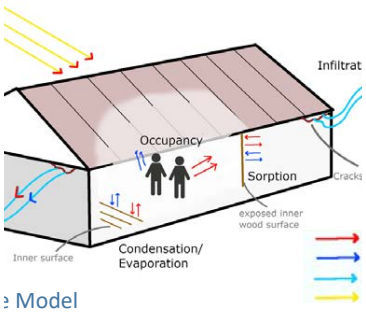
Final Year Projects 2020.



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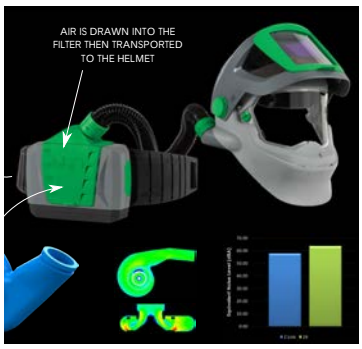

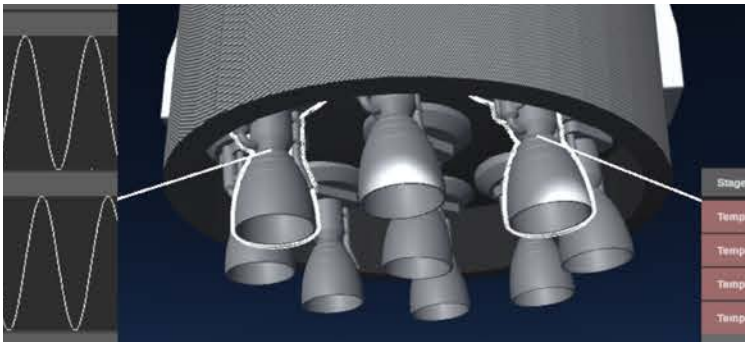

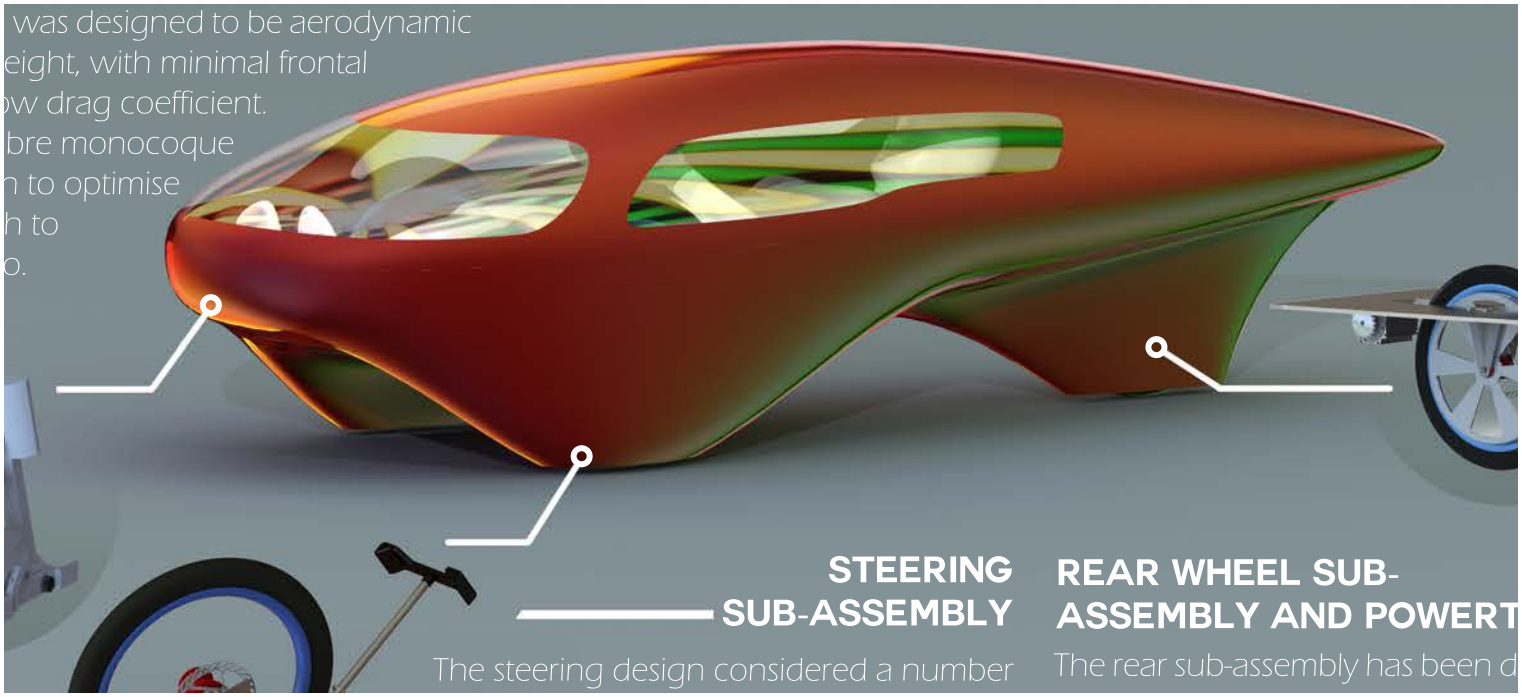
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STEERING SUB-ASSEMBLY

The steering design considered a number

REAR WHEEL SUB-ASSEMBLY AND POWERT

The rear sub-assembly has been d

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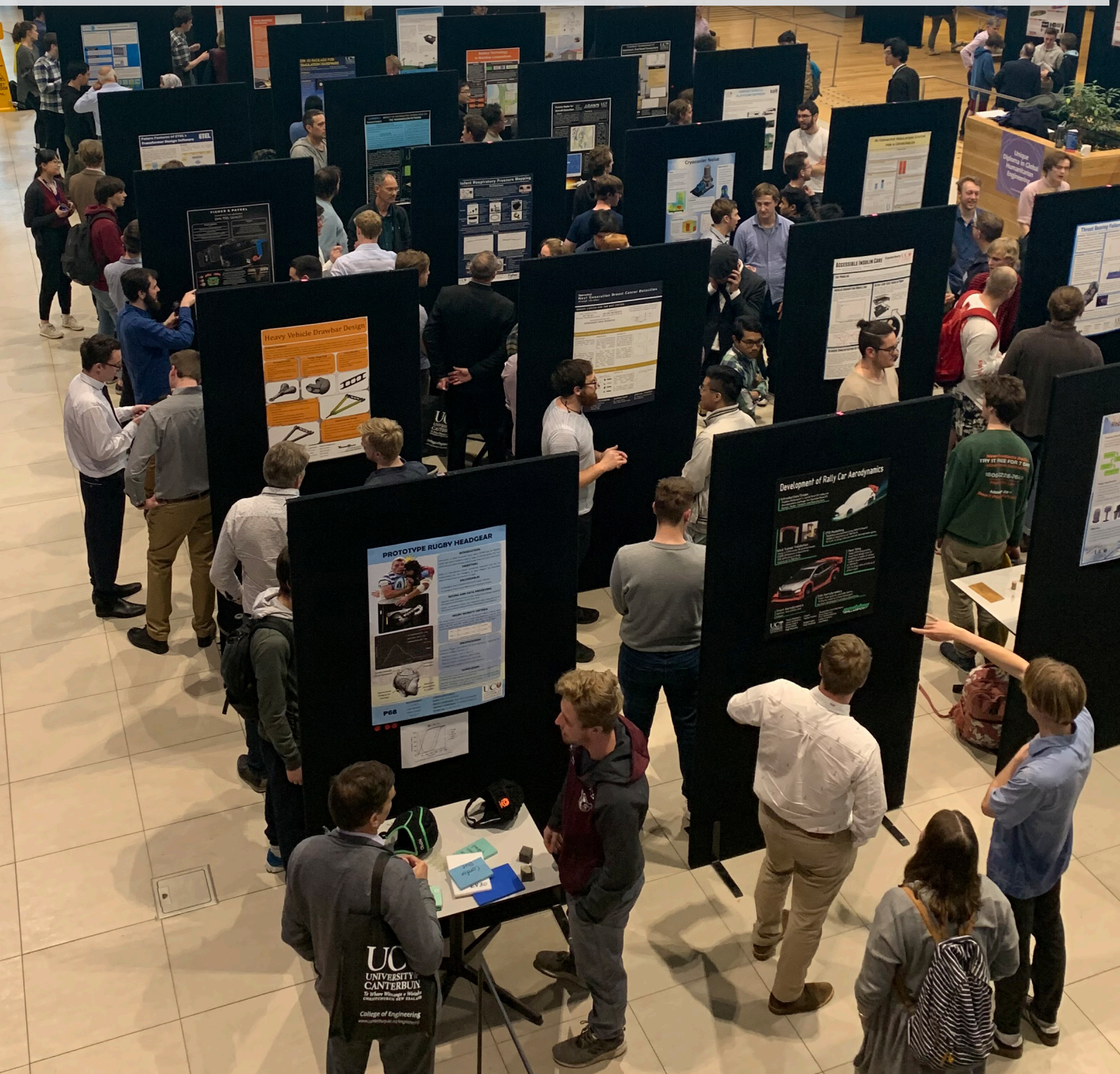

Project sponsorship

Project sponsorship is a great way to participate in education, complete projects you wouldn't normally have time for, and get in-depth research or consultancy for your organisation. Students are available at many levels of study, in teams or as individuals. Students' areas of study include all disiplines of Engineering, Forestry, Maths and Product Design. Projects and internships culminate in the production of a prototype, report or case study that is made available to the sponsor organisation. The following pages show a selection of projects that were completed by engineering students at UC, with fantastic support from their sponsors, during 2019.

Thank you to our 2020 project sponsors

Thank you to all our industry Final Year Project sponsors, who challenged and supported our students this year. Without your support and encouragement, our graduate engineers wouldn't be the amazing well rounded graduates they are.

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Scion
Seedigital
Seequent
Skope
Solar Revolution ltd
South Pacific Sera Ltd
Tait Communications
Take My Hands
Taska
The Seaweed Solution
Transtech Dynamics
UNISON
Virtual Medical Coaching Ltd
Vynco Industries Ltd
Wattwheels Ltd
Wyma Solutions

The Peoples Choice Award 2020

Each year attendees at the Final Year Project Showcase are able to vote for their favourite project. This year due to the disruption caused by COVID-19, not all students were tasked with producing posters for their projects and as a consequence, the event was a more low key affair. For those that did produce posters, the standard was very high and fiercely competitive between some students. The award this year was announced and presented by the Pro-Vice-Chancellor College of Engineering Professor Jan Evans-Freeman.

Photograph from left to right:
Professor Andreas Willig, BE(HONS) Software Engineering student Flynn Doherty, Senior Flight Operations Software Engineer Rocket Lab Chris Ching, and Pro-Vice-Chancellor College of Engineering Professor Jan Evans-Freeman.

People's Choice Award Winner:

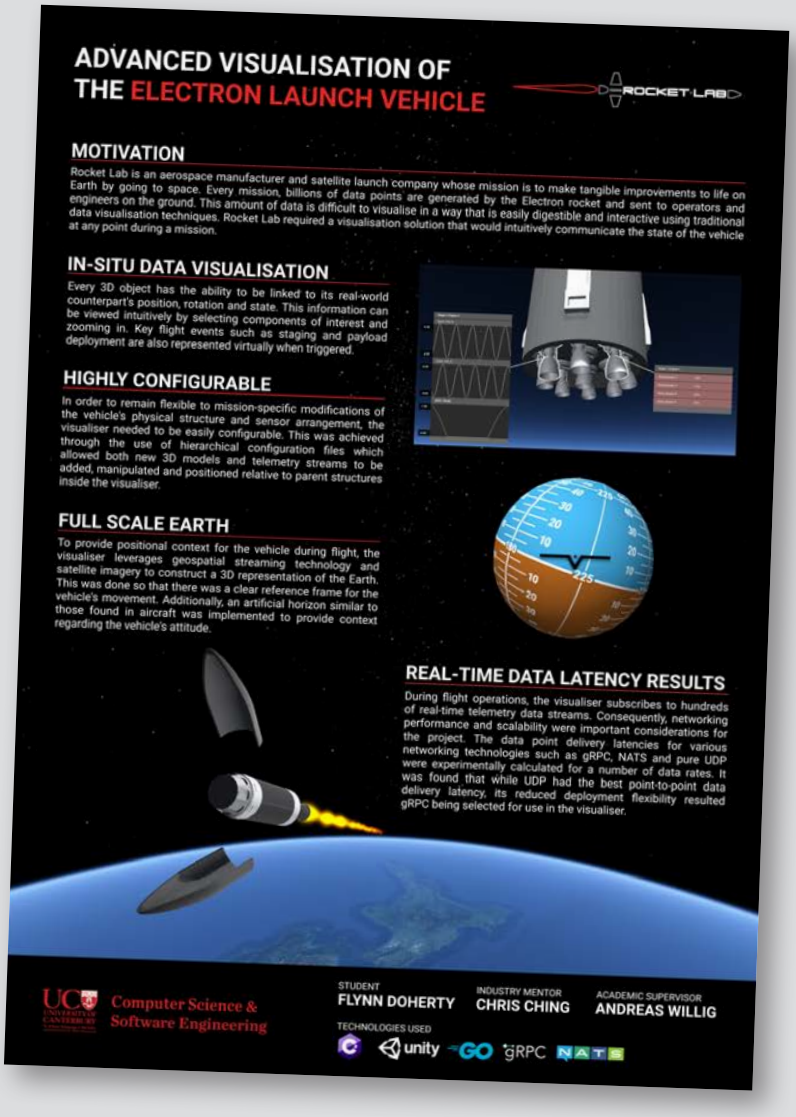
Project Poster:
"Advanced Visualisation of the Electron Launch Vehicle"

Project Sponsor: Rocket Lab – Chris Ching

Project Student: Flynn Doherty

Academic Supervisor: Professor Andreas Willig

See more on page 146



Student projects: Civil and Natural Resources Engineering

DESIGN OPTIMISATION OF HYDRAULICS AND ALKALINITY FOR THE STORMINATOR™

S. A. Pattinson and M. H. Wearn
Assoc Prof. A. D. O'Sullivan, Dr. F. J. Charters and Prof. T. A. Cochrane

OBJECTIVES

This research aims to optimise design of the Storminator™ with respect to hydraulic performance and water quality.

The first objective is to investigate the effect of mussel shell size distribution on hydraulic conductivity.

The second objective is to trial peat moss and alder cones as polishing layers for alkalinity management. This will include investigating performance after 24 hours.

BACKGROUND

The dissolved metals in roof runoff threaten the aquatic life of Aotearoa waterways. An innovative approach to managing this issue is the Storminator™ which is a downpipe treatment system (DTS) where roof stormwater is passed through a column of treatment media such as mussel shells.

Alder Cones

Mussel Shells

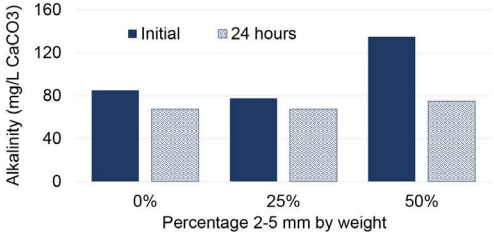
Peat Moss

Hydraulic conductivity of DTS columns informs design optimisation of stormwater capacity against treatment of dissolved metals. Hydraulic conductivity can be adjusted by changing the size distribution of the treatment media.

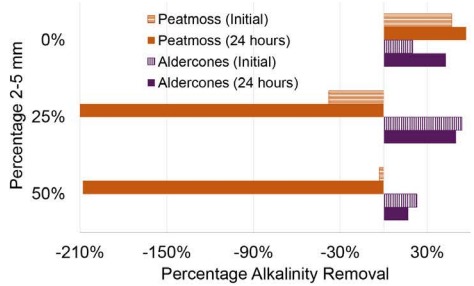
DTS mussel shell columns have been shown to spike alkalinity, harming the receiving environment. This effect has been found to worsen if columns dry between storm events. A polishing layer of alder cones or peat moss at the outflow might manage this spiked alkalinity.

ALKALINITY

There was no spiking effect on the alkalinity of mussel shells after 24 hours of drying, nor was there a consistent effect of size distribution on alkalinity elevation.

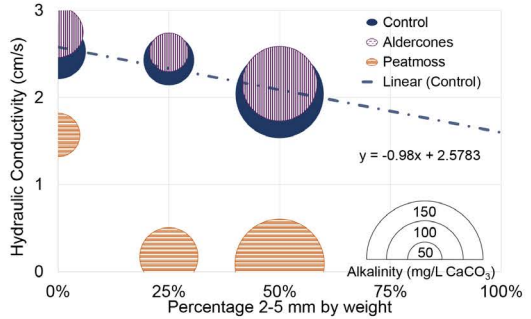


The alkalinity removal of the alder cones was consistent, but did not reach the 80% threshold for effective treatment. Peat moss showcased high variability and alkalinity spiking, rendering it counterproductive as an alkalinity polishing layer. This was likely due to mussel shell fines becoming trapped above the hydraulically restrictive peat moss layer during the initial flowthrough of the DTS column and spiking the outflow of the flowthrough completed 24 hours later.



HYDRAULICS

Hydraulic conductivity for mussel shells over increasingly fine particle sizes showed a noticeable linear decrease. The columns with alder cones followed this trend closely, but at a higher hydraulic conductivity likely due to the material acting as a free draining layer at the outlet. The columns with peat moss proved to be significantly more hydraulically variable and restrictive than the control columns.



RECOMMENDATIONS

It is recommended that more full-scale flowthrough tests be completed with higher percentages of 2-5 mm in order to validate the forecasted hydraulic conductivity trendline for decision-making.

Peat moss is not suitable for alkalinity management as it is hydraulically restrictive and exacerbates alkalinity issues.

Alder cones demonstrate excellent hydraulic conductivity and consistent alkalinity removal, so are recommended for consideration during future design of an alkalinity polishing layer.

Circularity, Standardisation and Sustainable Materials for Creative and Evolving Forms

Civil Engineering Final Year Research Project 2020

Project Team: H. Blakely and R. Inch

Project Supervisors: A. Palermo and S. Sparano

UNIVERSITY OF CANTERBURY

1. BACKGROUND

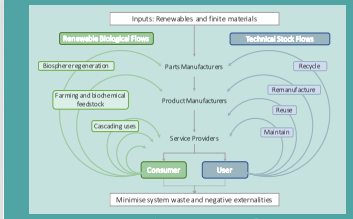


Figure 1: Circular economy resource flows

CIRCULARITY

- A circular economic framework incorporates **reuse, repair, remanufacturing and recycling.**
- **Modularity** allows for **element reuse** as a form of circularity.
- **Circular materials** can supply the biological and technical flows (Figure 1).

SUSTAINABILITY

- Current construction practices cause **excessive resource use and environmental harm.**
- **Fundamental changes** are required to transition to a sustainable future.
- **Circularity, Sustainability and Biomimicry** can be used for this change.

BIOMIMICRY

The **corrugated bivalve shell structure** inspired design by:

1. The structural integrity of these shells from their **corrugation**
2. The overlapped **microscopic structure**
3. The incremental **growth process**

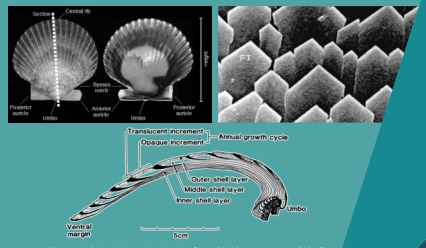
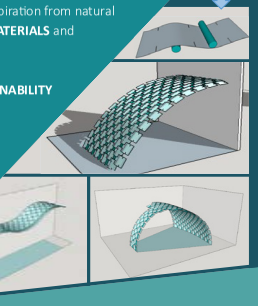


Figure 2: Biomimicry inspiration from bivalve corrugated shell.

2. OBJECTIVES

- Develop a structure that incorporates **CIRCULARITY** principles, through reuse and reducing construction waste.
- Explore **MODULAR** systems for resilient sustainable construction methods.
- Research **BIOMIMICRY** and draw inspiration from natural forms, **MATERIALS** and processes.
- Use **SUSTAINABILITY** concepts in structural engineering.



Biomimicry inspiration from bivalve shell and applying key concepts

Brainstorming/sketching

Module prototyping
= shell corrugation, interlock and layered growth

CAD modelling structures

Variety of structures
= reuse, modular, circular

3. CONCEPT DEVELOPMENT

4. NUMERICAL ANALYSIS

SINGLE ELEMENT FAILURE ANALYSIS IN ABAQUS

1. Plastic deformation of module from corrugation

- Corrugation was beneficial for overall stiffness, but detrimental when rods caused plastic deformations.
- Acceptable rod diameters determined as: < 18.9 mm (MDF), < 24.8 mm (plywood) and < 7 mm (bioplastic).

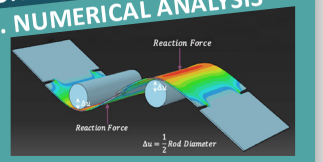


Figure 3: Overview of plastic deformation analysis in Abaqus. Rods induce stress and model used to determine when rod diameters caused permanent plastic deformations.

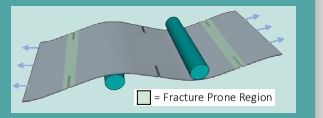


Figure 4: Overview of fracture analysis with fracture planes and tensile stresses applied.

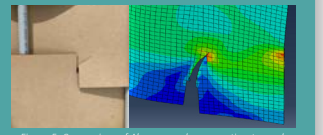


Figure 5: Comparison of Abaqus crack propagation to crack from physical prototyping. Similarities demonstrate the validity of the analysis.

2. Fracture of module from excessive tensile loading

- Critical applied tensile stresses were found to be 3.5 MPa (MDF), 7 MPa (plywood) and 6.5 MPa (bioplastic).

FOUR-MODULE ASSEMBLY ANALYSIS IN SAP2000

- Stresses under tension peaked in Slot 1 on Module 2 (yellow) at 12.1 MPa (MDF), 25.0 MPa (plywood) and 23.3 MPa (bioplastic) which were all less than the fracture and yielding limits, indicating better structural performance as an interlocked structure.

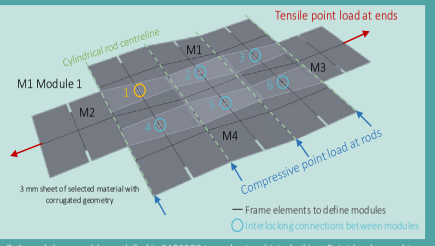


Figure 7: 4-module assembly modelled in SAP2000 to understand interlocking. Point loads equal to maximum critical loads determined in Abaqus applied in tension and then in compression.

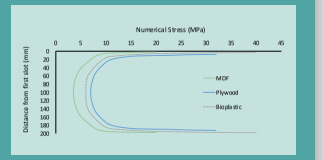
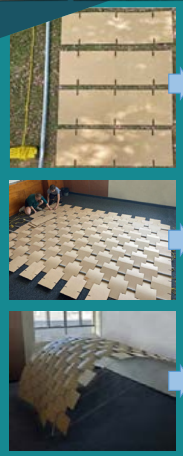


Figure 6: Stress distribution under critical tensile loading.

5. FULL-SCALE PROTOTYPING



Individual components.

Building in layers by interlocking modules around the rods.

Tension ropes through rods to achieve desired form.

Figure 8: Construction process.

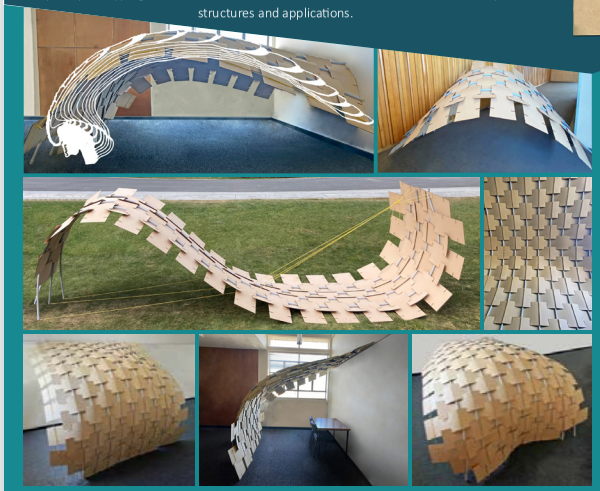


Figure 9: Series of structures created from the same interlocking modules.

6. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The project developed and analysed a modular design to satisfy circularity, modularity and biomimicry principles.

RECOMMENDATIONS

Further investigation into more novel circular materials that provide adequate structural capacity should be conducted.

Explore prototyping with more structural materials in order achieve a wider variety of structures and applications.

Cost-benefit Analysis of Green Homes: a Case Study in New Zealand

Project Team: Erik Jorgensen & Rebecca Till

Supervisor: Brian Guo

Objectives

- Produce a cost-benefit analysis of 'green' renovation options
- Evaluate the renovation options against the Homestar system
- Recommend improvement options to the home owners
- Evaluate the validity of the Homestar system

Background

A green home aims to minimise environmental impact although common perceptions exist that they are expensive and uneconomical. The benefits of green homes include financial savings, health, comfort and increased property valuations. Different systems are used globally to measure green buildings; Homestar is the system used in New Zealand. Homestar scores are out of 120; a 40 indicates a home built to minimum standards.

Methodology

Figure 1. A photo of the case study house on Happy Home Road.

The case study house on Happy Home Road in Westmorland, Christchurch, was scored against the Homestar V4 Technical Manual. Renovation options were considered to decrease the energy or water usage of the property.

These renovation options were evaluated using the payback period method. The payback period is the time it takes for the sum of the annual savings to be equal to the initial costs where a short payback period is beneficial. The costs of upgrades were taken from building supply merchants and product specifications and did not consider maintenance costs. The annual savings were calculated based on rates of \$0.29/kWh for electricity and \$1.95/m^3 for water (MBIE 2020). Benefits such as health, comfort and house value were not financially quantified but are an additional benefit of green homes.

Simulations were performed in Python to identify and recommend a combination of elements to meet different Homestar levels, with the shortest payback period.

Results

The existing Happy Home Road property has a Homestar score of 55.15, from the Homestar Built Scorecard. Renovation options which increase the Homestar score are shown in Table 1. The options were limited to simple renovations due to constraints associated with an existing house. Constraints include house orientation, layout, neighbourhood amenities and construction materials.

Table 1. The payback period and Homestar points associated with different 'green' renovation options.

'Green' Renovation Option	Payback period (years)	Homestar points
Light emitting diodes (LED's)	0.2	0.5
Compact fluorescent lights (CFL's)	0.7	0.5
Indoor washing line	1.8	0.4
Hot water cylinder lagging	1.9	0.2
Heat pump in bedroom 1	3.8	0.2
Heat pump in bedroom 1 & 2	5.2	0.4
Solar hot water (4kWp plates)	6.9	2.1
Solar hot water (3kWp plates)	7.0	2.1
Instantaneous electric hot water	7.0	0.3
Efficient shower heads (5L/min)	7.7	0.5
Solar hot water (2kWp plates)	8.3	2.1
Solar panels (2kW)	9.2	0.8
Solar hot water (tube system)	9.5	1.6
Slab insulation	9.6	1
Solar panels (3kW)	10.0	1.2
50L Hot water cylinder	10.3	0.2
Hot water heat pump	11.8	1.2
Roof insulation (R6 level)	13.7	1
Double glazing	17.2	3.4
600L rain tank – outdoors	26.4	0.5
2500L rain tank – toilet & outdoors	28.4	1
Efficient taps (4.5L/min)	30.4	2
5000L rain tank – toilet & outdoors	31.2	1.5
PVC window frame and double glazing	42.2	4.4
Efficient toilets (4.5/3L flush)	167.6	1

Recommendations

Simulations analysed all combinations of element improvements and produced recommendations for the home owners (Table 2).

Table 2. Recommended improvements for the Happy Home Road property.

'Green' Renovation Option	6-star	7-star
Slab insulation	✓	✓
Hot water cylinder lagging	✓	✓
Light emitting diodes (LED's)	✓	✓
Efficient taps (4.5L/min)	✓	✓
Indoor washing line	✓	✓
Double glazing		✓
Roof insulation (R6 level)		✓
Instantaneous electric hot water		✓
Efficient shower heads (5L/min)		✓
Solar hot water (4kWp plates)		✓
Heat pump in bedroom 1		✓
Solar panels (2kW)		✓
Cost (\$)	1,440	29,505
Annual saving (\$)	536	4,316
Payback period (years)	2.68	6.83

Evaluation of the Homestar System

The Homestar points and benefit should fit linearly, regardless of the category. This is not evident between Homestar points and annual savings, however reasons such as the high proportion of renewable electricity in New Zealand (MBIE 2019), undervaluation of water (Kviberg 2008) or flaws with the Homestar system can explain this disparity, so the system is still valid.

Conclusions

The Happy Home house has many 'green' renovation options, with different payback periods and Homestar scores (Table 1). Recommendations are shown in Table 2. There is a poor linear fit between annual savings and Homestar points, but the system is still suitable.

References

- MBIE (2019). "Energy in New Zealand."
- MBIE (2020). *Quarterly Survey of Domestic Electricity Prices: Report 15 May 2020.*
- Kviberg, K. (2008). "Value and price: a transdisciplinary approach to urban water management." *Environmental Economics and Investment Assessment II.*

BGU02

Student projects: Civil and Natural Resources Engineering

Gravity Currents Interacting with Sloped Obstacles

A. Gibbs and K. Andrew
Project supervisor: C. McConnochie

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Background Research

Gravity currents are formed when a fluid of one density flows horizontally into a fluid of a different density. Gravity currents occur from both natural and man-made situations. Examples of these flows include sea breezes, thunderstorm fronts, avalanches, haboobs and accidental releases of dense gas.

The leading edge of a gravity current is characterised by the "head". The head is typically deeper than the subsequent flow and maintains control of the current. The level of mixing that occurs within a gravity current is influenced by the density difference between fluids.

Gravity currents propagating into a field of roughness elements is of importance to many physical applications. Examples of gravity currents encountering rough mediums are sea breezes meeting tall buildings, dense ocean currents over rough sea floors and haboobs interacting with cityscapes and mountain ranges.

Figure 1. Haboob encountering a city. Source:https://www.techeblog.com/5-fascinating-things-about-gravity-current-powered-haboobs/

Figure 2. Haboob encountering mountains. Source: https://www.accuweather.com/en/accuweather-ready/how-and-where-dust-storms-occur/686881

Objectives

To extend the understanding of how gravity currents interact with obstacles, the behaviour of a gravity current as it meets with a non-vertical barrier will be investigated. A focus will be on how the gravity current propagates after the interaction with the sloped barrier and the amount of mixing observed as a result of the obstacle. The response of the current when the sloped obstacles are spaced apart will also be studied.

Methodology

Gravity currents were simulated in the laboratory using the density difference between salt and freshwater solutions. When L = 0 mm, three different water heights of H = 150 *mm*, 200 *mm* and 270 *mm* were tested. A second set of experiments were conducted with H = 200 *mm* with spacings of L = 50 mm, 100 mm and 200 mm between the obstacles.

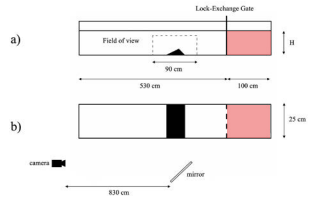


Figure 3. An (a) elevation view and (b) plan view of the lock-exchange experimental set-up.

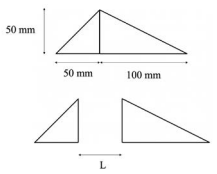


Figure 4. The dimensions and configurations of the obstacles.

Observations

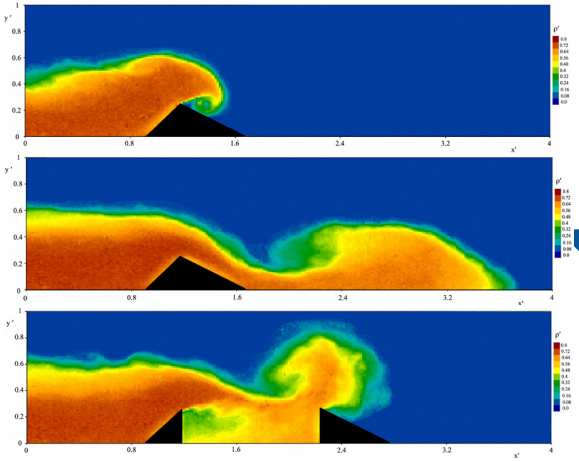


Figure 5, 6 and 7. The intensity field produced using Streams of the gravity current encountering a sloped obstacle with L=0 mm and two obstacles spaced at L= 200 m.

Results

A difference was seen in the Froude number before and after the currents interacted with the spaced obstacles.
The spacing configurations also affected the density profile of the current between the obstacles. The current experienced a period of slow mixing followed by different levels of rapid mixing until the speed of mixing slowed and converged.

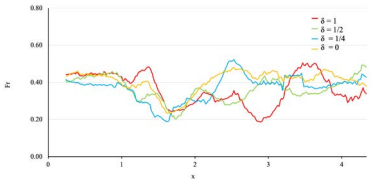


Figure 8. The average Froude number of the gravity current.

The maximum height of varying density concentrations over time was found at each point along the horizontal axis. The density stratification within the current shows the amount of additional mixing that occurred from the obstacles.

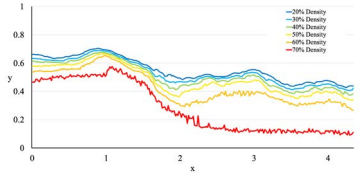


Figure 9. Density contours showing the maximum height over time of varying density concentrations when L=0 and H= 200 mm.

Conclusions

The presence of the sloped obstacles and the relative spacing impacted the current in different ways. The Froude number of the current depended more on the obstacle spacing than the height. A larger spacing between the obstacles also allowed for more dense fluid to be confined in the region contributing to the maximum average density. It was found that the overall current height was affected by the presence of the obstacle but insensitive to the spacing size.

CDM04

Soil-Foundation-Structure-Interaction

Civil Engineering Final Year Research Project.
Project Team: Charlie Walsh & Richard Leacock
Academic Supervisor: Christopher McGann

WHAT IS SFSI?

Figure 1. Residual deformations following seismic SFSI. (Photo credit: GEER)

SFSI accounts for the difference between the theoretical fixed-base response and the observed dynamic response. It is a complex issue due to the uncertainty associated with soil properties, structural properties, ground motion, and dynamic interaction.

PRINCIPAL EFFECTS

(1) Inertial Interaction Effects

Inertial interaction describes the impact of the vibrating superstructure on the observed system response. Inertia - driven forces, such as base shear and overturning moment result in displacements and rotations at foundation level.

Inertial interaction are responsible for two fundamental aspects of the SFSI problem: (1) period lengthening due to increased system flexibility; and (2) increased energy dissipation due to material damping and radiation damping.

(2) Kinematic Interaction Effects

Kinematic interaction results from the inability of stiff foundation elements to conform with free-field ground motion. Base-slab averaging is one kinematic effect whereby stiff foundation systems average spatially varied ground motion within the building footprint.

(3) Soil-Foundation Flexibility

Soil-Foundation flexibility permits rotations and displacements at foundation level and significantly contributes to the overall system flexibility. If the foundation can deform in the soil then it can lead to irrecoverable and permanent deformations (differential settlements, tilt...) which can have detrimental secondary implications for the superstructure.

BENEFITS AND DETRIMENTS

Whether SFSI effects are beneficial or detrimental can be conceptually explained by considering the shape of the acceleration response spectra between the fixed based period, T_F, and the elongated period, T_e.

Period elongation and increased system damping result in reduced seismic demand when combined with conventional code-based design spectra. Therefore, SFSI has been interpreted as beneficial in some major design codes. However, If the structure has a fixed-base period less than the predominant period of the input ground motion and/or site, then the structure could be located on an ascending branch of the response spectra. In such instances, period elongation due to SFSI may increase the seismic demand.

Figure 2. Acceleration spectra which demonstrates occasions when the induced accelerations, due to period elongation of SFSI, are likely to be beneficial of detrimental

PROJECT OBJECTIVES

The purpose of this study was to investigate how SFSI effects are amplified or diminished by soil and structural variability, and input ground motion. This was done by comparing the response of a fixed-base SDOF oscillator to the response of a flexible-base (equivalent) SDOF oscillator as illustrated in Figure 3.

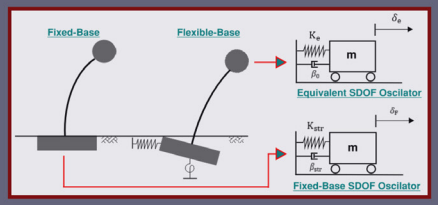


Figure 3. Schematic of SDOF systems and corresponding oscillators used to model SFSI effects.

The study was split into three interrelated parts, and the Structural Distortion Modification Factor (SDMF) and Period Modification Factor (PMF) were used to quantify SFSI effects. These parameters are defined below.

SDMF - Ratio of structural distortion in the equivalent system to fixed-base system displacement. SDMF greater than unity indicates increase in structural distortion.

PMF - Ratio of elongated period, T_e, to fixed-base period, T_F.

PART 1 - A parametric study was undertaken for an SDOF system consisting of a unit mass with a soil spring and structural spring connected in series. From this, a theoretical relationship between the variation in structural distortion and the relative stiffness between the two springs was developed.

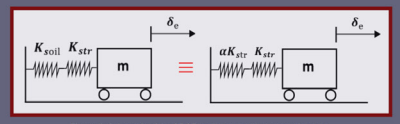


Figure 4. Schematic of the SDOF oscillator used in parametric study.

PART 2 - Simplified provisions outlined in ASCE 7-16 were used to determine period elongation for a range of SDOF systems located on NZS 1170.5 site subsoil classes (SSC) C, D, and E. The SDOF systems were developed such that the parameters were reflective of real structures and soil conditions. NZS 1170.5 design spectra were used to determine spectral acceleration ordinates corresponding to the fixed-base period and elongated period. These were converted to spectral displacements to estimate the total displacement of the fixed-base system and flexible-base system. The structural distortion in the flexible - base system was then calculated from the total displacement using established physics principals for two springs connected in series.

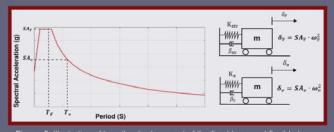


Figure 5. Illustration of how the displacement of the fixed-base and flexible-base (equivalent) SDOF oscillators were determined from code-based design spectra

PART 3 - Response history analyses were performed using Newmark's method for a range of fixed base SDOF systems and the corresponding equivalent SDOF oscillators. The observed variation in structural distortion was compared with that predicted for the respective site subsoil classes in PART 2.

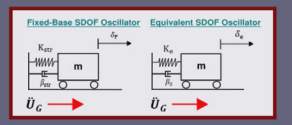


Figure 6. Schematic of fixed-base and flexible-base (equivalent) SDOF oscillators subject to earthquake ground motion recordings.

RESULTS AND CONCLUSIONS

(1) The parametric study (Part 1), shown as black in figure 7, generally resulted in a conservative reduction in SDMF, across the entire PMF range, when compared with the code-based provisions approach (Part 2) and the response history approach (Part 3).

(2) The PMF increases with the ratio of structural stiffness to soil stiffness indicating SFSI effects are more important for stiff structures on soft soils.

(3) Simplified code - based provisions for incorporating SFSI are available, but these can only reduce seismic design actions when used with code - based design spectra.

(5) Structures with shorter natural periods are more likely to be on an ascending branch of the response spectra and experience detrimental SFSI effects.

(6) Non-linear effects were excluded from this study but are likely to shift the mean SDMF toward unity thereby lessening the perceived SFSI benefits.

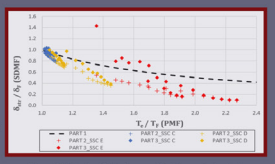


Figure 7. Structural distortion modification against period modification. The theoretical curve corresponds to PART 1, the '+' correspond to PART 2, and the '♦' correspond to PART 3.

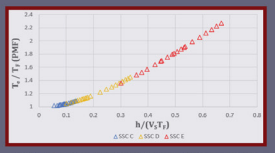


Figure 8. Relationship between structure-soil stiffness ratio and period modification factor.

PROJECT CODE: CMC04

Student projects: Civil and Natural Resources Engineering

Mapping Soil Shear Wave Velocity using Cone Penetration Test Data

Supervisor: Dr. C. McGann

Students: Y. Wong and S. Rajanayagam

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Definitions

CPT = cone penetration test
V_s = shear wave velocity (m/s)
V_{sz} = V_s from ground surface to CPT termination depth (m/s)
V_{s30} = V_s from ground surface to 30 m depth (m/s)
I_c = soil behaviour type index

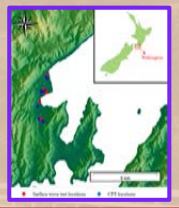
1. Introduction

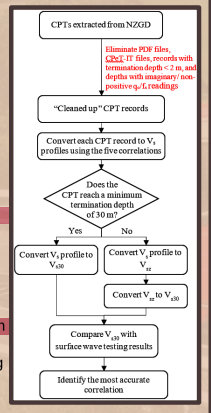
The purpose of this project was to create a V_{s30} map for the greater Wellington region through the validation of five CPT - Vs correlations, including (i) Andrus et al. (2007); (ii) Hegazy and Mayne (2006) ; (iii) McGann et al. (2015b); (iv) McGann et al. (2018); and (v) Robertson (2009). CPT data is more readily available across New Zealad compared to shear wave measurements and could be used to supplement direct measurements of V_{s30} from surface wave tests.

2. Methodology

The project was separated into two stages.

Surface wave data was retrieved from DesignSafe, while CPT data was retrieved from the NZGD.





Stage 1: Comparing Correlations

Compared the applicability of five CPT to V_s correlations using the "adopted dataset" to find the preferred correlation. This involved the utilisation of 83 CPTs.

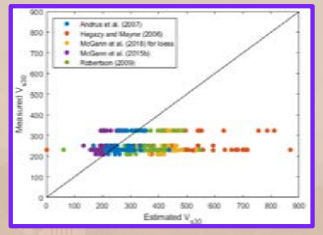
Stage 2: Mapping V_{s30} for Wellington

Produced a V_{s30} map of the Wellington region using the "entire dataset" using findings from Stage 1. This involved the utilisation of 537 CPTs.

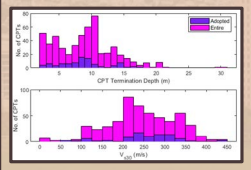
3. Results

Stage 1: Comparing Correlations

It was evident that McGann et al. (2015b) underestimated V_{s30}, while the other four correlations produced overestimations. The correlation by Andrus et al. (2007) was deemed the preferred correlation due to its centricity about the 1:1 line.



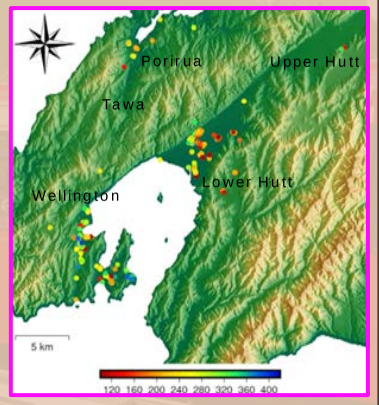
Stage 2: Mapping V_{s30} for Wellington



The histograms showed that the adopted and entire datasets have similar trends and therefore the correlation by Andrus et al. (2007) was determined to be a suitable fit for both datasets.

From the V_{s30} map, Upper Hutt and Lower Hutt were observed to have lower V_{s30} estimates overall than Wellington City.

Maps of CPT termination depth, V_{sz} and I_c were created to aid in the interpretation of the V_{s30} map.



4. Conclusions

A primary investigative result showcased that a deep termination depth yielded a smaller difference between V_{sz} and V_{s30}.

CPTs with low termination depths, around 2 m, resulted in severe variance between V_{sz} and V_{s30} values. This is likely due to soil profile characteristics as some CPTs show V_{sz} in close proximity to V_{s30}.

In terms of soil profiles, Tawa and Porirua showed characteristics of higher I_c values indicative of clay, with comparatively lower V_{sz} values compared to other towns of the study area. The V_{s30} results observed suggest Class C or D soil types as described in NZS 1170.5.

For a comprehensive V_{s30} map of New Zealand to be developed, more shear wave testing must be conducted across the country. Should the project be pursued, a Wellington-specific correlation could be created based on the findings of this study.

5. Acknowledgements

We would like to offer a huge thanks to our supervisor, Dr. Christopher McGann, for guiding us on this project and helping us to process the raw data. We would also like to thank our classmate, Claire Dong, for providing and explaining codes she developed for a similar project previously. A special thanks to Dr. Robin Lee for providing helpful feedback on our milestone submission and never failing to chat with us on how the project was fairing. Without CPT records from the NZGD and shear wave testing records from Cox and Vantassel (2018), the research would not be successful.

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Project Code: CMC05

VR EXPERIMENTS IN A HOTEL ROOM CONFIGURATION

J. Bromley and N. Yung Project Supervisor: D. Nilsson

UC UNIVERSITY OF CANTERBURY

1. BACKGROUND AND OBJECTIVES

The MGM Grand Hotel fire broke out at approximately 7 am on 21 November 1980. The primary cause was an electrical ground fault in the deli area of the ground floor casino. It took six minutes from discovery, for the entire casino to be engulfed in flames. 87 people died and over 700 people were injured in this fire. Bryan (1983) conducted a post-fire questionnaire to determine the behaviour of the occupants and collected data on their experiences.

Options to evaluate fire risks include unannounced fire drills, performing life-sized experiments, and using virtual reality (VR).

The objective was to test whether the use of VR results in realistic human behaviour in a fire situation. More specifically, to study human behaviour in fire of people trapped in a hotel room.

2. METHOD

A total of 36 participants took part in the experiment.
The participants were asked to see how interactive the VR setup was and how realistic the simulation felt.

Participants were not informed that a fire was going to occur during the experiment and there was no reference to fires/smoke in the information sheet, consent form or briefing.

Figure 2. HMD and controllers in use.

A photo of the lab where the experiments were conducted can be seen in Figure 1. Figure 2 shows what the head mounted display (HMD) equipment (HTC Vive) looks like on the participants.

For this project, the MGM Grand Hotel was simulated as the virtual environment (VE) as shown in Figure 3. Figure 4 shows what the room looks like with the smoke entering from the vent.

The flow chart to the right outlines the experiment procedure.

Figure 1. VR experiment room.

Figure 3. Overview of the room.

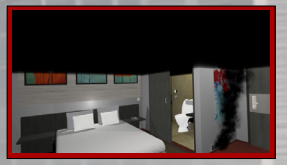

Figure 4. Smoke accumulation.

3. RESULTS

Table 1 shows the results from Bryan's study for the MGM Grand fire responses compared to the data collected from the VR experiment.

The results below were obtained from the conducted questionnaire. The numbers in the following figures represents the number of participants.

Table 1. Results from experiment compared to Bryan's study.

	VR experiment		Bryan	
	Number	%	Number	%
Attempted phone	24	21.2	275	27.4
Put materials - door	3	2.7	224	22.3
Turned on radio/TV	16	14.2	148	14.8
Put materials - HVAC	28	24.8	105	10.5
Wet towels - face	6	5.3	85	8.5
Prepared sign	15	13.3	29	2.9
Other	21	18.6	109	2.7
	113	100	1002	100

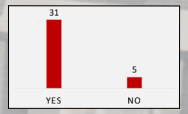

Figure 5. Did the participants feel immersed in the VE.

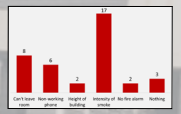

Figure 6. What made the participants feel stressed out.

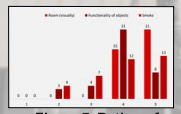

Figure 7. Rating of realism for components of the VE, from 1 (low) to 5 (high).

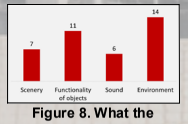

Figure 8. What the participants thought was realistic in the VE.

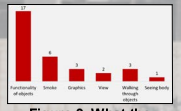

Figure 9. What the participants thought was unrealistic in the VE.

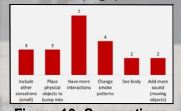

Figure 10. Suggestions to improve realism in the. VE

4. CONCLUSION

- For future studies, it is suggested to implement consequences such as a decreasing health bar for lack of actions and include other sensations to enhance the VR experience.
- In addition, a modern scenario should be conducted to decrease the disparity between the participants' actions and guests' actions.
- Overall, participants felt immersed enough in the VE to perform actions as they normally would in a real situation.
- Therefore, VR has the potential to be a tool to model realistic human behaviour for participants trapped in a hotel room by a fire.

5. ACKNOWLEDGMENTS

The researchers would like to give a big thank you to our supervisor Daniel Nilsson for giving us direction and feedback throughout this project. The researchers would also like to acknowledge Silvia Arias. Lastly, the researchers would like to acknowledge the HEC and the participants for being involved in the experiments, for whom the experiment would not be possible without.

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Bryan, J. (1983). "A review of the examination and analysis of the dynamics of human behavior in the fire at the MGM Grand Hotel, Clark County, Nevada as determined from a selected questionnaire population". *Fire Safety Journal,* 5(3-4), 233-240.

Student projects: Civil and Natural Resources Engineering

The influence of the University of Canterbury campus on the hydrologic and hydraulic behaviour of the Avon River: now and in the future

Department of Civil and Natural Resources Engineering: Final Year Project 2020
Project Team: Monica Hoetjes and Alex Tong
Academic Supervisor: Dr Frances Charters

PROBLEM

- The Haereroa-Avon river is a **receiving environment** for campus stormwater runoff and air conditioning discharges
- The Haereroa-Avon River flows through the **University of Canterbury Ilam Campus**. This study considers the section between Ilam Road and Clyde Road
- **Little previous research** has examined the hydrologic and hydraulic behaviour of the Haereroa-Avon River
- **Future campus developments are planned** that will change the volume of stormwater that flows into the river – and may pose flooding and ecological risks
- The outcomes from this research can be used to **assist UC with future decision making** around stormwater management

OBJECTIVES

- To determine the **influence of current UC campus stormwater runoff** on Haereroa-Avon River water depth and flow, under varying rainfall conditions
- To predict the influence of **future campus development** on stormwater runoff into the river and the resulting instream flow

METHODOLOGY

Fieldwork

- **Surveying** to characterise the stream bed slope and cross-section
- Continuous **water depth logging** at five sites to determine current stream response to campus stormwater runoff
- **Flow gauging** under dry and wet weather conditions, to derive a relationship between water depth and flow at each site

Model Development

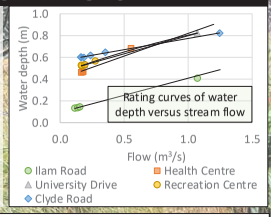
- **StormWater Management Model** was used to represent the influence of campus stormwater runoff on river flow over time
- **Model inputs** collated from UC Facilities Management and other local sources
- **Sub-catchment delineation** using CCC and UC stormwater asset maps (right)
- **Calibration** to fit modelled river flow to observed river flow
- **Validation** to check model performance at predicting flow, using another data set

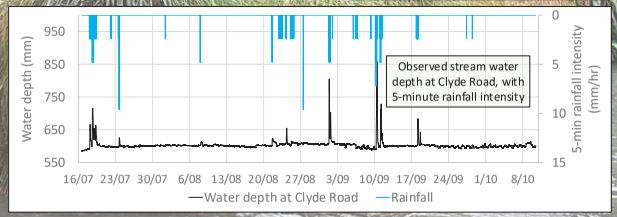
Scenario Modelling

- **Scenario development** using UC Campus Master Plan and UC Landscape Master Plan (CLMP) to predict future changes in stormwater runoff from campus into the river
- Further scenario modelling of **planned low-impact development (LID) stormwater management**, intended to reduce and delay stormwater runoff into the river

RESULTS: FIELD OBSERVATIONS

- During rain events, the **river rose quickly and became turbid** in response to stormwater runoff
- Water depth was observed to react similarly across all sites with **short lag times and steep peaks** (below), typical of urban stream catchments with high percentages of impervious surfaces i.e., roof and paved surfaces
- **Rating curves** (right) were developed, and show the relationship between water depth and flow is mostly **linear**

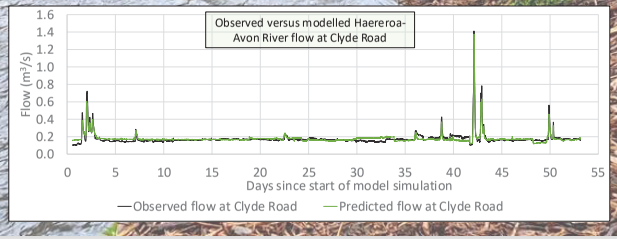




RESULTS: MODELLING

- The **modelled river flow accurately represented observed flow** at all sites, particularly for baseflow (below)
- The **model underestimated stormflow** for low intensity (2.5-5.0 mm/hr) rain events
- **Very high Nash-Sutcliffe efficiencies** were calculated during model validation. A 'perfect fit' would be equal to 1 (right)
- The **peak runoff from UC sub-catchments was observed to be small** compared to contributions from the upstream residential catchment, at **9.9%** of observed Ilam Road inflow

Monitoring Site	Nash-Sutcliffe efficiency after validation
Health Centre bridge	0.92
Halfway along University Drive	0.86
Recreation Centre bridge	0.95
Clyde Road	0.83

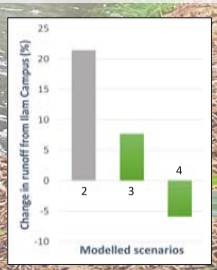


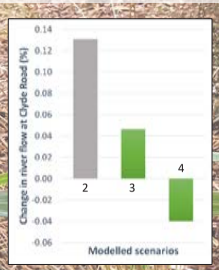
RESULTS: SCENARIO MODELLING

The following **planned UC developments** are expected to change the volume of stormwater generated from Ilam Campus, and are represented by the **four scenarios** below:

- A formal entrance around Ilam Green field with a large looped road
- A central plaza linking Central Library and the UC Students' Association building, and a courtyard between Matariki and Ernest Rutherford
- Additional stormwater from new building footprints
- Implementation of LID stormwater management devices e.g., raingardens, infiltration trenches, swales

	Campus % impervious area relative to planned CLMP development	Relative implementation of planned LID devices
Scenario 1	○○○○	○○○○
Scenario 2	●●●●	○○○○
Scenario 3	●●●●	●●○○
Scenario 4	●●●●	●●●●





CONCLUSIONS

- A model was produced that **accurately represents the influence of current UC stormwater runoff** on Haereroa-Avon River water depth and flow, over a range of rain events – as validated by the high Nash-Sutcliffe efficiencies
- **Future campus developments will increase the volume of stormwater** that enters the river. However, this additional stormwater runoff will be small compared to flow contributed from the upstream residential catchment
- Therefore, **implementation of LID stormwater management would have a minimal influence on reducing instream flow**
- Further research is recommended to consider the **additional benefits improved stormwater management would provide** e.g., improved water quality and ecological habitat

FCH01

Environmental and Geotechnical Engineering Properties of Tyre-Gravel Mixes

Civil/Natural Resources Engineering Final Year Research Project Conference 2020

Research Students: David Thoo and Sara Whibley
Supervisors: Gabriele Chiaro, Laura Banasiak and Ali Tasalloti

Environmental Analysis

Leaching Tests

Purpose
Though rubber is relatively inert, tyres are also composed of steel fibres and additives which contain ~1.5% by weight of hazardous compounds. Extensive laboratory and field research suggest contaminants from tyre leachate are toxic to various bacteria, invertebrate and fish species. Therefore, clarification is needed to understand whether and to what extent metals and other inorganic constituents will leach into the environment. This is to ensure there are no negative, **long** term impacts to the environment.

Table 1. Mixes Tested

Test	Volumetric Rubber Content (VRC) (%)	Tyre chip size	Gravel shape
1	40	Large	Rounded
2	40	Large	Rounded
3	40	Large	Rounded
4	40	Small	Rounded
5	40	Small	Rounded
6	40	Small	Rounded

Testing Procedure
Six batch tests (Table 1) were conducted under representative water chemistry conditions over a 28 day period to give a preliminary and conservative understanding on the leachability properties of the mixes.

The periodic sampling procedure involved:
- Recording pH and electrical conductivity.
- Filtering 50 mL samples through a 0.45 µm membrane filter and splitting into 12 and 30 mL samples.
- Acidifying the 30 mL sample to pH<2 and test for total organic carbon using a Shimadzu TOC high temp combustion analyser and autosampler.
- Acidifying the 12 mL sample to pH<2 and test for organic and inorganic concentrations using ICP-MS.

Results and Discussion

Analysis
Predominant inorganic constituents in the leachate were found to be Ca, Na, K, Mg and Zn. It is expected that the Ca, Na and K contents are attributed to the gravel and the Zn and Mg to the tyres. There was noticeable difference between the two testing groups (1-3 and 4-6). The leachate from smaller tyre chip mixes (tests 4-6) had a higher content of metals, implying that particle size and surface area influences the concentration and mass of elements in tyre-gravel mix leachate. Hence, in its uncompacted state, gravel-tyre mixes **with small tyre** chips have more significant potential for negative environmental impact.

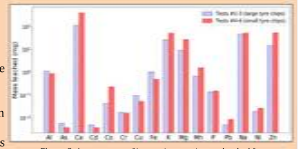


Figure 3. Average mass of inorganice constituents leached for large and small tyre chip mixes.

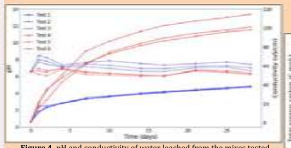


Figure 4. pH and conductivity of water leached from the mixes tested. (Dotted line - pH; Solid line - electrical conductivity).

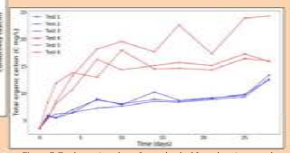


Figure 5. Total organic carbon of water leached from the mixes tested.

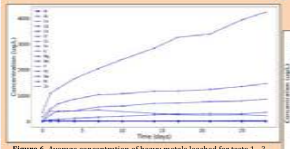


Figure 6. Average concentration of heavy metals leached for tests 1 - 3 (large tyre chips).

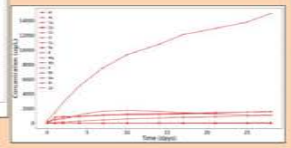


Figure 7. Average concentration of heavy metals leached for tests 4 -6 (small tyre chips).

Summary

Project Purpose

In New Zealand, over 3.5 million end-of-life tyres are disposed in unsustainable ways that pose environmental concern. To sustainably reuse tyres, a tyre chip-gravel mix is being developed for proposed use as seismic-resilient foundation systems for low-rise residential buildings. This requires a comprehensive understanding into both the geotechnical and environmental properties of the tyre-gravel mix.

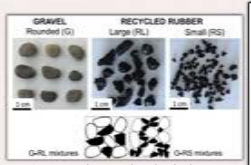


Figure 1. Tyre-chip sizes and gravel used in the mixes

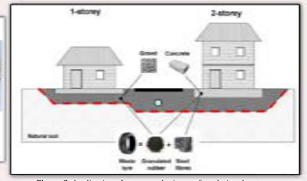


Figure 2. Application of tyre-gravel mixes as foundational systems (Source: Dr. Gabriele Chiaro).

Objectives

Environmental Objectives:
- Gain a conservative understanding of the leaching characteristics of tyre-gravel mixes by testing for pH, electrical conductivity, total organic carbon, and concentrations of organic and inorganic constituents.
- Compare leaching of large and small rubber chip – gravel mixes.
- Determine whether there are any major environmental concerns due to element concentrations in the leachate.

Geotechnical Objectives:
- Apply the composite model to the results from 1-D compression tests to derive geotechnical characteristics of tyre-gravel mixes.
- Determine the relationship between the composite model parameters and the tyre-gravel composition.
- Simulate a real-world scenario through a parametric study of the parameters derived.

Conclusion and Recommendations

Conclusion:
For environmental analysis:
- Predominant inorganic constituents in the leachate were found to be Ca, Na, K, Mg and Zn.
- Tyre chip size affects the mass and concentration of elements in the leachate.

For geotechnical modelling:
- Parameters that define the model, *C'c*, *b* and *c*, were found to increase with VRC.
- **This model** was concluded to be beneficial in providing a preliminary analysis in axial behaviours of tyre-gravel mixes.

Recommendations:
- Additional leachate testing to understand how and whether gravel angularity, compressibility and packing state, and aquatic/soil environments will affect leachate
- Further development of the model to incorporate additional geotechnical properties such as void ratio

Ultimately, it is intended that the model will be used to predict the geo-environmental performance of various tyre-gravel compositions to determine the optimum tyre-gravel mix composition.

Geotechnical Modelling

Developing and Applying the Model

Purpose
Conventional compressibility models are unable to model tyre-gravel mixes' axial compressive behaviour accurately due to the difference of elastic moduli of both materials.
Therefore, a composite compressibility model derived for landfills was used in attempt to model the axial compressive behaviour of tyre-gravel mixes.
If the model proved successful, a parametric study would be done for a defined scenario to assess **the ability of the model.**

Model Application
Two equations that defined the model were applied to experimental data obtained from 1-D compressibility studies of tyre-gravel mixes (Bloeman and Thom, 2019).
This application was done for a total of 7 mixes (Table 2) and done through Python.

Instantaneous Strain:

$$\varepsilon_v = C'_c \log\frac{\sigma_0 + \Delta\sigma}{\sigma_0} \quad (1)$$

where C'_c is the compression ratio; σ_0 is the initial axial stress; and $\Delta\sigma$ is the change in axial stress.

Mechanical Creep

$$\varepsilon_c = b(\Delta\sigma)(1 - e^{-ct'}) \quad (2)$$

where b is the coefficient of mechanical creep; c is the rate constant for mechanical creep; and t' is the time since application of the stress increment.

C'c, *b* and *c* from the equations were derived by applying the equations to the experimental results of the mixes.
These parameters define the axial compressive behaviour of the mixes, **and** are key in modelling the aixal strain profile of the mixes.

Table 2. Mixes Tested

Mix	Volumetric Rubber Content
1	0% (100% rounded gravel)
2	10% large tyre chips
3	25% large tyre chips
4	40% large tyre chips
5	10% small tyre chips
6	25% small tyre chips
7	40% small tyre chips

Results and Simulation

Model Accuracy
The model was able to mimic the general axial strain behaviour of the mixes under instantaneous strain and mechanical creep.
It was noted (Figure 8) that there **is an under**estimation and overestimation of the first and second instance of instantaneous strain respectively.

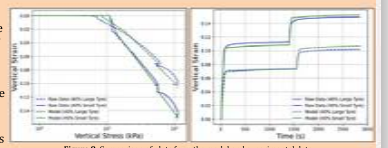


Figure 8. Comparison of plots from the model and experimental data.

Table 3. *C'c* values for the mixes.

Mix	$C'_{c(1)}$	$C'_{c(2)}$	$C'_{c(3)}$
1	8.0×10^{-3}	8.4×10^{-3}	1.2×10^{-2}
2	23.2×10^{-3}	1.1×10^{-2}	2.0×10^{-2}
3	5.5×10^{-3}	7.6×10^{-3}	5.8×10^{-2}
4	5.6×10^{-3}	6.9×10^{-3}	9.9×10^{-2}
5	34.5×10^{-3}	1.2×10^{-2}	2.2×10^{-2}
6	90.3×10^{-3}	5.2×10^{-2}	7.2×10^{-2}
7	0.4×10^{-2}	28.2×10^{-2}	13.4×10^{-2}

Analysis of Parameters
The general trend for *C'c*, *b* and *c* (Table 3 and Figure 9) is that it increases with VRC and size of tyre chips.

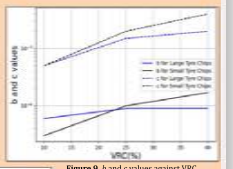


Figure 9. *b* and *c* values against VRC.

Table 4. Loading scenario for the parametric study

Loading	Time Period (Days)	Reason
Instantaneous 5 kPa	2	Foundation Materials
Mechanical Creep	28	Construction
Instantaneous 5 kPa	2	House Materials
Mechanical Creep	28	Construction
Instantaneous 5 kPa	1	Roof Materials
Mechanical Creep	9	Construction
Total: 15 kPa	Total: 70	

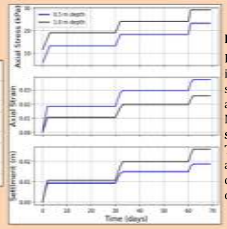


Figure 10. Strain and settlement profile over time alongside the stress profile.

Parametric Study
Figure 10 show that the model is able to produce a strain and settlement profile, for 0.5 m and 1 m deep mixes.
Mix 4 was chosen for this **simulation.**
The two analyses, took into account self-weight as well, depending on the depths of the mixes.

GCH01

Student projects: Civil and Natural Resources Engineering

Geotechnical Properties of Gravel-Rubber Mixtures

Civil Engineering Final Year Research Project

Authors: O. E. Ross and J. M. Young

UC UNIVERSITY OF CANTERBURY Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND

1. BACKGROUND

New Zealand produces over 5 million end-of life tyres (ELT) per year and disregards 70% of these in landfills, stockpiles or illegally[1]. A sustainable multi-disciplinary solution to this problem is to **re-use** and **re-cycle** ELTs. The geotechnical properties can be utilised through mechanically shearing ELTs for use in **Gravel-Rubber Mixtures** (GRM) for foundations.

Figure 1. ELTs in Waikato Landfill[2].

ERGSI: eco-rubber geotechnical seismic isolation foundation systems

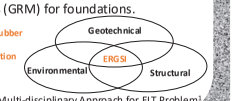


Figure 2. Multi-disciplinary Approach for ELT Problem[3].

2. OBJECTIVES

This study investigated the following, for varying volumetric rubber contents (VRC):

Properties	Method
Seismic properties	Impact testing
Long-term 1-D compressibility	1-D compression test with 1-day creep
Frictional and arching effects	Load cell analysis

Figure 3. Schematic of Project Objectives.

3. MATERIALS

Rounded Gravel	$D_{50,G}$ = 6.0 mm	G_s=2.72
Tyre Rubber	$D_{50,R}$ = 4.0 mm	G_s=1.15

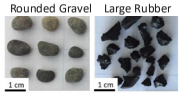


Figure 4. Material Used (left: gravel, right: rubber) [1].

The following VRC were selected for testing:

VRC (%)	0	10	25	40
Density (g/cm^3)	1.66	1.52	1.37	1.19

4. SEISMIC PROPERTIES

Method:

1. Hit the bottom of GRM specimen with an impact hammer.
2. Measure input and output accelerations (with accelerometers placed on the top and bottom of specimen).
3. Calculate frequency response functions (FRF) using cross power spectral density method.
4. Determine natural frequency and damping effects.

Apparatus:

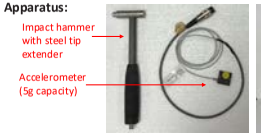


Figure 5. Impact Hammer and Accelerometers.

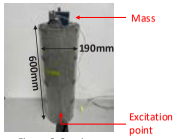


Figure 6. Specimen Set-Up.

Results and Discussion

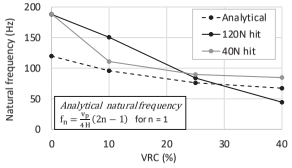


Figure 7. Natural Frequency versus VRC Showing the Isolation Effect.

- Increasing VRC increases the **effect of isolation**; this is proportional to a decrease in the natural frequency of the specimen.

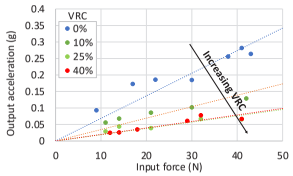


Figure 8. Input Force versus Output Acceleration Showing the Dissipative Effect.

- Increasing VRC increases the **dissipative effect**; this is proportional to a decrease in the output acceleration read by the accelerometer at the top of the specimen.

Figure 6 demonstrates the above results:

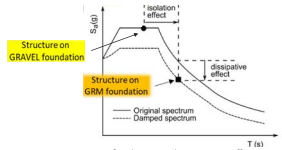


Figure 9. Demonstration of Isolation and Dissipative Effect on GRMs[1].

5. LONG-TERM 1-D COMPRESSIBILTY PROPERTIES

Method:

1. Set-up rigid cell apparatus with GRM layered in 20 mm layers.
2. Apply 20 kPa vertical load via a bellofram, connected to two pressure cylinders. Use computer logging system to record axial displacement and back pressure over time. Leave for 24 hours to observe creep behaviour.
3. Repeat Step 2 for 50 kPa, 100 kPa and 200 kPa.

Apparatus:

Figure 10. Long-Term 1-D Compressibility Test Set-Up.

Results and Discussion:

Figure 11 shows the total strain (ε_t) and long-term strain (ε_c) for different VRC at each pressure increment. The difference between total and long-term strain represents instantaneous strain.

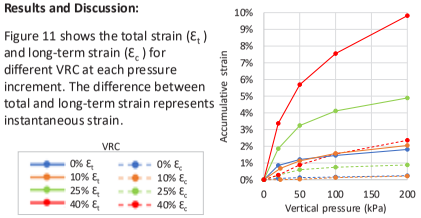


Figure 11. Vertical Stress versus Strain Showing 1-day Creep Behaviour.

- Increasing VRC is proportional:
  - to an increase in total strain.
  - to an increase in long-term strain and **creep behaviour**.
  - to an increase in the rate of long-term strain for any applied vertical stress.

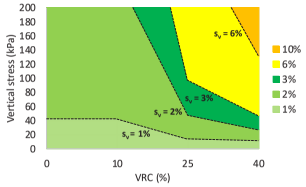


Figure 12. VRC versus Vertical Stress Showing Settlement Zones For 1-day Creep.

- Green-shaded zones show allowable settlement regions for each VRC.
- Increasing VRC is proportional to increasing settlement for a given vertical stress.

6. FRICTIONAL AND ARCHING EFFECTS

The load transfer efficiency (LTE) of each specimen used in the 1D compressibility tests can be estimated using a load cell, placed at the bottom of the apparatus. A porous stone was placed on top of the load cell to ensure even distribution of stress (Figure 13).

Method:

1. Place a known mass on top of the porous stone/load cell.
2. Record and plot voltage output.
3. Repeat Steps 1 & 2 with various known masses.

Apparatus:

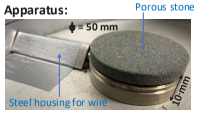


Figure 13. Load Cell and Porous Stone Configuration.

Results and Discussion:

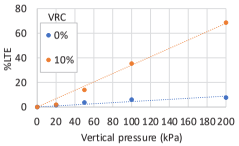


Figure 14. LTE for Various Specimens.

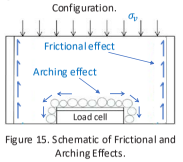


Figure 15. Schematic of Frictional and Arching Effects.

- Increasing VRC is proportional to a higher LTE.
- Possible reasons for inefficiencies:
  - **Frictional effects:** Interface behaviour between particles and apparatus reduces the pressure experienced by the load cell and lower particles.
  - **Arching effects:** Interlocking of particles surrounding the load cell redistributes the pressure via arching action, towards the base of the apparatus and away from the load cell.

7. RECOMMENDATIONS

- Undertake further impact tests using a specimen with a larger area, to mitigate and quantify possible boundary effects.
- Perform impact tests with incremental layer heights and relate to real life applications.
- Use a force-application mechanism to ensure the same input load is applied for each impact test.
- Evaluate frictional and arching effects for all GRM specimens.
- Use the LTE analysis results to correct 1D compressibility data.

8a. REFERENCES

1. Chiaro, G., Tasalloti, A., Banasiak, L.J., Palermo, A., Granello, G., Rees, S. (2020). "Sustainable recycling of end-of-life tyres in civil (geotechnical) engineering applications: turning issues into opportunities in the New Zealand context." 99, 38-47.

8b. ACKNOWLEDGEMENTS

The authors wish to thank Dr. Gabriele Chiaro and Dr. Ali Tasalloti for providing guidance and advice throughout the project. Thanks is also given to Dr. Sean Rees, Dr Gabriele Granello and Mr. Siale Faitotonu for contributing greatly to the success of the project.

Supervisors: Dr. G. Chiaro and Dr. A. Tasalloti

GCHO3

DESIGN AND ANALYSES OF GRAVITY-CANTILEVER RETAINING WALLS BACKFILLED WITH A LIGHTWEIGHT MATERIAL

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CHRISTCHURCH NEW ZEALAND

STUDENTS: T. TAN AND S. ABD RAHMAN | **SUPERVISORS:** G. CHIARO AND A. TASALLOTI

BACKGROUND

70% of the **5 million end-of-life tyres** produced each year in New Zealand end up in the land-fill or unaccounted for (Cann, 2017).

These waste products could be reused as low-cost lightweight backfill materials for retaining walls when mixed with gravel such as shown in Figure 1. The material's low unit weight could **reduce the lateral earth pressure and effective stress** behind the wall (Chiaro et al., 2020).

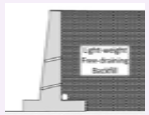

Figure 1. Example of potential reuse of material (Chiaro et al., 2020)

MATERIAL ANALYSED

The rubber-gravel mixtures consisted of a uniform pea gravel with rounded grains (G) and coarse-sized granulated recycled rubber (RL). The rubber-gravel mixtures that were analysed for this project were of **0%, 10%, 25% and 40%** volumetric rubber content (VRC) as shown in Figure 2. Mixtures with rubber contents beyond 40% were not considered due to compressibility issues in engineering applications (Chiaro et al., 2020).

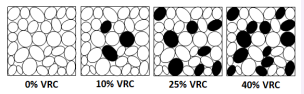

Figure 2. Volumetric fraction of the rubber-gravel mixtures tested.

METHODOLOGY

Physical Testing

Physical testing was undertaken for **0% and 25% VRC** material using the small-scale retaining wall apparatus in Figure 3.

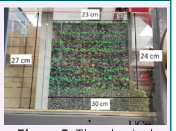

Figure 3. The physical testing setup.

Numerical Simulation

The small-scale laboratory setup was also modelled on PLAXIS as Model A in Figure 4. A larger scale model was also established as Model B. **Single layered and multi-layered models were considered.**

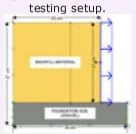

Figure 4. Example of a numerical model used.

LATERAL EARTH PRESSURE DISTRIBUTION

The results from the numerical simulations in Figure 5 showed that **the lateral earth pressure increased with higher VRC.**

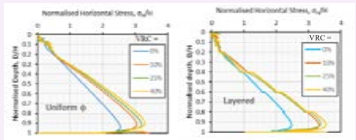

Figure 5. Lateral earth pressure distribution for the different materials

These findings **reject** the hypothesis that the decrease in unit weight due to the addition of shredded rubber particles would reduce the active pressure behind the retaining wall as seen with rubber-sand backfill mixtures. This is likely because of the decrease in friction angle in rubber-gravel mixtures with the increase in VRC. This is presumably because the rubber and gravel particles are roughly of similar size. As a result, there is likely less inter-granular friction between them hence causing the friction angle to decrease with higher addition of rubber.

The decrease in friction angle also meant that there is an increase in the active pressure coefficient with higher VRC. This increase was much greater than the decrease in the unit weight as shown in Figure 6.

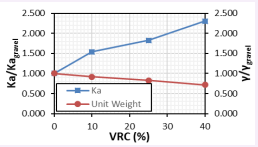

Figure 6. Increase in active pressure coefficient (Ka) and decrease in unit weight (γ) against %VRC.

Rankine's Theory?

Rankine's Theory largely **under approximates** the lateral earth pressure behind the wall as shown in Figure 7. It was also observed that simulated distributions followed Rankine's Theory less closely beyond 20% of the wall depth.

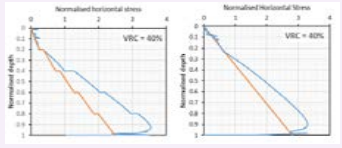

Figure 7. Comparison of lateral earth pressure distribution from PLAXIS and estimation from Rankine's Theory

REFERENCES

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Chiaro G., Tasalloti A., Banasiak L., Palermo A., Granello G., and Rees S. (2020). "Sustainable recycling of end-of-life tyres in civil (geotechnical) engineering applications: turning issues into opportunities in the New Zealand context." *NZ Geomechanics News*, 99, 38-47.

INCLINATION ANGLE

The simulations on the scaled model showed that the angle of inclinations observed on PLAXIS were smaller than those estimated through Rankine's Theory. Physical testing of the 0% VRC and 25% VRC material also found that experimental values were smaller than the theoretical and simulation values. As shown in Figure 8, estimations from Rankine's Theory fell outside the 5% and 10% tolerated errors which suggest that **the approximation is not reliable.**

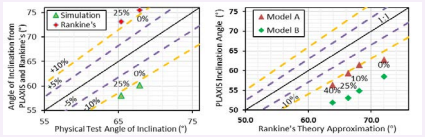

Figure 8. Comparison of inclination angles with different analysis methods.

STABILITY ANALYSES

Stability analyses were conducted on the model shown in Figure 9 using Rankine's Theory for the overturning and sliding failure cases. **The overturning case was found to be the critical failure mode.** The factors of safety (FoS) obtained using PLAXIS were much smaller than those estimated due to the under approximation of lateral earth pressure in Rankine's Theory as shown in Figure 10.

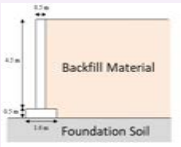

Figure 9. Model setup for stability analyses

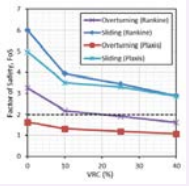

Figure 10. FoS for overturning and sliding failure.

Combined Failure

The model was also calculated using phi-c reduction on PLAXIS to obtain a combined failure critical FoS for the wall. These FoS increase with increased VRC as shown in Figure 11.

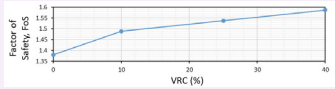

Figure 11. FoS for combined failure modes from PLAXIS.

CONCLUSION

The study observed that the active earth pressure increased with VRC. Rankine's Theory also under-approximated the active earth pressure. The inclination angle from the numerical simulations were smaller than the estimated values but both were larger than the experimental results. Estimations from Rankine's Theory fell outside the tolerated error which suggest that it is not reliable. Stability analyses was also conducted using Rankine's Theory. The FoS were also computed using lateral earth pressure distributions obtained on PLAXIS. These were much smaller than those estimated from Rankine's Theory due to the under approximation of theoretical lateral earth pressure. The deformed mesh obtained from phi-c reduction calculations on PLAXIS clearly showed a combination of multiple failure modes. The FoS obtained from these calculations increase with higher VRC.

Student projects: Civil and Natural Resources Engineering

Biomimetic Architecture and Structural Engineering: Chasing the Optimum in Stadium Design

C. Mulligan and B. Wang
Final Year Project, 2020 — Dept. of Civil and Natural Resources Engineering — Project supervisor: G. Loporcaro

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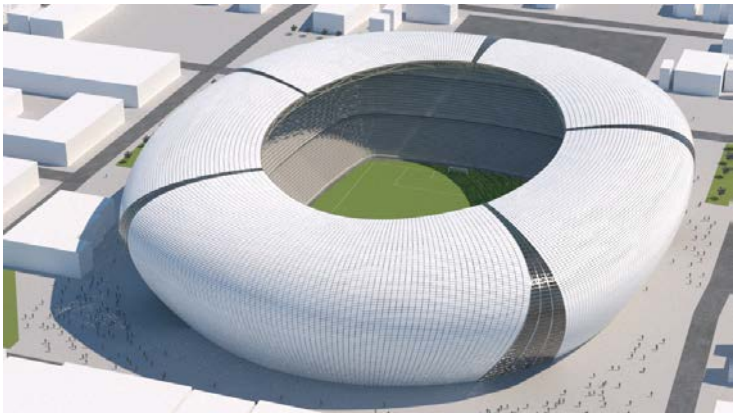

Figure 1. 'Te Puwāi Puti', Concept design for The Christchurch Stadium.

1. Biomimicry and Parametric Design

Biomimicry is the study and replication of nature, the mimicking of biology to inspire problem solving. Whether it is for form or functionality, these time-tested patterns and biological codes have helped designers produce innovative solutions. As the construction industry has digitalised, there is increasing opportunity to explore biomimicry and its benefits to how we build. Parametric modelling is an approach used to automate computer aided design through a series of preprogramed algorithms. This is the fast track to early design exploration with huge research potential and industry application. As the integrated concept design is the starting point for success in any project, it is important to identify problems early on. Using parametric modelling to optimise the concept design phase saves time and cost and while improving the end product. The aim of this research paper is to explore the use of parametric modelling for biomimicry in the concept design of a stadium. The primary software being used for this is the 3D modeller, Rhinoceros 6 (Rhino), and the visual programming language, Grasshopper (GH) shown in Figure 2.

Figure 2. Rhinoceros 6 (right) and Grasshopper (left).

2. Architectural Design

The concept shown in Figure 1 was first ideated through biomimetic exploration. The mānuka flower was chosen from a collection of native New Zealand fauna for its natural beauty and symbolic embodiment of health and vitality in Māori lore. Stages of growth from the bud to the sepal drop are shown in Figure 5.

A defining feature of the mānuka flower is its rule of five, so this became a fundamental element of the design. The basic form was developed from the ovary at the base of the pistil depicting five segments of a circle. This was extrapolated to an oval with five concentric curves and integrated with the undulation of the petals. The influence of a hexagonal façade was highlighted by the rich nectar of the mānuka flower and its interdependence on pollination and bees. Therefore a honeycomb lattice was superimposed over the base form. The basic shapes and structures taken from the mānuka flower, were then developed into concept sketches shown in Figure 3. These sketches were reimagined through parametric design in Rhino GH shown in Figure 4.

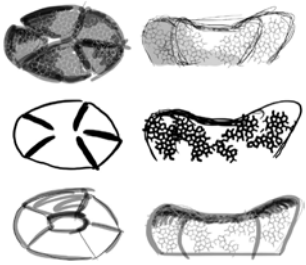

Figure 3.. First set of concept sketches.

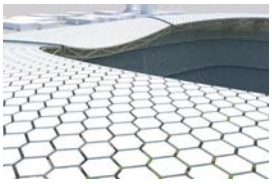

Figure 4. Early representation of hexagon panelling. These panels were later changed to quadrilaterals before being optimised.

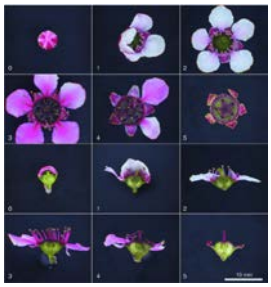

Figure 5. Stages of growth from the flower bud to the sepal drop (Clearwater,2018).

3. Structural Design

A cantilevered truss system was chosen for the structural support. The benefit of this is that it provides spectators with an unobstructed view of the pitch .

Grasshopper and its plug-ins resource the ability to automate and optimise the structural design process. Karamba3D (KB), a structural analysis tool for Rhino GH was used to design the supporting truss in this project. The analysis results for deflection and utilisation (demand/capacity ratio) were then generated for each member. Octopus, a multi-objective optimisation solver was then used to minimise the structural mass without compromising structural performance. The optimisation process was fully automated, simplifying the design process of a predominantly complex structure. The exposed structural skeleton is shown in Figure 6.

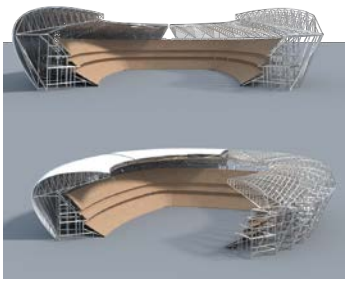

Figure 6. Exposed structural skeleton.

4. Conclusions

This paper explored biomimicry and parametric design in the concept design stage of a stadium façade. The relationship between the architectural and structural model was used to optimise and automate design choices which resulted in a flexible and reactive design. The final concept is shown in Figure 7.

Biomimicry was used as the design approach to the architectural form. The mānuka flower was chosen for its distinctive white petals and healing properties which has established itself as a symbol of health and vitality. This concept was successfully integrated into Rhino GH, in which the structural analysis was also carried out.

Parametric design was observed to be a highly effective way to reduce the time and cost associated with a high quality product.

References

Clearwater, M. J., Revell, M. (2018). "Influence of genotype, floral stage, and water stress on floral nectar yield and composition of mānuka"

Figure 7. Northern Elevation (evening).

GL001

Student projects: Civil and Natural Resources Engineering

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Augmented Reality as an Aid Tool For Building Inspection and Repair

By T. Phillips & M. Patel. Supervisors: G. Loporcaro & S. Ralston

Trimble

Background

The construction industry has shown no significant increase in productivity compared to other industries over the same timeframe. A factor that contributes to this is the lack of innovation and technological advancements in the industry. One potential technological advancement is augmented reality (AR). Despite being used in other industries, there is a current lack of utilisation of AR in the construction industry. AR provides the possibility for increasing the productivity of the construction industry.

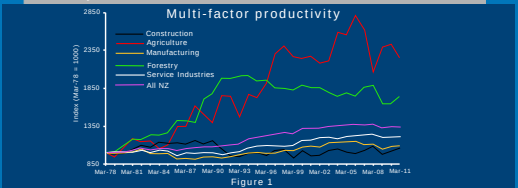


Figure 1

Objective

Investigate the use of AR as an aid tool in building inspection and repair.

What is AR?

AR superimposes computer generated holograms onto a user's vision. An optical headmounted display such as the Microsoft HoloLens (Figure 2) is an example of this technology.

Figure 2

Methodology

In this research, the commercial software Trimble Connect and Microsoft Dynamics Guides 365 were employed to investigate their feasibility as a digital tool for inspections and repairs of buildings. Custom-made instructions within the software were produced to guide users through the inspection and repair of a building case study.

Case Study

The case study is the Trimble Navigation Office building in Christchurch. Is comprises of a Pres-Lam timber frame and shear wall structural system. This system will need to be inspected for damage and repaired after large earthquakes. A part of the inspection process is inspectors and contractors locating dissipators, inspecting if they have yielded and then replacing them with new units. AR can be employed to assist them in this process.

Trimble Connect

Trimble Connect on the HoloLens superimposes 3D building models onto the users view at 1:1 scale and at the exact location. This allows visualisation of what is to be built, current progression of building works and compare the as-built building to the model. A detailed investigation through the case study of the software revealed the following advantages and disadvantages:

Advantages:

- Compatible with traditional building model files (.rvt, .fbx, .ifc)
- Alignment tools catered for quick and simplified alignment of large building models
- Collaborative tool allows for multiple users within the same AR environment

Disadvantages:

- No capability to add in animations, pictures, videos as part of guide
- Compatible only with HoloLens 2
- Sequence tool is not designed for step-by-step instructions
- Frequent need for model alignment is time consuming
- No QR code alignment method for automatic alignment

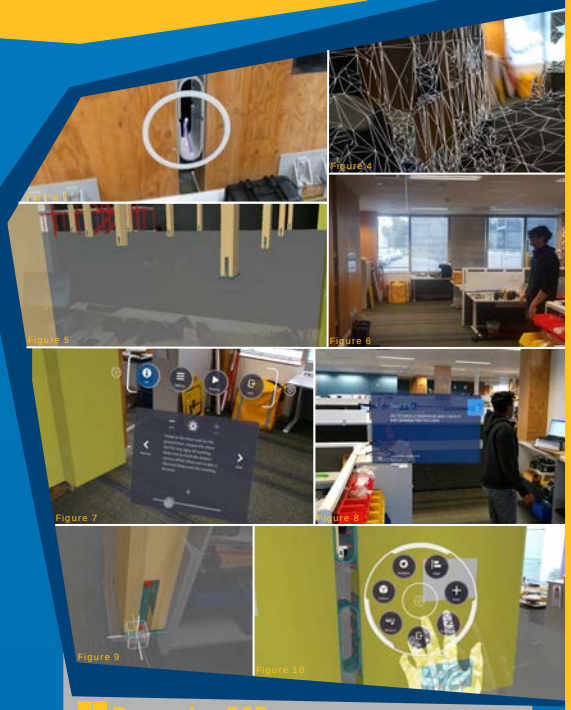


Figure 4 Figure 5 Figure 6 Figure 7 Figure 8 Figure 9 Figure 10

Dynamics 365

Microsoft Dynamics Guides 365 is a tool dedicated to the creation of step-by-step holographic instructions. A detailed investigation through the case study of the software revealed the following advantages and disadvantages:

Advantages:

- The software is designed specifically for the creation of step-by-step holographic guides
- Holographic 3D animations and symbols can be used in guides
- Allows for pictures, videos, link to documents to be added to guides
- Can be a fully handsfree experience via gazing feature
- Compatible with both the HoloLens 1 and HoloLens 2
- Multiple alignment methods available for the user
- Dotted line guides the user from the text instruction to the area of interest in the real world

Disadvantages:

- The software is designed for small-scale operations
- The author of the guide must be within the building to create the models
- The authoring of the guides for tasks involving hidden elements (e.g. within walls) is difficult
- Not compatible with traditional building model file types (e.g. .rvt)
- QR alignment method for the user can produce misaligned results

Recommendation

This research showed that the software available in the market is not feasible in their current state. The main reason for this is that neither software was designed to be such a tool. A software designed with the main functionality as an aid tool for building inspection and repair should be developed.

Future Testing

Recommendations are provided to overcome the limitations highlighted for each software (available in the companion paper). A software developed with these recommendations should be tested to determine its effectiveness. The experiment should compare the traditional method for building inspection and repair with using AR. The experiment will look at the following parameters:

- Time taken to complete the tasks
- Accuracy of the tasks performed
- User feedback
- Situational awareness
- Mental workload
- Useability

Figure 1: Multi-factor productivity for comparator industries
Figure 2: HoloLens 1 Device
Figure 3: The hologram animations in Dynamics Guides 365
Figure 4: Spacial mapping of the shear wall
Figure 5: 3D building model aligned onto real environment in Trimble Connect
Figure 6: The user using HoloLens infront of shear wall
Figure 7: Text instructions in Trimble Connect
Figure 8: Text instructions in Dynamics Guides 365
Figure 9: Anchoring process using Trimble Connect
Figure 10: The users view using Trimble Connect

GLO05

Student projects: Civil and Natural Resources Engineering

Building Drift Measures

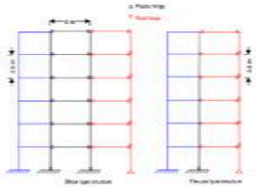
G. A. Hogan and Y. Lin Final Year Projects, 2020
Project supervisor(s): G. MacRae and H. Soleimankhani

ABSTRACT

Inter-storey drift is a key performance criterion for assessing structural performance of structures in seismic events, specifically with regards to damage sustained. However, these parameters are not always directly correlated to damage. Two new measures of drift have been proposed to provide more specific drift measures for specific structural elements. Firstly, a relative drift measure which compares the difference in inter-storey drifts between two floors. This drift measure can be used to better represent damage to elements such as pipes running up the profile of a structure which are damaged by changes in the gradient of drift profile. Secondly, an element drift measure which quantifies the out of plane behaviour of bracing elements and cladding.

METHOD

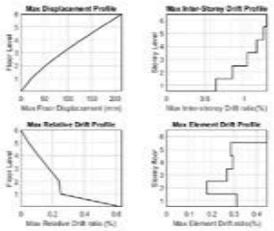
Modelling different structures behaviour under several different analyses was necessary, for this reason a numerical based approach was ideal. The numerical modelling was completed in OpenSees, which is a terminal based structural analysis program. This program works by running '.tcl' text files through the OpenSees terminal. The program specific terminology will not be covered in depth; however, the model parameters and choices of inputs will be reasoned. All OpenSees models follow the same general process. The model parameters and loading are defined, then the analysis conditions are defined, then recorders are specified to record data of interest. Consistent base units of metres, seconds, kg's, and the corresponding higher dimension units were used.



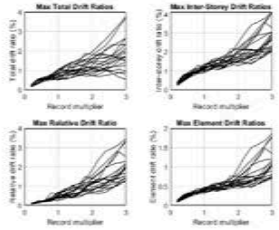
Three standard analysis methods were conducted for both structural types. The three analyses types were a fully elastic analysis, a pushover analysis, and series of non-linear time history analyses. At each stage during the analyses, internal forces, moments, drifts, and deformed shape were inspected to check for irregularities or errors in the model.

RESULT

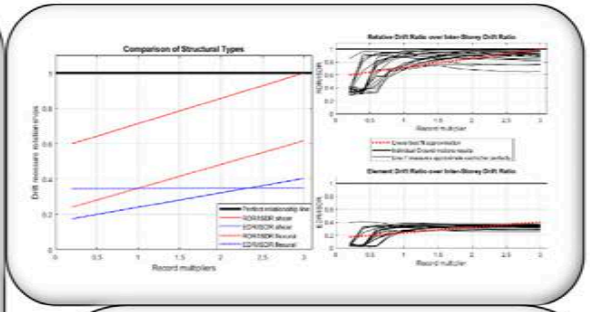
THA was conducted for both models. The displacement profile and profiles for the maximum inter-storey, relative and element drift ratios at each level for each time step for a single ground motion are shown for each structural type (Figures 6 and 7). The overall shape of these profiles is representative of the all 20 ground motions.



This relationship occurs for each of the ground motions and for each model. The data for each model for each measure is shown in Figure 9 and 10. This shows the clear and expected relationship that as the ground motion intensity is increased, the maximum experienced drift also increases. The total drift is unconservative when compared to inter-storey drift. Element drift is significantly lower than the rest of the measures. The spread of the data is quite large, due to the variation in ground motion data. To account for this a median method of statistical



The summary of the flexural and shear relationships from Figures 11 and 12 have been merged and are shown.



General points

is expected that the element drift ED will reduce with increasing continuous column stiffness, this is a result of the structure being more resistant to rotations and overall movement. Although not shown, total drift relationships to the new drift measures were derived. However, it was observed that the spread of relationships was significantly high such that an average or median relationship would be non-conservative for many ground motions yet using the envelope would be overly conservative for most of the ground motions. This was expected, as total drift represents the average drift the model will experience which will always be a lower-bound approximation of the inter-storey drift. Splitting the analyses into two distinct structural forms is a simplification. A real structure is unlikely to perfectly deform in only shear or only flexure. This work forms the basis of new drift measures for specific elements and structural forms. Further work into more complex structures and a variety of periods would expand the applications of these measures.

Recommendation for Designers

It is recommended designers use relative and element drift to optimise the design of specific elements, this will result in more resilient designs and designs which are more cost effective. It was found that relative drift was maximum at the base of the structure for both structural types. The relative drift at this point is also equivalent to inter-storey drift at this level. Designers are recommended to place flexible connections on vertical elements at this point to prevent breakages from the high relative drift demand.

Inter drift remains the key drift measure for assessing structural performance of the total structure. However, the two newly developed drift measures provide a new measure which more accurately calculates the drifts of specific elements such as cladding, BRB's and pipes. The results show inter-storey drift to be a conservative estimate of the newly proposed relative and element drift, with total drift being deemed a non-valuable parameter. This confirms current design practises to be conservative when considering relative and element drift. This also means there is a potential for more optimised design solutions to be developed using an element wise method of design, where specific elements use different more accurate drift calculations.

A multi-hazards, resilience, and habitability assessment of social housing in Christchurch

Project Team: A. R. Bruynel and O. R. Posimani
Academic Supervisor: Dr. Matthew Hughes

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Objectives

This project was an assessment of the resilience of Christchurch City Council's Social Housing portfolio to multiple cascading hazards, and the impacts of these hazards on the habitability of the houses. This project identified social housing as a critical infrastructure facility based on the vulnerable nature of its dependent population.

This assessment will assist in the development of a multi-hazards resilience and habitability assessment framework that can aid Christchurch City Council's Social Housing policy development to support vulnerable people in social housing.

Background

Social housing (SH) is important to provide safe and secure housing for vulnerable and disadvantaged members of society. Once housed, they are better equipped to focus on other aspects of their lives such as employment, education and health.

The Christchurch City Council (CCC) provides low-cost social housing as part of their strategy to ensure safe and healthy housing for vulnerable people.

Christchurch has experienced significant disasters including the 2010-2011 Canterbury Earthquake Sequence (CES) which have increased the vulnerability of the city to hazards such as liquefaction and flooding.

The effects of multiple interacting and cascading hazards on Christchurch SH units must be understood to ensure the continued wellbeing of vulnerable tenants.

Figure 1: Examples of current CCC SH units. Left to right: Concord Place, Knightsbridge Lane, Lyn Christie Place

Method

- Selected of SH complexes were chosen for analysis based on: building type, exposure to previous hazards, and exposure to future hazards
- Assessed of potential multi-hazard impacts, including earthquakes, ground contamination, and tsunami on a subset of the CCC SH portfolio
- Defined habitability criteria based on the Healthy Homes Standards for heating, insulation, ventilation, moisture ingress and drainage, and draught stopping
- Defined building performance thresholds based on previous and projected disaster impacts
- Constructed a multi-hazards resilience and habitability assessment framework to aid CCC SH policy development

Table 1: Three of the chosen subset with analysis selection criteria

Complex	Year Built	No. Storeys	Roof	External wall	Window	Foundation	Hazard	MMI CES	MMI AF8	Tsunami Depth (m)
Concord Place	1970	1	Light	MV, FC	Al	S	E	6.75	7.15	0
Knightsbridge Lane	1977	1	Heavy	MV	Ti, Single	P, CP	E, T*	7.25	6.85	0
Lyn Christie Place	1974	1	Light	MV	Al, Single	P, CP	E, C, T*	6.50	6.48	0

No. Storeys = number of storeys, LD class = Land Damage class.
MV = Masonry veneer, Ti = Timber, FC = fibre cement, Al = Aluminium.
P = concrete perimeter, S = concrete slab, CP = concrete piles.
E = risk of earthquake, C = on LLUR and potential for contamination, T = tsunami risk, T* = accessibility cut in a tsunami

Earthquake Impacts

- Differential settlement from the CES affected many of the SH units - all complexes in the analysis subset incurred damage (Figure 2)
- The Modified Mercalli Intensity (MMI) scale was used to establish thresholds for earthquake damage which was grouped into five hazard intensity classes as shown in Figure 4
- The modelled AF8 seismic hazard as taken from Bradley et al. (2017) has modelled MMI values for each SH location.
- The expected damage occurring in the complexes in the AF8, and the subsequent impacts on habitability can be predicted (Figure 4)
- The analysis also considered contamination to be an issue manifested through earthquakes and liquefaction.

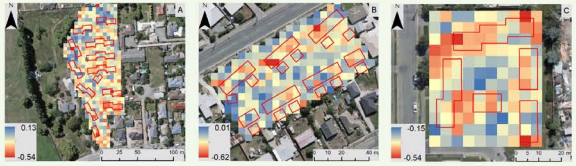

Figure 2. Total CES differential ground movement at three selected SH complexes, shown at 5 m resolution. Positive values denote uplift, negative values denote subsidence. Red polygons are building outlines. A = Concord Place; B = Knightsbridge Lane; C = Lyn Christie Place.

Tsunami Impacts

- Five of the analysis subset are anticipated to be affected by tsunami inundation (Figure 3)
- Two of the subset (Lyn Christie Place and Knightsbridge Lane) are not expected to experience flooding but will have accessibility issues
- The hazard intensity classes determined by modelled tsunami inundation depths are displayed in Figure 5

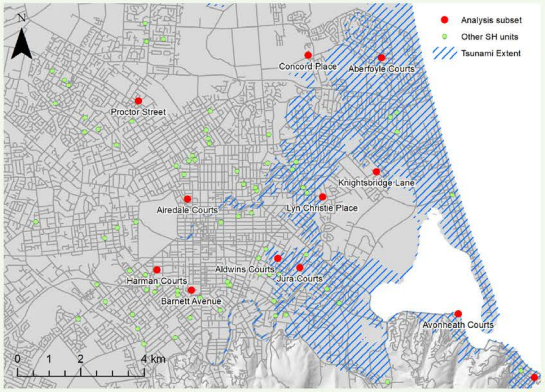

Figure 3: Housing subset and modelled tsunami extent

Conceptual Models

Each hazard has a direct impact on building habitability. Conceptual models were developed that linked the hazard intensity classes, determined by thresholds, to the subsequent impact on habitability (Figure 4 and 5).

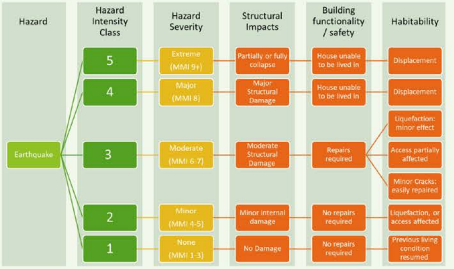

Figure 4: Conceptual model for an earthquake linking the hazard intensity class and the MMI threshold with habitability.

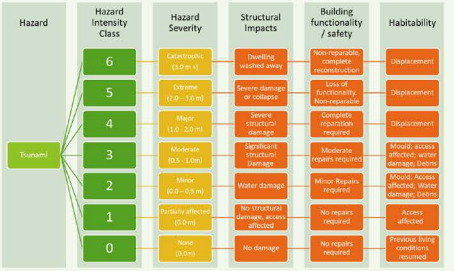

Figure 5: Conceptual models for a tsunami linking the hazard intensity class and inundation depth threshold with habitability .

Conclusions and Recommendations

- Structural and non-structural damage from hazards threaten the quality and habitability of SH in Christchurch. This increases the vulnerability of the residents in SH.
- Poor quality housing has various detrimental health effects on the tenants. High quality housing, executed by exceeding minimum building standards, ensures CCC's goal is achieved of providing safe and healthy housing for vulnerable people.
- This multi-hazard assessment will help future SH policy development and aid decision making on whether to abandon and build new or upgrade existing.
- Awareness of climate change implications means being able to support vulnerable communities not only at the current time but for the entire lifespan of the unit.

MHU04

Student projects: Civil and Natural Resources Engineering

Cross-comparison of numerical solutions for car-following models

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Project team: Q. Cao and A. Dong
Academic Supervisors: M. Keyvan-Ekbatani
Co-supervisor: D. Ngoduy

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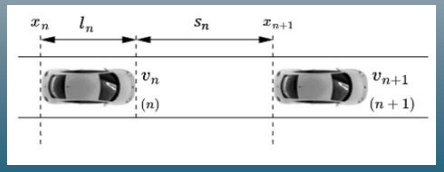
Abstract

Most time-continuous car-following models are formulated as a system of non-linear ordinary differential equations (ODEs), which required to be augmented with a numerical integration method. To achieve more accurate traffic simulation, three numerical methods, Euler's method, trapezoidal rule and RK4 have been applied on three car-following models (OVM, FVDM, IDM) to simulate two single lane traffic scenarios.

Background

Time-continuous car-following models is one of the fundamental microscopic traffic models, it describes the acceleration of individual cars as a function of the driver's characteristic behaviour and the surrounding traffic. The output of car-following models are the time-varying position and speed of individual cars along the road. In contrast to car-following models formulated in discrete time (cell automata models), time-continuous car-following models without explicit reaction time delay are formulated as a system of non linear ordinary differential equations (ODEs), which required to be augmented with a numerical integral method.



Methodology

While using the car-following models (OVM, FVDM, IDM) for traffic flow simulation, the value of specific parameters in the model are required to be adapted to situations. A calibration approach was applied to determine the optimal value of the model parameters. Then, a validation process was applied to check the reliability of the simulation results based on real-life observation data.

Coefficient of determination (R-square) values was used for comparing the predictive power of models based on different integration methods. According to the MATLAB guide, this value is based on the comparing the variability of the estimation errors with the variability of the original values (MATBLAB, 2020).

Euler: $\overrightarrow{k_1} = \vec{f}(\vec{y}, t)$,

$\vec{y}(t+h) = \vec{y} + h\overrightarrow{k_1}$.

trapezoidal: $\overrightarrow{k_1} = \vec{f}(\vec{y}, t)$, $\overrightarrow{k_2} = \vec{f}(\vec{y} + h\overrightarrow{k_1}, t+h)$,

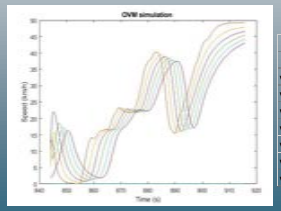
$\vec{y}(t+h) = \vec{y} + \frac{h}{2}(\overrightarrow{k_1} + \overrightarrow{k_2})$.

RK4: $\overrightarrow{k_1} = \vec{f}(\vec{y}, t)$, $\overrightarrow{k_2} = \vec{f}\left(\vec{y} + \frac{h}{2}\overrightarrow{k_1}, t + \frac{h}{2}\right)$,

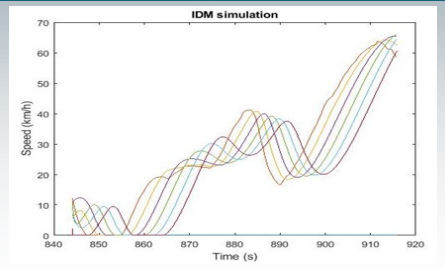
$\overrightarrow{k_3} = \vec{f}\left(\vec{y} + \frac{h}{2}\overrightarrow{k_2}, t + \frac{h}{2}\right)$, $\overrightarrow{k_4} = \vec{f}(\vec{y} + h\overrightarrow{k_3}, t+h)$,

$\vec{y}(t+h) = \vec{y} + \frac{h}{6}(\overrightarrow{k_1} + 2\overrightarrow{k_2} + 2\overrightarrow{k_3} + \overrightarrow{k_4})$.

Results



Optimal Velocity model (OVM) R-square			
	Euler's method	Trapezoidal rule	RK4
veh 1 (leading car)	0	0	0
veh 2	0.99629	0.99634	0.99635
veh 3	0.99210	0.99226	0.99228
veh 4	0.98669	0.98697	0.98701
veh 5	0.98775	0.98811	0.98816
veh 6	0.98759	0.98801	0.98806
veh7	0.99292	0.99314	0.99316



Intelligent driver model (IDM) R-square			
	Euler's method	Trapzium rule	RK4
veh 1 (leading car)	0	0	0
veh 2	0.96493	0.96796	0.96523
veh 3	0.96079	0.96213	0.96091
veh 4	0.94534	0.94669	0.94549
veh 5	0.89290	0.90438	0.89333
veh 6	0.84881	0.87000	0.84951
veh7	0.67638	0.71615	0.67602

Conclusion

In contrast to low-density traffic condition, high-density traffic condition is having a higher traffic complexity. One representative of such traffic condition is the stop-and-go traffic. A higher-order integration method, RK4 is required for a better predictive power of the model. While the low-density traffic condition leads to a smooth trajectory, a lower-order integration method, trapezoidal rule is good enough for simulation. With lower evaluation on each time step, time could be saved.

MKE 07

Modelling High-Capacity CLT Shear Walls

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Supervisor: M. Li

UC UNIVERSITY OF CANTERBURY

Background & Objectives

The types of connections used to anchor shear walls (such as the one shown in Fig. 1) in mass timber buildings have a significant impact on the behaviour of these buildings during earthquakes. Therefore, it is important to have a good understanding of how the design of these connections affects the performance of shear wall systems.

In this research project, the software CLTWALL2D was used to investigate how different factors affect the shear wall performance. These investigations included the effects of gravity loading, lap joint stiffness, hold-down design and wall aspect ratio. Most simulations were conducted using self-tapping screws as hold-down fasteners, a method yet to be used in the construction industry.

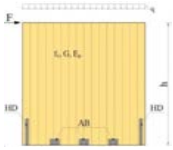

Fig. 1: Timber shear wall.

Gravity Loading

The effects of gravity loading on the wall performance were investigated by applying different levels of loading to the top of the shear walls. The load-displacement curves generated using CLTWALL2D are shown in Fig. 2.

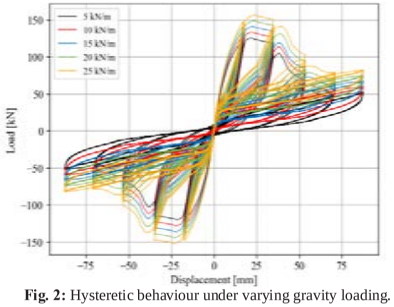

Fig. 2: Hysteretic behaviour under varying gravity loading.

This investigation showed that with an increasing gravity load:

- The stiffness and strength of the wall increased.
- Changes to the energy dissipation and ductility were insignificant.

Lap Joint Stiffness

The coupling effect of two CLT shear walls was investigated by changing the stiffness of the lap joint connecting these two walls. To do this, more screws were added into the joint to see how this would change the performance. The results of this analysis are shown in Fig. 3.

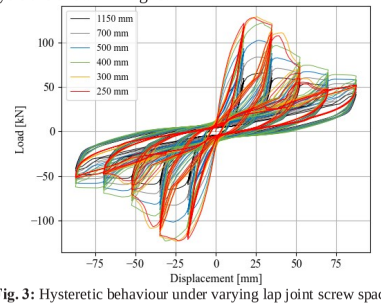

Fig. 3: Hysteretic behaviour under varying lap joint screw spacing.

This investigation showed that reducing the screw spacing in the lap joint:

- Increased energy dissipation in most cases.
- Increased the stiffness and strength of the wall system.
- Decreased the ductility.
- Changed the wall behaviour from coupled to single (Fig. 4).

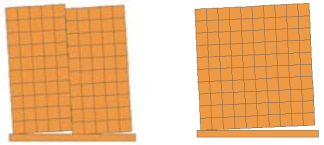

Fig. 4: Varying wall behaviours: coupled (left) and single (right).

Connection Type & Wall Aspect Ratio

Finally, an investigation of the effects of hold-down connection type and wall aspect ratio was conducted. During this investigation, dowelled hold-down connections with mixed angle screwed hold-down connections were compared. The wall height was also varied from one storey to three storeys. The backbones of the hysteretic load-displacement curves are given in Fig. 5.

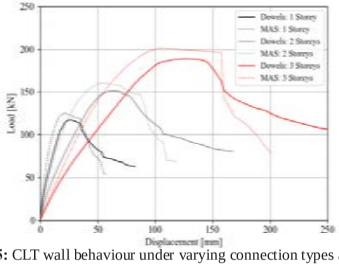

Fig. 5: CLT wall behaviour under varying connection types and wall aspect ratios.

The results of this investigation showed that:

- Walls with screwed hold-downs exhibited higher strengths and ductility, while dowelled hold-down walls had higher energy dissipation.
- The ductility ratio decreased with wall height due to bending and shear deformations in the wall.

Conclusions

- Higher gravity loading increases wall stiffness and strength.
- Higher lap joint stiffness generally increases wall stiffness, strength and energy dissipation but reduces the ductility.
- Screwed hold-downs provide higher stiffness and ductility, but reduced energy dissipation, compared to dowelled hold-downs.

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http://archplanbaltimore.blogspot.com/2019_12_13_archive.html

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https://www.holmesstructures.com/portfolio-articles/brentwood-public-library/

MLI04

Student projects: Civil and Natural Resources Engineering

Making Decisions on Earthquake-Prone Public Buildings

Final Year Projects 2020 - Department of Civil and Natural Resources Engineering
Project Team: Hysham Rasheed & Diana Solis Trueba
Project Supervisor: Mark Milke

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Background & Objectives

Following the Kaikoura Earthquake in 2016, several changes were made to the Building Code in New Zealand under the Building Amendment Act 2016.

This led to the closure of many public buildings, such as libraries and museums because they were classified as Earthquake Prone Buildings (EPB's).

The decision of closing the building or having it remain open is made by the governing Territorial Authority (TA).

Research Objectives:

- → Develop a regulatory framework for public EPB's in New Zealand, that ensures more proactive decision-making to address their earthquake prone status.
- → Undertake a case-study of a resolved public EPB by analysing the decision-making process.
- → Develop a method that quantifies and balances seismic risk to users of public EPB's with social, economic and environmental factors.

Why is a better regulatory framework needed?

Public buildings are hubs of trade and service, their closures result in negative social and economic impacts, especially to local businesses and the community spirit. Due to the novelty of the legislation, most TA's do not have a policy that manages their EPB's and are pressured to proactively manage these buildings.

What is %NBS?

- → %NBS = Percentage of New Building Standard.
- → It is a score. It represents a building's relative life-safety risk in a moderate earthquake.
- → New buildings are rated 100%NBS or more.
- → EPB's are rated 33%NBS or less.
- → A low %NBS does NOT mean a building is dangerous to occupy.
- → e.g. In an earthquake a 33%NBS building and a 100%NBS building could perform similarly.

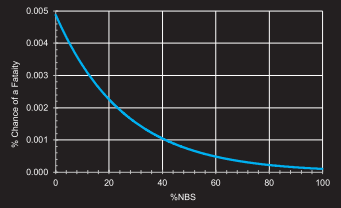


Figure 1. Fatality risk from a moderate earthquake w/ %NBS

Government guidelines were used to model fatality risk from an earthquake relative to a new building, and is shown in Figure 1.

A 100%NBS building always has a chance of fatality and a <15%NBS building always has a chance of survival.

Methods

Case-study - Palmerston North City (PNC) Library

The PNC library was classified as an EPB in 2018 and was chosen as a case-study for decision-analysis. The City Council had a dedicated EPB policy and decided to implement interim measures to mitigate risk instead of closing the library.

Several hypothetical alternatives were evaluated with a Multi-Criteria Decision Analysis (MCDA) model. The highest scoring decisions were subjected to a Cost-Benefit Analysis (CBA). This tool compared impacts such as cost of construction with other impacts such as heritage preservation through monetisation.

Results

The highest scoring decisions from the MCDA were 'Low-level Remediation (34%NBS)', 'Full Closure and Remediation (67%NBS)', and 'Rebuild on the same site (100%NBS)'.

The Benefit-Cost Ratio of all options were below 1.0 from the CBA. The decision to rebuild provided the most benefits and was the most expensive option. All costs outweigh the benefits.

Iterations of the multiple hypothetical decisions with MCDA and CBA resulted in a decision-making framework applicable to other public EPB's as shown in Figure 2.

Discussion

The MCDA was an effective tool at illustrating the overview of the problem by the weightage of stakeholder's criteria. Its iterative style encouraged community engaged decision-making. The cost to operate public buildings is always greater than the revenue generated. However, there are multiple unquantifiable benefits that are critical to the community. The CBA tool quantified these as 'Shadow' benefits, shown in Figure 3.

Outcomes of the CBA

- → The reduction in risk had large diminishing returns after 67%NBS.
- → Community Resilience and Economic Development had similar values for all options.
- → The most 'feasible' option came at the cost of Heritage & Cultural Preservation.
- → The monetary comparison allows TA's to make a decision specific to their budget.

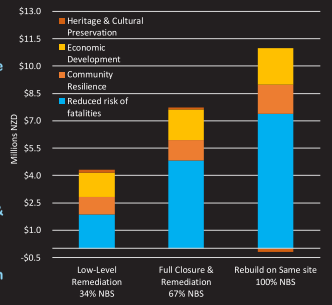


Figure 3. Comparison of the 'Shadow' Benefits of the CBA - PNC Library.

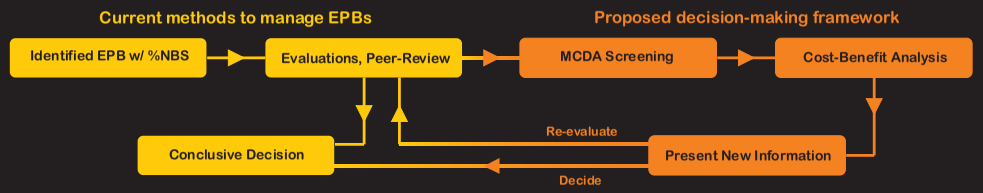


Figure 2. New decision-making framework for managing public EPBs.

Features of the decision-making framework

- → MCDA screening allows many alternatives to be quickly analysed eliminating ineffective decisions.
- → Incorporation of fatality risk in the CBA allows decision-makers to consider the trade-offs associated with a desired %NBS.
- → Designed to work in synergy with the existing procedure for EPB management.

Conclusion

The MCDA was useful at distinguishing the decisions that best fit the stakeholder objectives. The monetary representation of risk and other aspects in the CBA gave a common ground for all decision-makers unlike the MCDA, which was subjective. As seen from the case-study, the recommended decision was different for both methods. Therefore, this proposed framework allows any disagreements between stakeholders to be re-evaluated. A beneficial tool for governmental based decision-making, where factors other than expenses and revenues are prioritised.

"To the general public, it may seem presumptuous to 'value' something as precious as human life, but failing to monetize them may make them worthless when decisions must be made."

Effects of Clay-Cement Mixtures and Firing Temperatures on the Evolution of Wine

Civil Engineering Honours Project 2020
By A. E. Hicks & T. A. Dempsey | Supervisors: Dr M. E. Stringer & Associate Professor A. Scott

UC UNIVERSITY OF CANTERBURY

Background

Conventional viticulture involves the fermentation of wine in stainless-steel tanks or wooden barrels but the Greeks and Romans traditionally used ancient clay vessels called amphora. Amphora wines are said to increase wine's fruity, minerality, and floral flavours and are making a return particularly among natural winemakers. If grapes were fermented in vessels made from clay they grew in rather than conventional stainless-steel tanks, the wine would have a truer expression of terroir. Clay is variable between vineyards therefore the soil may need its strength and porosity modified to create an amphora. The addition of concrete to clay would provide strength and firing the clay to higher temperatures would decrease the porosity. Samples with varying degrees of cement and samples fired to a range of temperatures corresponding to clay transformations were created to test the changes they made to wine. This information could then be used to create personalised amphora for wineries.

Objectives

The ideal sample would have little effect on the wine but be able to replicate the valuable air exchange that is provided by wooden barrels. Clay-cement mixes were created to investigate if there was a threshold ratio that provided adequate strength without detrimentally effecting wine. These mixes had varying degrees of metakaolin (calcined kaolin clay) and cement present. The mixes were made with ordinary Portland cement and 0, 30, 50, 70, and 90% metakaolin. The second batch of samples was kaolin fired to a range of temperatures which affect the sample's strength and porosity. The samples were fired to 800, 1000, 1200, and 1320°C. The clay-cement and clay samples were placed in Marlborough sauvignon blanc and the pH, titratable acidity, conductivity and elemental composition were tested over a period of 28 days.

Results

The clay samples fired to different temperatures had a smaller effect on the pH and titratable acidity. Specimen's fired to 1000, 1200, and 1320°C were within expected values for sauvignon blanc. The samples fired to higher temperatures also had less effect on the elemental composition of the wine. Lower temperatures caused major changes in Al, Fe, and Mn as well as other elements shown by Figure 3. The wine also changed colour in the clay samples, more obviously in the samples fired to lower temperatures, as seen in Figure 1.

Strength of the mix significantly reduced after 50% metakaolin replacement. But the clay-cement mixes affected the wine's pH and titratable acidity past consumption no matter the percentage of cement present. Figure 2 shows that the wine also turned a dark sherry colour and salts formed on the clay-cement mixes. This was more prominent for the samples with lower metakaolin content. Therefore, cement cannot be used in an amphora mix except if lined with a glaze.

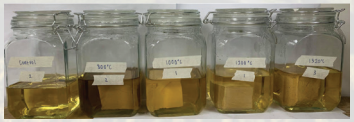


Figure 1: Observed changes in the wines colour caused by the fired clay samples.

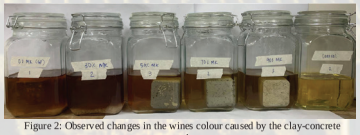


Figure 2: Observed changes in the wines colour caused by the clay-concrete samples.

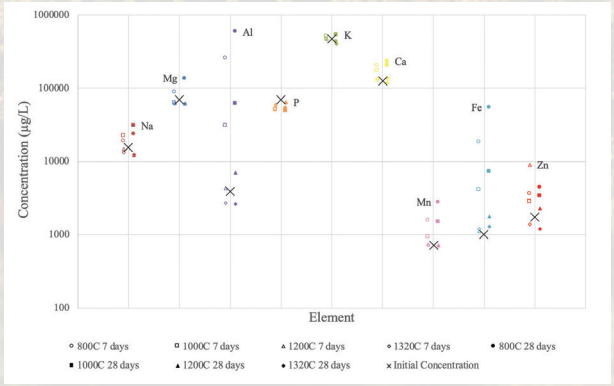
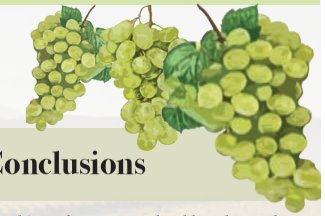


Figure 3: ICP-MS Results for Major Elements for Clay Samples.



Conclusions

From this study, concrete should not be used in an amphora mix unless the vessel is glazed to limit the interaction between the wine and the clay. For the clay samples, they should be fired to at least 1000°C to maintain the wine's original chemical composition. Kaolin clay was used in the samples which is a pure clay with known chemical composition, to apply this to vineyard soils, an investigation into local clays should be completed.

Future

Future work would involve testing more variable clays from local vineyards. This will help wineries predict how the amphora will affect their wines' chemical and biological composition and sensory attributes. Some clays are also not suitable for firing due to their differing mineralogical composition. Thus, it would be necessary to determine whether the local material can be fired to create the amphora.

This study used sauvignon blanc, but it is hoped that all types wines will be able to become amphora wines using the mix designs created from this study. Experiments using different types of wines will be required in case there is any large variance in results from the different elemental composition of wine.

Department of Civil & Natural Resource Engineering
University of Canterbury

MST09

Student projects: Civil and Natural Resources Engineering

An approach for guiding equitable climate adaptation and community resilience

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

M. Anderson
Dept of Civil & Natural Resources Engineering

D. Kiddle
Dept of Civil & Natural Resources Engineering

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Dept of Civil & Natural Resources Engineering

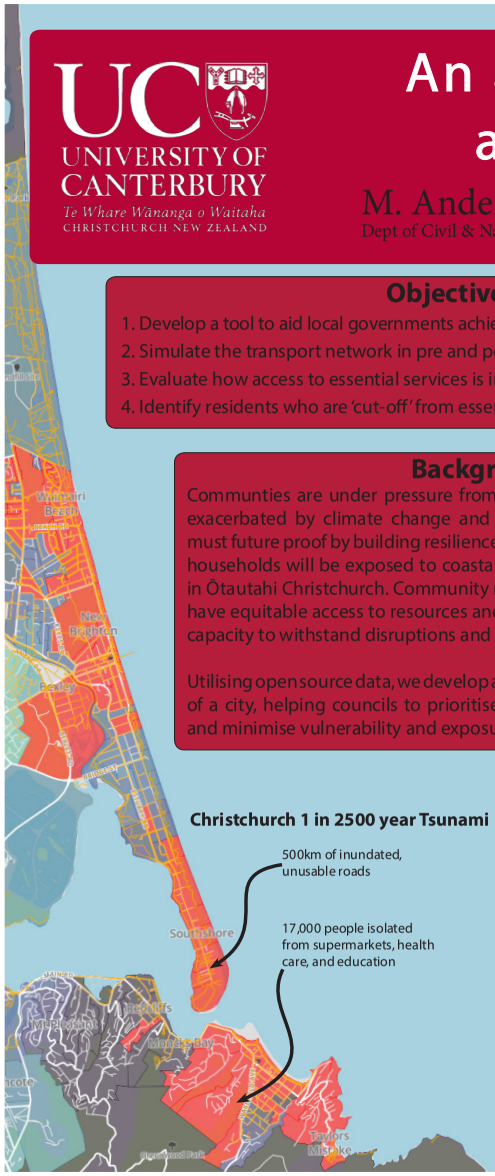
Objectives

1. Develop a tool to aid local governments achieve equitable climate adaptation
2. Simulate the transport network in pre and post hazard scenarios
3. Evaluate how access to essential services is impacted and highlight inequity
4. Identify residents who are 'cut-off' from essential services following a hazard

Background

Communties are under pressure from increasingly severe natural hazard exacerbated by climate change and social inequities. Worldwide, cities must future proof by building resilience. For example, approximately 25,000 households will be exposed to coastal flooding within the next 100 years in Ōtautahi Christchurch. Community resilience is fostered when residents have equitable access to resources and opportunities as that provides the capacity to withstand disruptions and recover faster.

Utilising open source data, we develop a tool to evaluate the access resilience of a city, helping councils to prioritise investments that maximise equity and minimise vulnerability and exposure.



Fragilities

Table 1: Fragility bounds for roading and building infrastructure under different hazard types and exposures[2]

Infrastructure Type	Hazard Type	Exposure Level	Post Hazard Probability of closure
Road	Earthquake Liquefaction	Low	5%
		Medium	30%
		High	75%
	Tsunami/Hurricane Inundation	Low	10%
		Medium	40%
		High	80%
	Earthquake induced tsunami (multi hazard scenario)	Low	15%
		Medium	45%
		High	85%
Building	Earthquake Liquefaction	Low	10%
		Medium	33%
		High	80.5%
	Tsunami/Hurricane Inundation	Low	40%
		Medium	80%
		High	97.5%
	Earthquake induced tsunami (multi hazard scenario)	Low	45%
		Medium	85%
		High	99%

Implementation

To demonstrate the tool three cities were chosen as case studies (Christchurch, Seattle, & Houston). Interactive results can be found on our website: apps.urutau.co.nz/access_resilience

Seattle
Hazard: Liquefaction

Houston
Hazard: Hurricane Inundation

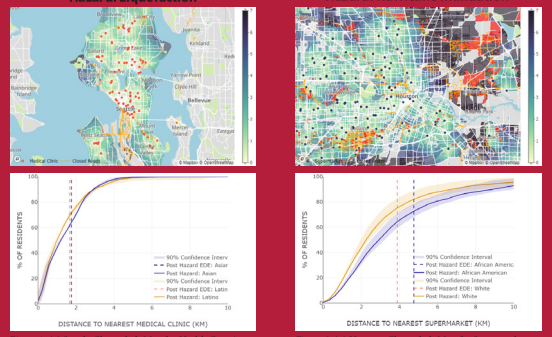


Figure 1: (a) Seattle Choropleth Map for Health Care Access. (b) ECDF & measure of equality (an EDE)

Figure 2: (a) Houston Choropleth Map for Supermarket Access. (b) ECDF & measure of equality (an EDE)

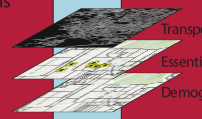
Impact

This tool has been designed for decision makers to quantify the resilience of a city's access. Engagement with local councils has shown that this tool would be extremely valuable in:

- Pre and post disaster investment prioritisation
- Vulnerability assesments
- Community engagement
- Policy analysis

This tool provides exciting new opportunities for future developement within areas such as: cascading infrastructure failures, maximising access to emergency services, and optimising hazard recovery strategies.

Method



1: Overlay
Transport Network
Essential Services
Demographic data

2: Baseline Access
Calculate the network distance from every neighbourhood block to the chosen services (e.g., health care, supermarkets, schools)

3: Simulate Hazard
Simulate a hazard and determine which roads and services are no longer operable based on their fragilities (Table 1)

4: Hazard Access
Re-calculate the network distance after removing damaged roads

Monte Carlo Hazard Simulation
Repeat x1000

5: Calculate Equity & Visualise
Evaluate the access distribution with an inequality measure (an EDE[1]). Plot geographic results to highlight vulnerabilities.

References: (1) Logan, T., Anderson, M., Williams, T., and Conrow, L. (2020). "Measuring inequality in the built environment: an approach for evaluating the distribution of amenities and burdens". *Computers, Environment and Urban Systems*. (2) Williams, J., Wilson, T., Horspool, N., Paulik, R., Wotherspoon, L., Lane, E., and Hughes, M. (2020) "Assessing transportation vulnerability to tsunamis: utilising post-event field data from the 2011 Tohoku tsunami, Japan and the 2015 Illapel tsunami, Chile". *Natural Hazards and Earth System Sciences*

TLO-01

SEISMIC DESIGN AND ANALYSIS OF A MULTI-STORY MEDIUM DENSITY RESIDENTIAL BUILDING

C. Gribbon and Z. Jennings

Dept. of Civil and Natural Resources Engineering
University of Canterbury
Project supervisor(s): T. J. Sullivan and G. De Francesco

1. INTRODUCTION

Historically, multi-storey buildings have been designed to prioritise life-safety. As shown by the performance observed during the 2010-2011 Canterbury and 2016 Kaikoura earthquakes, seismic performance should also be quantified in terms of losses or non-structural repairs. An effective design should provide life-safety criteria while minimising monetary losses and disruption. Minimising expected loss associated with seismic damage is important to all stakeholders due to the adverse monetary and downtime impact. Low damage seismic design (LDSD) guidelines are being developed to provide engineers with a guideline to work within to minimise losses.

2. METHODOLOGY

In this research, a case study four-storey residential building, assumed to be located in Wellington, was designed using the current New Zealand Standards and low-damage seismic design. The seismic performance was then assessed using the FEMA P-58 Performance-Based Earthquake Engineering (PBEE) methodology.

Building designs:
- New Zealand Standard compliant design
- Low-damage seismic design

Analysis Process:
- Modal response spectrum analysis, via SAP2000
- Non-linear time history analysis, via RUAUMOKO3D using 180 ground motions
- Loss assessment, using fragility and consequence functions via PACT

3. CASE STUDY BUILDING DESIGN

Figure 1. Elevation view of case study building.

The building designed is based on a architectural concept four-storey apartment building provided by Interspace from 2014 (Figure 1). The structural system is composed of a set of RC structural walls, lateral resisting system, and a steel-framed structure for the gravity system.

The LDSD of the structural system was refined in SAP2000 (Figure 2, 3). The wall sections were increased and relocated to provide additional lateral restraint, minimise the torsional effects, and reduce inter-storey drift. SAP2000 was used to conduct a modal response spectrum analysis of the code compliant and LDSD structural systems.

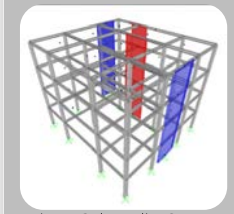


Figure 2. Code compliant SAP2000 model

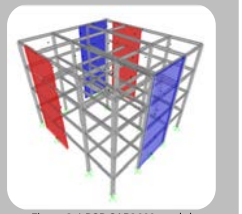


Figure 3. LDSD SAP2000 model

4. NON-LINEAR TIME HISTORY ANALYSIS

RUAUMOKO3D was used to conduct a series of non-linear time history analysis of the two buildings designed. Each RC structural wall was modelled as a set of four beam elements. A floor diaphragm constrain was assumed, and the mass properties of the systems have been modelled by an additional column containing the lumped storey masses in the X and Y direction and rotational inertia about the Z-axis at each level.

The RUAUMOKO3D models were run in batch mode to complete 20 non-linear time-history analyses for the 9 different hazard levels investigated. The hazard levels of 1-9 corrosponded to return periods of (1) 50, (2) 62.5, (3) 100, (4) 250, (5) 1000, (6) 2500, (7) 5000, (8) 10000, and (9) 25000 years respectively. The engineering indices of interest were then extracted and exported using a MATLAB code to be in the correct format for the loss assessment analysis (Table 1, 2).

Table 1. Non-linear time-history output for code design.

HL	Inter-storey drift X (%)	Inter-storey drift Y (%)	Acceleration X (g)	Acceleration Y (g)
1	0.10	0.10	0.08	0.08
2	0.26	0.26	0.16	0.16
3	0.68	0.59	0.30	0.29
4	1.43	1.34	0.49	0.50
5	2.16	2.31	0.59	0.66
6	2.30	2.54	0.82	0.82
7	4.34	3.53	0.92	0.92
8	4.69	3.80	1.03	1.06
9	3.22	2.93	1.13	1.23

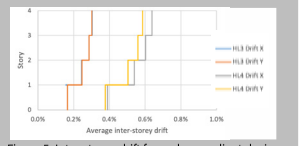


Figure 5. Inter-storey drift for code compliant design

Table 2. Non-linear time history output for LDSD

HL	Inter-storey drift X (%)	Inter-storey drift Y (%)	Acceleration X (g)	Acceleration Y (g)
1	0.06	0.05	0.12	0.11
2	0.16	0.14	0.24	0.22
3	0.25	0.25	0.45	0.45
4	0.54	0.51	0.72	0.71
5	0.78	0.97	0.85	0.90
6	1.17	1.54	1.07	1.04
7	2.06	2.53	1.20	1.22
8	2.91	2.94	1.28	1.32
9	2.50	2.51	1.40	1.51

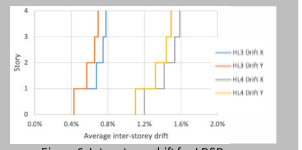


Figure 6. Inter-storey drift for LDSD

The LDSD shows lower inter-storey drift demands and higher accelerations over the nine hazard levels. The inter-storey drift demands for the 1 in 250-year (HL3) and 1 in 500-year (HL4) return periods show the notable decrease in drift from the code compliance design to the LDSD (Figure 5, 6). The larger wall section for the LDSD increases the stiffness of the structural system. A stiffer system generally results in a decrease in drift and increase in floor accelerations. This relationship is evident in the case study building.

5. LOSS ASSESSMENT

The electronic fragility and consequence data calculation tool PACT was used to conduct the loss assessment and compare the expected loss of the code-compliant design to the LDSD. Drift and accelerations obtained with RUAUMOKO3D non-linear time-history were used as the building demands for PACT. The expected loss of both designs increases with the hazard level as anticipated (Figure 9, 10). The loss area charts show an increasing probability of large repair costs as the intensity levels increases.

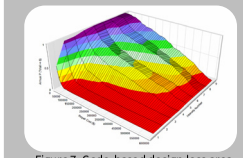


Figure 7. Code-based design loss area chart: repair cost curve

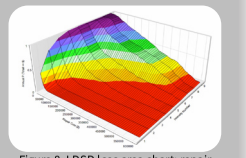


Figure 8. LDSD loss area chart: repair cost curve

The normalised loss area chart is based on the mean annual frequency of exceedance (MAFE). This considers the repair cost at each hazard-level and the probability of an earthquake of that hazard level occurring. The loss area charts show that the normalised loss is considerably less for LDSD than for code design as anticipated (Figure 9, 10). Both the code-compliant design and LDSD have insignificant normalised damage costs for HL4 and higher.

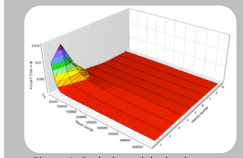


Figure 9. Code-based design loss area chart: repair cost curve normalised based on MAFE

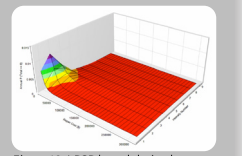


Figure 10. LDSD based design loss area chart: repair cost curve normalised based on MAFE

The annualised total repaid costs for the code-compliant building and the LDD was NZD 1536 and 893 respectively.

Table 3. Expected annual loss

Design	EAL (NZD)	Ratio of EAL to building replacement cost
Code	1536	0.035%
LDSD	893	0.021%

6. CONCLUSION

This research compared the loss estimates obtained for buildings designed according to current New Zealand Standards and low damage seismic design (LDSD). The expected annual losses of the LDSD building were significantly less than the code compliant building, as the drift decreased significantly and the major sources of building losses being drift sensitive. This was shown through the expected annual losses which confidently showed the LDSD having less monetary losses. The disruption and downtime for LDSD also decreased in comparison to the code-compliant design. It is concluded that the low-damage criteria lead to a significant reduction in losses, and hence improved seismic performance. This decrease in expected loss for the LDSD will save money and reduced downtime and disruption for the stakeholder.

7. FUTURE DIRECTION

The non-structural drift sensitive components, such as partition walls, contribute significantly more towards losses at lower and medium hazard levels compared to the higher hazard levels. Future research could investigate the effectiveness to use low damage solutions for non-structural elements and evaluate the expected cost-benefit compared to standard non-structural components.

Student projects: Mechanical Engineering and Mechatronics Engineering

Ergonomic Support for Welders

The Product: Z-Link+

Personal Protective Equipment (PPE).
Includes: - Grinding visor - Welding visor - Hardhat protection - Inbuilt respirator
These features improve user safety but add weight.

The Problem

Welders experience significant back and neck pain from the positions they hold. Additional weight on their heads only makes this worse.

The Project

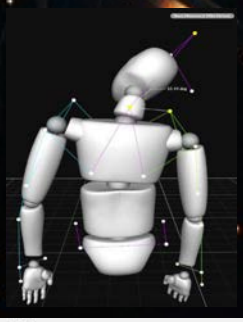
- Gather data on user comfort and fatigue levels when wearing the Z-Link+.
- Design a prototype to reduce the load from the helmet on the neck.

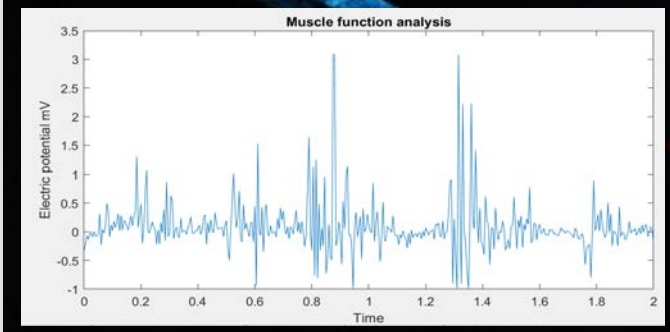
Initial Research

- The neck and shoulders are the most affected region of the body.[1]
- Extended hours, repetitive work and heavy welding helmets increase pain.[1]

Data Collection

Three different welding postures were tested. Each posture test was repeated without the helmet, with the helmet and with the helmet and a test rig designed to simulate the effects of our prototype so we could fully quantify the effect of the helmet and our prototype.
The data collection consisted of; motion capture (to measure neck angles), EMG sensor analysis (to measure muscle voltage which is connected to fatigue), and heart rate measurements (also connected to fatigue).
There were three test subjects and nine test runs for each participant. The four different data types were collected simultaneously during each test.





Prototype Design

The load on the neck from the helmet's weight must be reduced.
Concepts were designed and evaluated in several decision matrices to develop the final concept. The final concept was refined with input from the client.

What Next?

If this project was to be carried on for further development, future steps should be:

- Increase subject pool for data collection
- Materials selection process for prototype
- Prototype testing and validation

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REFERENCES:

[1] Merkle, A. C., Kleinberger, M., & Uy, O. M. (2005). The Effects of Head-Supported Mass on the Risk of Neck Injury in Army Personnel. JOHNS HOPKINS APL TECHNICAL DIGEST, 26), 75–83. Retrieved from https://www.jhuapl.edu/Content/techdigest/pdf/V26-N01/26-01-Merkle.pdf

PROJECT TEAM:
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Tessa Impey
Joe McDonald

CLIENT: Julia Bartnik-Thumm
SUPERVISOR: Dan Zhao
Thank you to Julian Murphy and Dr Tracey Pons for their contributions to our project.

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IN-HELMET NOISE REDUCTION

PROJECT OBJECTIVE

RPB Safety seek a means of reducing the noise inside the Z4 welding helmet by 5 dB when used with a PX5 powered respirator.

This was achieved by identifying the noise generation mechanisms within the system, researching standards on fan design and sound measurement procedures.

DESIGN PROCESS

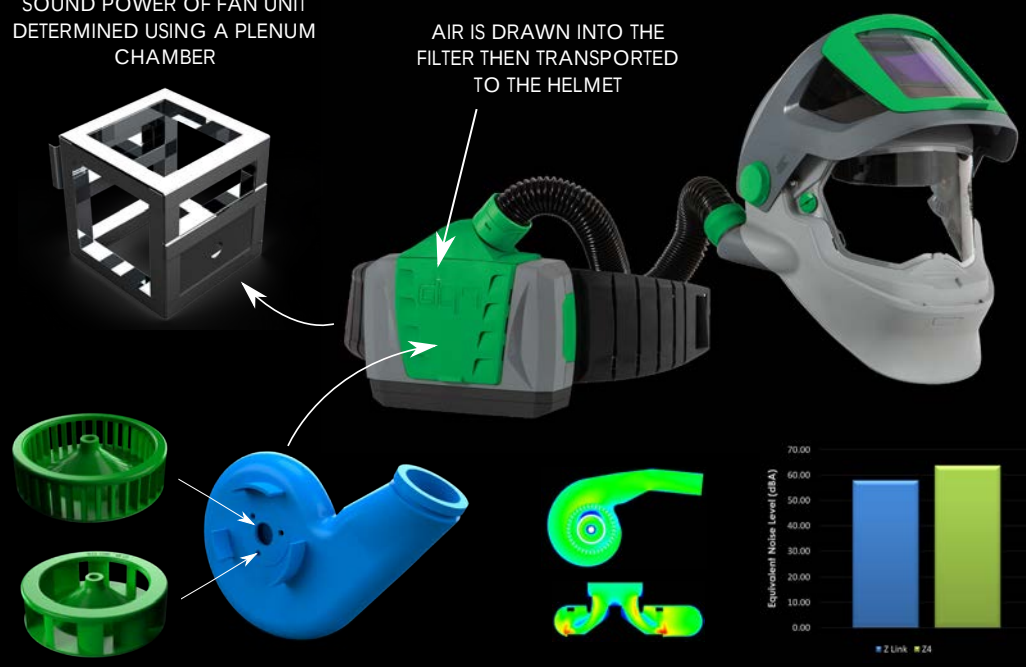
Analysis of the system showed modifying the fan unit to be the most efficient method to reduce noice

The main tasks of the project were:

1. Measure sound produced by each part of the system
2. Model air flow through the fan unit
3. Design and build new components
4. Test new components to compare against original design

SOUND POWER OF FAN UNIT DETERMINED USING A PLENUM CHAMBER

AIR IS DRAWN INTO THE FILTER THEN TRANSPORTED TO THE HELMET



IMPELLER AND SCROLL HOUSING DESIGN

VELOCITY MODELLING

NOISE COMPARISONS

FINAL CONCEPT & FUTURE WORK

Preliminary testing found that the best way to reduce the noise in the system was to reduce the noise produced by the fan. Two types of fans were chosen: forward-curved and backward-curved centrifugal fans. Both have advantages for noise control: forward-curved fans can be operated at a lower rotational speed, while backward curved fans are more efficient. A scroll housing was also designed, which is critical for the efficiency of the fan.

Systems designed for this project will be used by RPB in future design work. The plenum chamber designed and built to ISO 10302-1 will allow RPB to test and measure the Sound Power of future products, as an RPB fitting piece embedded in the chamber will allow easy connection to new fan units. New impeller designs can be used in future products, to achive quietier than ever before fan units. New testing procedures and ANSYS modelling methods designed by the team will also further assisst the client with future products. Future investigation of the design of the helmet inlet has also been proposed, as this was another likely source of noise generation

Student Team - Cameron Burridge, Leon Chun, Michael Soper, Anna Woods
Supervisor - John Pearse
Client Mentor: Edward Williams
Technicians: Julian Phillips, Illia Chyrva, Tony Doyle

FYP Project P02, 2020

This Project was made possibly with assistance from the University of Canterbury

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Student projects: Mechanical Engineering and Mechatronics Engineering

Automatic Detection & Processing of Parsnips

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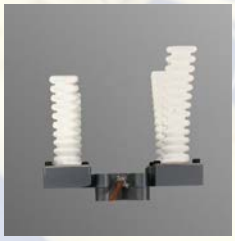
AIM

Parsnip processing consists of removing the stem and tail of the parsnips before packaging. Our automated solution uses a vision system to determine the parsnip position on the conveyor belt. A robotic manipulator was programmed to pick up the parsnips from the conveyor belt and slice them using a cutting mechanism.

MANIPULATOR ATTACHMENT

To pick up the parsnips with the robotic arm, the system uses a soft gripper for the irregular shapes of the parsnips without damage.

- Flexible fingers 3D printed with TPU
- Pneumatically actuated
- Different lengths for different parsnip radii



COMPUTER VISION

The vision system is responsible for determining the parsnip position and appropriate cut paths.

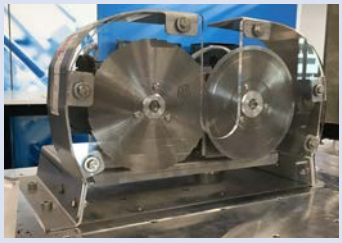
Contour plots were used for cut path calculations.

- Stem cut location from contour slopes
- Tail cut location from relative distances
- Lighting enclosure for consistent lighting
- 30ms average computation time
- 94% accuracy

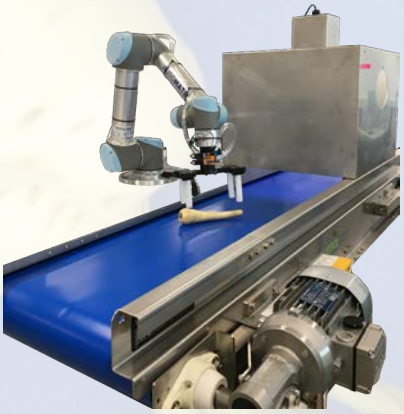
SLICER

The manipulator carries the parsnip along the radical line path of the blades.

- Two Blades—Flat and Serrated
- 1340 rpm
- Vertical blades to conserve space



PROTOTYPE



Team Members

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- Caleb Ibbotson
- Hayden Leete
- Miria Chin

Clients
- Cory Smitheram
- Reuben Miller

Supervisor
- Chris Pretty

Technicians
- Rodney Elliot
- Steve Whitby

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Water Recycling in the Vegetable Packhouse Industry

Problem

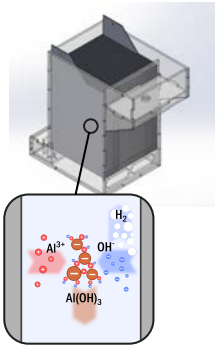
Vegetable Packhouses are critically dependent on water to clean root vegetables such as carrots, parsnips and potatoes. Encroaching water use and discharge policies around the globe are contributing to higher operating costs, and will mandate greener practices in future. The client sought a turnkey solution which could be installed within existing plants.
Existing systems are currently limited in water recirculation due to the accumulation of unsettlable solids, bacteria and organic matter.

Approach

A comprehensive study of existing fluid-solid separation techniques was completed. Techniques such as media filtration and sedimentation tanks were deemed unsuitable for their respective high fouling rates and poor efficiency removing suspended clay and silt particles.
Three potential design areas were identified from this investigation. These were a pre-treatment stage, electrocoagulation and lamella gravity separation.

Electrocoagulation

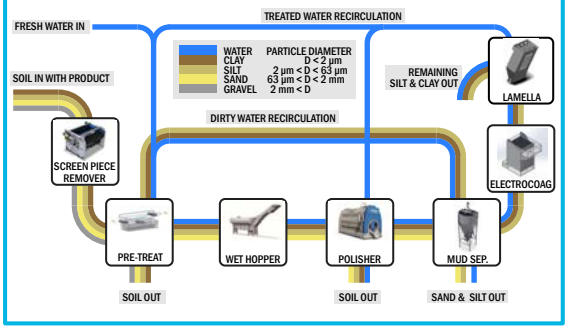
Fine particles develop a negative surface charge in water and can remain suspended indefinitely.
EC uses electrolysis to introduce cations which interrupt particle surface charges causing aggregation. The aggregates produced are large enough to settle or be filtered.
Benefits:
- Minimal residual contamination
- TSS removal
- Removal N and P nutrients
- Coliform removal



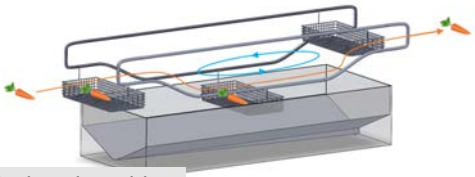
Lamella Clarification

Lamella separators remove solids larger than 25 microns from suspension without the addition of chemicals. They rely on gravity and the difference of density between the water and the particulate to remove solids.
Compared with a traditional settling tank, lamella separators can have 2 to 4 times the overflow rate while requiring 65-80% of the footprint.

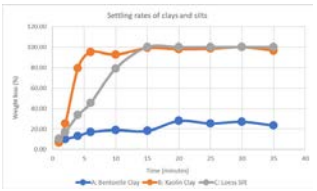
System Diagram



Soaking Pre-Treatment

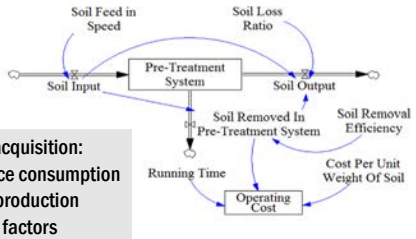


It has been observed that soil with a high clay concentration will expand and fall apart when immersed into water, without mixing and becoming suspended. This phenomena will be utilised in a pre-treatment operation.



System Modelling and Analysis

VenSim software is used to create the dynamic models. The purpose is to analyze the different plant process flow scenarios and perform the measure of merits. Below is a model example for the Pre-Treatment System.



Key data acquisition:
- Resource consumption
- Waste production
- Capital factors

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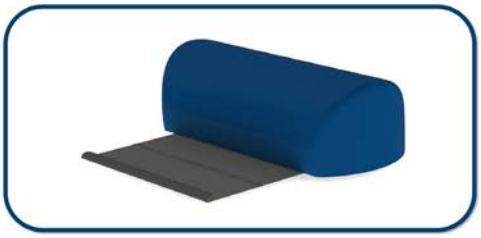
Student projects: Mechanical Engineering and Mechatronics Engineering

Rapidly Deployable Flood Protection Barrier

Flooding in New Zealand causes approximately $16 million worth of damage annually. A self-filling barrier design was chosen to differentiate from competitors and remove the reliance on electricity and large volumes of fresh water. This allows our barrier to be deployed much faster than competing products.

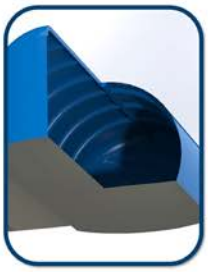
Design Parameters

- Criteria outlined by Invercargill City Council
- Flood depths of up to 1 meter
- Flood velocity of up to 0.5 m/s
- Can be deployed around irregular shapes
- Will conform to the contours of the ground
- Deployed for a minimum 2 days

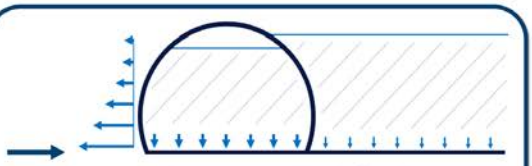


Design Characteristics

- Two main components — bellow and tail
- Self filling main bellow
- Tail to increase the effective seating
- Check valve for filling
- Inflatable tubes to allow self filling
- Each unit protects a length of four metres
- Modular joining capabilities

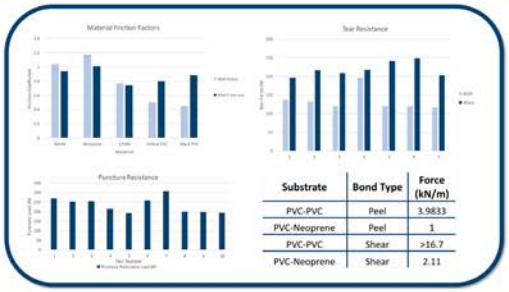


- Hydrostatic forces act on the barrier both vertically and horizontally
- The horizontal component is resisted by a force acting upon the base, created from the interaction between hydrostatic pressure and friction
- The resultant force on the tail is slightly lower than that within the bellow because the average coefficient of static friction is lower due to water ingress



The static loading experienced by the flood barrier

1100 Denier PVC coated Polyester was selected as the bellow material due to its flexibility, weatherability, weight and cost. Unreinforced Neoprene Rubber was selected for the base. It was found to have the highest coefficient of static friction on wet concrete and grass compared to other materials. Adhesive tests verified the performance of Bostik 999 HR glue in the join configurations and material combinations present in the design. Tear and puncture tests were performed on the PVC to ensure its resistance to damage was sufficient.



Substrate	Bond Type	Force (kN/m)
PVC-PVC	Peel	3.9833
PVC-Neoprene	Peel	1
PVC-PVC	Shear	>16.7
PVC-Neoprene	Shear	2.11

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Team Members
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Matthew Hansen
Matthew Sweet
Samuel Jamieson

Supervisor:
Dr Mark Garnich

Client:
Randall Grenfell

FORKLIFT SAFETY

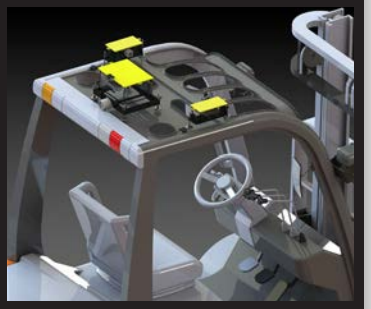
Pedestrian Detection

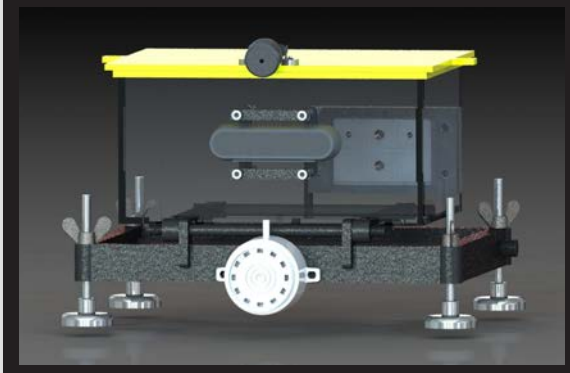
Project Background:

Linfox Logistics wish to improve upon their current forklift safety measures for interactions between pedestrians and forklifts.

Project Goals:

- Provide a solution that does not use any permanent fixtures and is easily detachable.
- Provide a solution that is universal, such that it can be used with any model of forklift or reach truck.
- Provide a solution that reduces the risk of accidents as close to zero as possible.





Design Details:

- Three separate enclosures to house the various components: two side enclosures and one main enclosure.
- Detachable fixtures: neodymium magnets or suction cups.
- Ingress protection: minimum rating of IP54.
- Enclosure lids have a layer of sheet metal, enabling the mounting of magnetic components.
- Design split into three parts: the audio cue, the visual cue, and the detection.

Detection:

Application Programming Interface (API) in the TensorFlow Lite is used to identify pedestrians for detection within a 5 meter range. A combination of two Raspberry Pi 4's and three Intel Realsense D435 cameras are used to obtain close to a 270 degree field of view.

Audio cue:

An AW-10FW-NSVC buzzer is used to alert both the operator the and nearby pedestrians of the forklifts presence when pedestrians are detected within a range of 5 meters.

Visual cue:

Three Transquip forklift safety laser lights are used to project red lines on both sides and the rear of the forklift to create a pedestrian exclusion zone.

Special thanks to Julian Murphy, Garry Cotton, Tony Doyle, Richard Green and Sam Schofield.

Team: Thomas Wilson, Xavier Hey, Shane Kow, and Jonathan Yuan

Client: Linfox Logistics

Supervisor: Mark Garnich

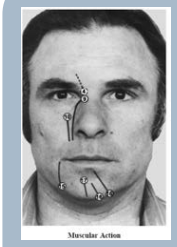
Fisher and Paykel Healthcare Animatronic Baby Head

Purpose

To create an animatronic baby head to be used for repeatable testing of Neonatal respiratory products.

Fisher and Paykel Healthcare currently offer Neonatal respiratory products targeted towards Nasal High Flow, Continuous Positive Airway Pressure (CPAP) and Resuscitation therapies. The dynamic movement of the face can prevent effective therapy from taking place and therefore a method to repeatedly replicate facial movements will provide insightful data during product development.

Background

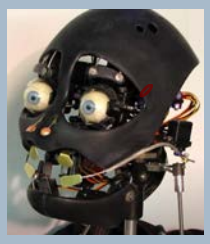


Facial Action Coding System [1]

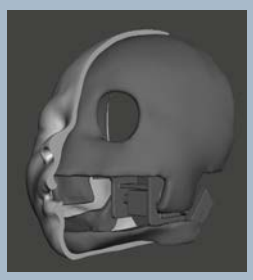
- Provides a quantitative method to describe facial expressions.
- In conjunction with research papers, FACS was used to prioritise critical skin manipulation locations.

Current Animatronic Designs

- Provided a starting point for the initial design phase.
- Designs, such as ToMoMi [2] (pictured right) commonly use a series of rigid bodies to manipulate an outer silicone layer.



Previous Prototypes



The simplified skull prototype was designed to support a skin layer and actuating jaw.

The more complex anatomically correct skull prototype increased the realism of the facial dynamics. The skin layer in the model was connected to the skull using a secondary layer simulating the fat and tissue below the skin.

Current Prototype

Corner Lip Manipulator: Rigid mechanism for 3 degrees of freedom corner lip manipulation.

Upper Lip Manipulator: Rigid mechanism for 2 degrees of freedom upper lip manipulation.

Skin: A thin silicone based skin layer to replicate feel and deformation of Neonatal skin.

Skull: Simplified skull acts as supporting structure and simplifies the implementation of manipulators.

Back Plate: 3D printed structure to ensure uniaxial translation and correct positioning of the manipulators.

Cables: Solid core Bowden cables connect the servos to the manipulators. This enables the force to be transmitted from the servos.

Servos: SG90 Servos are used as the method of actuation.

Embedded System: An Arduino Uno development board is used. A PCA9685 WM board controls the servos via an I2C communication protocol.

References:

[1] Ekman P. (1978), *Facial Action Coding System Manual.*

[2] http://www.animatronicrobotics.com

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CHRISTCHURCH NEW ZEALAND

Team members: Gerard Chesterman, Anna Percy, Jaime Sequeira, Ben Tait, Ben Todd
Clients: Zak Flintoff and Hemanth Pemmaraju
Supervisors: Tim Giffney and Mark Jermy

Fisher & Paykel HEALTHCARE

Reducing the Environmental Impact of Medical Device Packaging

Final Year Project – University of Canterbury, 2020

Team: Diardu Terblanche, James Sinclair, Natalie Brannigan, Manu Prosser

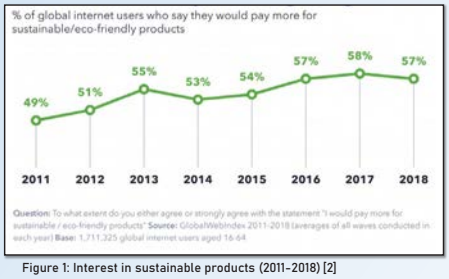

Figure 1: Interest in sustainable products (2011-2018) [2]

Best-practice Guidelines:

- Contains steps in the decision-making process from material selection to end-of-life, backed up by extensive background research
- A simplified decision matrix enables screening out of less favourable ideas without carrying out a full analysis
- Key points of our guidelines: Material selection, packaging design, and end of life (figure 5)

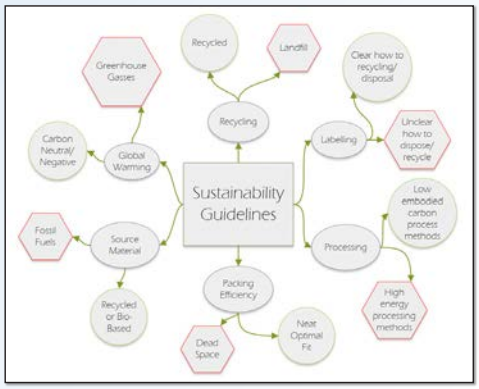

Figure 5: Sustainability guidelines flow chart

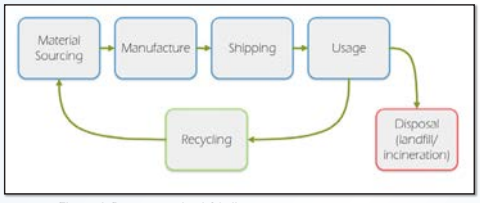

Figure 6: Representative LCA diagram

References:
1. Carbon footprint of medical industry, URL: https://iopscience.iop.org/article/10.1088/1748-9326/ab19e1/meta#erlab19e1s3
2. Interest in sustainable products, URL: https://blog.globalwebindex.com/chart-of-the-week/lifting-the-lid-on-sustainable-packaging/
3. F&P FlexiTrunk Interface, URL: https://www.fphcare.com/nz/hospital/infant-respiratory/cpap/
4. Recycled PET Demand Projected to Surge: https://www.plasticstoday.com/packaging/recycled-pet-demand-projected-surge

The Problem: The medical device industry produces around 4% of global carbon emissions [1] and medical device packaging presents an opportunity to reduce both carbon emissions and waste generated by the medical device industry. From talking to hospital clinicians and supplementary research, we have seen a groundswell of demand for sustainable packing in the medical space.

Goals:

1. Create a set of best-practice guidelines for sustainable packaging
2. Generate concepts and prototypes to improve sustainability of existing F&P product packaging (figure 4)
3. Using sustainability research and life-cycle-analysis (LCA) to quantify improvements

Figure 3: Recycled PET plastic [4]

Figure 2: FlexiTrunk Interface product [3]

Figure 4: FlexiTrunk Interface packaging

Concept & Prototype:

- Our concepts include kitting to improve usability and sustainability.
- Our solutions provide 60-140% better packaging efficiency to reduce secondary packaging needs and reduce transport cost.
- Bio-based plastic gives negative embodied carbon.
- Recycled PET reduces embodied carbon in our solutions up to 60%
- Life cycle analysis (LCA) analysis has shown a significant global warming potential reduction with our concepts.

Life Cycle Analysis:

- Quantitative sustainability data was generated in GaBi LCA to conclusively evaluate our concepts against the current packaging.
- Primary packaging analysis shows a 74% decrease in global warming potential over our concept's life-cycle
- Supplementary sustainability metrics such as waste streams and recycling ergonomics (ease of correct disposal) were also analysed, to provide a holistic sustainability perspective on our concepts.

Clients: Sam Davis, Ella Meisel (F&P)

Academic Supervisor: Dr Catherine Bishop (UC)

Fisher & Paykel HEALTHCARE

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CHRISTCHURCH NEW ZEALAND

Student projects: Mechanical Engineering and Mechatronics Engineering

THE SEAWEED *Solution*

MISSION STATEMENT

Introduce novel ideas for scalable seaweed blue carbon offsets that are ecologically, culturally and economically sound.

SCOPE

Design a cost-effective structure that will sequester a gigaton of blue carbon offshore and to design an integrated multi-tropic aquaculture to combat climate change and improve ocean health.

CHOSEN PROTOTYPE

OUR SOLUTION

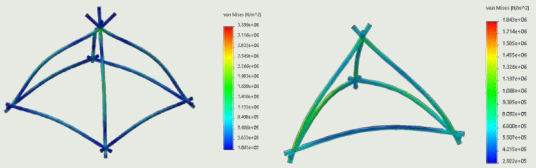
A free floating structure made of bamboo and hemp rope that grows seaweed then sinks, absorbing carbon from the atmosphere and sending it to the deep ocean. The manufacuring of our pyramids will support developing communities.

The sale of our carbon credits is an alternative scalable carbon offset to pine trees.

Why seaweed is our solution: it is the fastest growing organism in the world, growing up to half a meter a day locking in carbon faster than anything on the planet, while alleviating ocean acidification and eutrophication.

FEA ANALYSIS

FEA was used to identify the stress profiles of two main design configurations. The square based design allowed double the growing area with only a minimal reduction in strength.

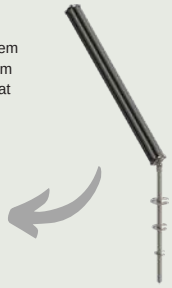


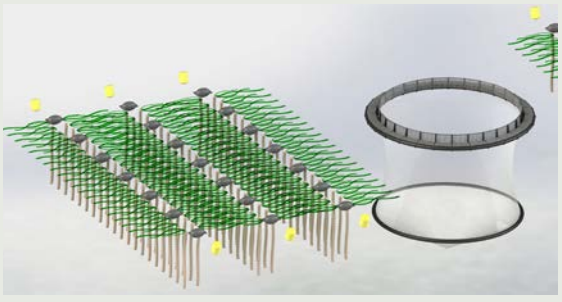
INTEGRATED MULTI-TROPHIC AQUACULTURE

This future farming aquaculture system incorporates species to a salmon farm to help minimise nutrient pollution that finfish aquaculture typically creates.

Mooring benefits:

- Minimise sea floor impact
- Recycled materials
- Strongest hold to size
- Long lasting





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CHRISTCHURCH NEW ZEALAND

Team: Dominique Poff, Jack Paulin, Arun Raju & Keeshent Thevanarayanan
Client: Finn Ross
Supervisor: Yilei Zhang

With special thanks to Akaroa Salmon Farm, Gemma Burnside, Mads Thomsen, Leslie Mann, Caroline Gilbertson & Jordi Boyd

THE SEAWEED SOLUTION

Sustainability of Refrigerated Cabinets

Objectives

Develop a method to quantify and communicate product environmental sustainability. Use this method to analyse product impacts. Recommend projects that maximise environmental benefit.

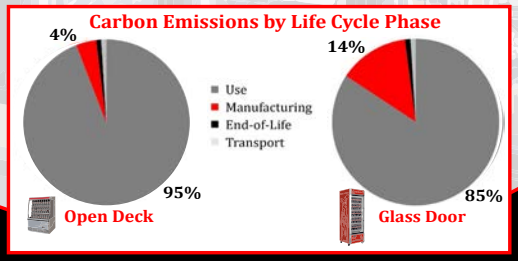
Modelling

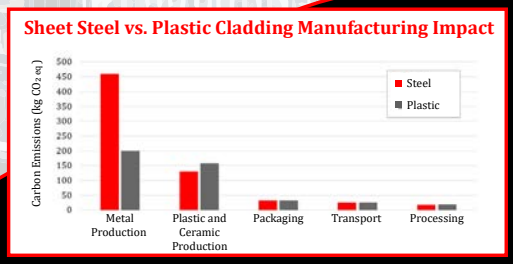
The openLCA software package and Environmental Footprint Life Cycle Database were used to quantify impacts and simulate the effectiveness of proposed recommendations.

Analysis

Life Cycle Assessment was identified as the most appropriate tool for sustainability analysis. Impact categories were chosen according to the GRI sustainability reporting standards. The approach involves breaking a complex product down into basic constituents to sum their individual impacts across the product lifecycle.

Life Cycle Assessment





How can impacts of the use phase be minimised?

Use of the night-blind, which acts as a curtain to prevent air infiltration in open deck products during closing hours, can reduce total carbon emissions by 21%.

Glass vs. Acrylic Environmental Performance

Material	Mass (kg)	Recyclable?	Production Energy (MJ)
Tempered Glass	18.9	✗	320
Acrylic	9.8	✓	960

What impact does material choice have on manufacturing?

Replacing sheet steel with ABS plastic cladding reduces manufacturing emissions by 40% and total emissions by 4%.

How does designing for recyclability influence the other impact categories?

Replacing glass with acrylic improves overall product recyclability by 11% but also increases total manufacturing energy by 10%. This energy increase may be offset by reduced energy consumption during use and end-of-life processing. Further analysis is required.

UC University of Canterbury
Te Whare Wānanga o Waitaha Christchurch New Zealand

Team
Molly Evans
Lucy Fulton
Carlos Kershaw
Chris Park

Client
George Bell
Phil Jamieson

Supervisor
Daniel Bishop

Special Thanks
Bill Mohs
Enda Crossin

SKOPE

P11 RECONFIGURABLE WATER SPORTS BOARD

A product concept was presented as a new beach toy for kids. Identical board sub-units can be configured as a body board, a surfboard, a stand-up paddle board, or a floating pontoon/raft.

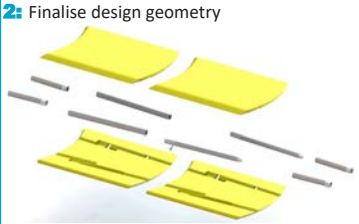
The project objective was to design a joining mechanism.

The project intends to make this beach toy more multipurpose

Prototyping steps:

1: Select materials for core and lock system
- EPS foam for core, fibre glassed outside
- Fibreglass tube for stringers and barrels
- 3D printed PLA for twist lock
- Acetyl for handle

2: Finalise design geometry



3: Cut barrels and stringers

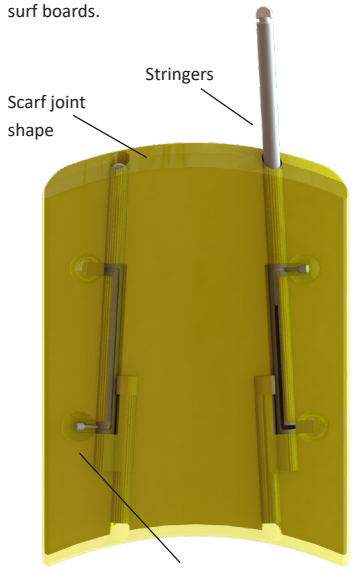
4: Cut foam core using CNC router

5: Machine handles and 3D print twist locks

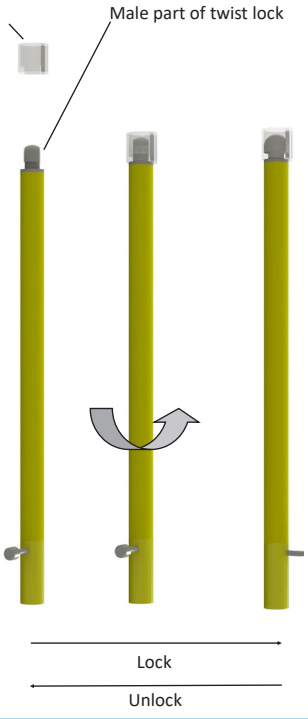
6: Fibreglass foam and assemble joining system

Design of board taken to prototype

This design is inspired by similar designs for collapsible surf boards.

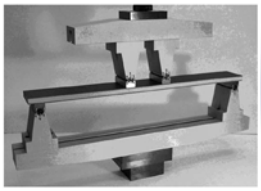


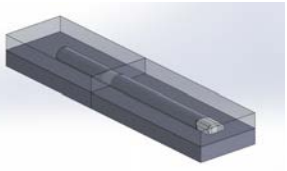
Internal joining system.



Testing Procedure: ASTM D7249 4 Point Bending Test

A sample of the board core structure will be tested until failure in a four point bending test to evaluate the structural strength.





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Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Team Members:
Millie Robinson
Campbell Shelley
Madeleine Burrows
Sam Suckling

Industry Client:
Clay Griffin

Academic Supervisor:
Mark Staiger

Technical Staff: Tony Doyle, Patrick Branje, David Read, Bruce Robertson

Hydro Response

FOOLPROOF MEDICINE

Novel Design for Tracheostomy and CPR

PURPOSE

Tracheostomies and CPR save lives, but are outdated and poorly performed procedures. This project designs reliable, low-cost devices allowing any medical professional to carry out a tracheostomy, and any individual to perform CPR in a simple and 'foolproof' manner.

SELECTED DESIGNS

The tracheostomy device improves care by:

- Combining parts required for the procedure to reduce complexity
- Reducing the number of steps to place to the tube from 3 to 1

These changes reduce operation time, error, and complications.

The CPR concept reduces complications by:

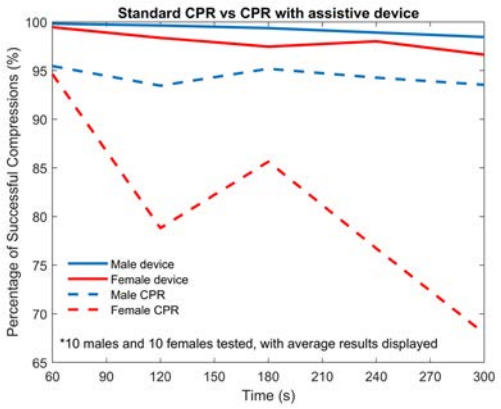
- Distributing compressions evenly over the chest volume
- Allowing ribs to hinge naturally

The success rate of CPR is improved by:

- Reducing fatigue associated with standard CPR

VALIDATION AND RESULTS

Testing on a simulated trachea found that this device can be safely inserted and deployed. The time taken to perform the procedure was reduced by 55%.



Testing with a manikin indicated the assistive device improves the frequency and consistency of successful CPR compressions. After 5 minutes, all users could achieve a 95% success rate with the device.

Canterbury District Health Board
Te Poari Hauora ō Waitaha

Client
Dr Geoff Shaw (CDHB)

Supervisors
Dr Geoff Chase
Dr Jennifer Knopp
Dr Cong Zhou

Team
Nicolas Davey
Marcus Taylor
Ryan McCormick
Francis Pooke

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Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Student projects: Mechanical Engineering and Mechatronics Engineering

Ultra Low-Cost Insulin Pump

Reducing Costs Through Technological Innovations

6% Of New Zealand has diabetes

100% Increase in NZ cases since 2000

$8,000 Pump cost every 4 years

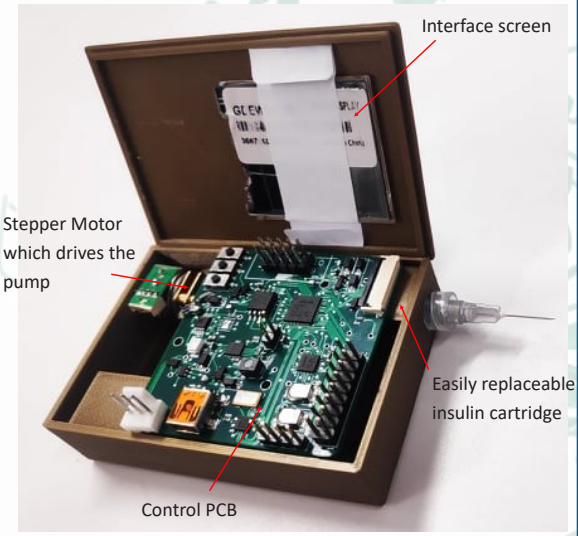
$15,000 Cost of Diabetes annually

30% Of NZ Median wage

The goal of this project is to create two low cost alternative to existing pumps. The pump is designed to be built from materials costing less than $300. Key features of the pumps include:

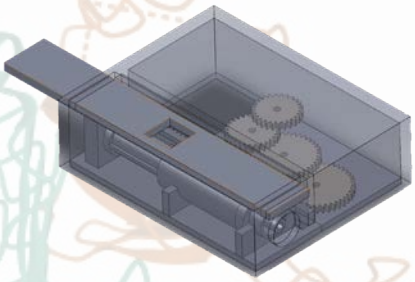
- Minimum 1 year lifespan
- Accurate to 5% or better
- Controllable insulin delivery rate
- Screen and/or Bluetooth functionality to interface with the device
- Use rechargeable or disposable batteries
- Easily replaceable/refillable insulin cartridges

Traditional Pump

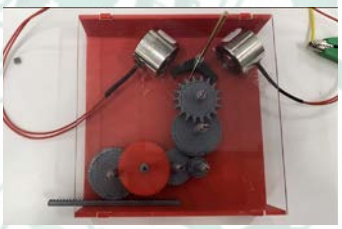


Testing of a prototype device has been completed. Current testing suggests the pump is accurate to within 1% while unloaded, and to within 10% when using a human subcut model.

Mechanical Pump



The mechanical pump a novel design using precision gearing to provide accurate insulin delivery. Initial prototypes have been tested, with a final prototype designed and in production. The current design of the board uses two electromagnets releasing the insulin through the use of an escapement



National Science Challenges

Student Team	Supervisory Team
Harrison Fulton	Prof. Geoff Chase
Matt Payne	Dr. Jennfier Knopp
Thomas Coulson	Lui Holder-Pearson
Hamish Shaw	Jake Campbell

UC BIOMEDICAL ENGINEERING

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INSPIRE ME
Modelling Breathing Effort

BACKGROUND

Adults increasingly require breathing support for a variety of conditions. Continuous Positive Airway Pressure (CPAP) is a type of MV designed to maintain a prescribed constant baseline pressure (PEEP) to prevent airway collapse and support breathing. However:

- ***Insufficient PEEP results in insufficient oxygenation*** -
- ***Excessive PEEP results in lung distension and damage*** -

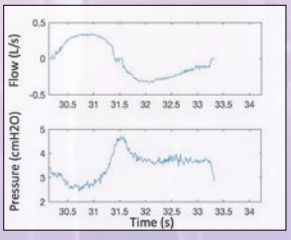
CPAP is commonly used for sleep apnoea which affects ***16,000*** *Adults in NZ*

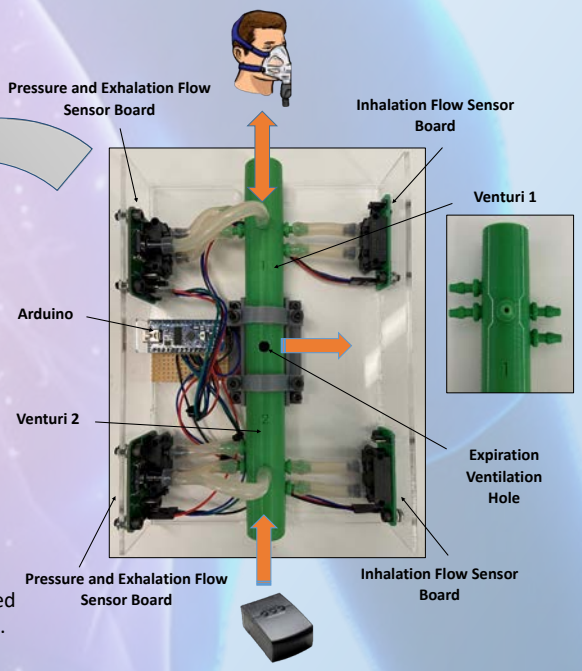
AIM

To use model-based methods to estimate lung stiffness, airway resistance, and inspiratory breathing effort in healthy and asthmatic adults.

METHODS

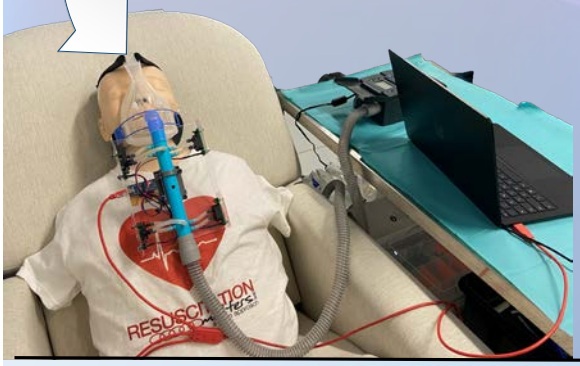
Custom-designed pressure and flow data collection system that was calibrated against a clinical standard was used to capture inspiration and expiration data. Pressure and flow data for one breath is shown to the right.





TRIAL DESIGN

Adult trial (N=30; 15M, 15F): Adults were tested over 4 respiratory rates and 2 CPAP PEEP levels. Breath rate visual and audio cue system used.



MODEL

Modelled using a single compartment lung model capturing elastance (E) and resistance (R).

$$P_{airway} = EV + RQ + R_{outlet}Q_{outlet} + P_{effort}$$

OUTCOME

Designed and built a custom pressure/flow data collection system.
Data was collected from adults at different breathing rates and PEEP levels.
Modelled to identify elastance (E), airway Resistance (R) and breathing effort (P_{effort}).

Project Team: Ella Guy, Oliver Gilbertson and Simon Blue

Supervisors: Dist. Prof. Geoff Chase and Dr. Jennifer Knopp

Special thanks to: Lui Holder-Pearson, Prof. Geoff Shaw, Dr. Bronwyn Dixon

Canterbury District Health Board
Te Poari Hauora ō Waitaha

UC University of Canterbury

Student projects: Mechanical Engineering and Mechatronics Engineering

wattwheels "POWER TO THE PEOPLE"

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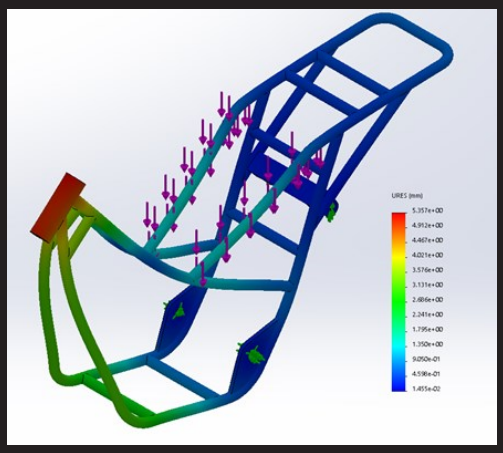
Electric Farm Utility Bike

The need for an electric alternative to the traditional NZ petrol farm bike has been highlighted by WattWheels Ltd. Our mechanical team has been working together with an electrical team to develop a frame and driveline for a lightweight, two wheel drive electric utility bike.

Specifications

- Range of 100km on flat land.
- Maximum speed of 50km/h.
- A total bike weight of 50kg
- Material must be able to withstand New Zealand farming environment.
- Ergonomic design
- Warning light to indicate low battery.
- Control interface
- Large storage space
- Easy to service
- Warranty life of 3 years.



Development

- Finite element analysis was used to simulate frame loadings. The frame design was optimised to better handle common loadings
- Simulation was used throughout the design process to improve the frame through 15 design iterations.

FEA showed that areas requiring reinforcement were:

- The main chassis
- The rear rack
- The head tube

These were strengthened in later design iterations.

Prototype Design

The final design incorporates the initial specifications into a lightweight structure. The electric motor powering the rear wheel is mounted inside the rear swing arm, allowing for the omission of any chain tensioning devices, further reducing weight and complexity. Long travel downhill suspension is utilised to increase off road capabilities and give a comfortable ride.

Note: The final design will incorporate a two wheel drive system with a hub motor powering the front wheel.

Mechanical Team: Michael Bradley, Adam Hodge, Connor Rose-Jecks, Hamish McLauchlan
Academic Supervisor: Dr Digby Symons

Client: Brad Mitchell
Technical Advisors: James Zwaagman, Nigel Beck

Pultruded Composites - Recycling and Design

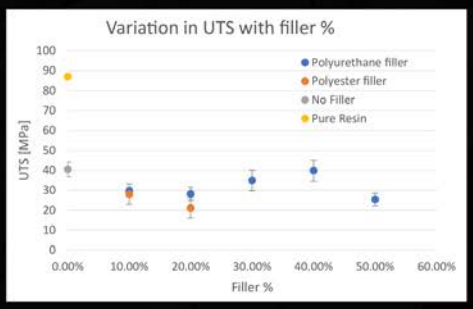
Recycling

We started out with waste from the manufacturing plant, in the form of fibreglass rovings and offcuts.

We did extensive research and decided that mechanical recycling using a fibreglass grinder was the most suitable way to crush the waste.

The output ground-up **powder** was then:
- Analysed for particle size distribution
- Made into tensile testing samples with varying percentages of filler

The tensile testing samples were then tested, and the **results** based on filler % and type are summarised in the graph below.



Microscopy was also performed to examine the layered surface of the composite samples, and to ensure a valuable product could be made.

Design

We developed a design tool (predictive software) that can estimate the moduli of a product based on its manufacturing inputs. The tool helps Gracol staff design products according to unique specifications. We developed a design guide to assist customers in designing with pultruded products.

Micro and Macromechanics

$$P = \frac{P_m[P_f + \xi P_m + \xi V_f(P_f - P_m)]}{[P_f + \xi P_m - V_f(P_f - P_m)]}$$

$$P = V_f P_f + (1 - V_f)P_m$$

Beam Theory

$$\begin{Bmatrix} N \\ M \end{Bmatrix} = \begin{bmatrix} A & B \\ B & D \end{bmatrix} \begin{Bmatrix} \varepsilon_x^0 \\ \kappa_{xy} \end{Bmatrix}$$

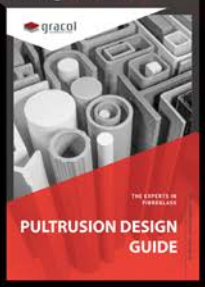
Design Tool:

STAFF

Flexural and tensile testing was performed on existing products to **validate** theoretical predictions.

Design Guide:

CUSTOMER



Solution

The recycled samples were successfully manufactured and data presented to Gracol to guide future development. For the design tool, the process of estimating the moduli of products was automated, this saved Gracol staff time in design and testing. As more component material testing is completed, the accuracy and usefulness of this tool will increase.

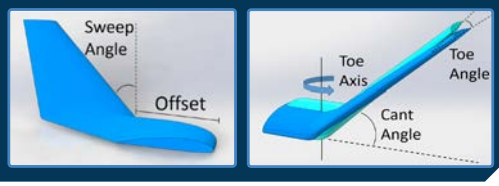
Acknowledgements: Mat Bancroft, Dr. Mark Staiger, Bella Strang
Project Members: Leo Lloyd, Nicole Otto, Zoe McQuoid, Will McEwan

Student projects: Mechanical Engineering and Mechatronics Engineering

Variable Geometry Discontinuous Winglet

- Client came to us with original winglet concept
- Winglets are fitted to wingtips on fixed wing aircraft to reduce induced drag from tip vortices
- Aims - To optimise a novel winglet concept to maximise lift to drag ratio

Winglet Variables

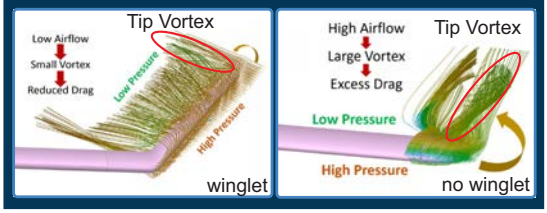


Project Approach: Fast Turnaround Cycle Method

Idea/Solution → *XFLR5 Model and Analysis* → *CFD Model and Analysis* → *3D Printed Winglet* → *Wind Tunnel Tests* → *Comparison to Simulations* → *Evaluation of Proficiency* → *Idea/Solution*

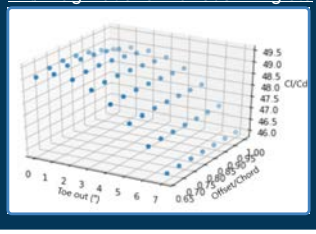
Iterative method until a desired solution has been attained (Lift/Drag improved by ~7%)

Advantage of a Winglet versus No Winglet



XFLR5

Lift/Drag Ratio for Various Winglets



- Modelled winglets in XFLR5 with differing parameter values
- Accumulated Lift/Drag data at relevant angles of attack
- Plotted lift to drag ratio (Cl/Cd) against four design parameters
- Optimum winglet corresponded to the highest Cl/Cd value

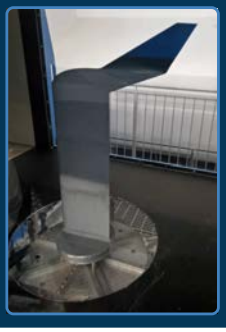
CFD

- Ansys Fluent 2019 R3 with Spalart-Allmaras and a 7 million cell mesh obtained lift, drag and vortex data
- CFD was within 10% of XFLR5 and wind tunnel for similar conditions
- Ansys Discovery Live 2019 R3 was used for flow visualisation

Wind Tunnel

- 3D Printed wing with interchangeable winglets

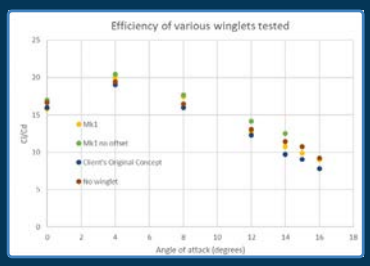
- Tested at 200 km/h between 0° and 16° angle of attack
- Analysed results in Excel and Python



Findings:

- The proposed design from the client did decrease the drag but it also reduced the lift
- Considering manufacturing feasibility and efficiency, conventional winglet is the most optimised

Results



UC University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand

Team members:
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Matt Henderson
Beng Phiansamoe
Isaac Ulusele

Client:
Cris Lawry

Supervisor:
Mark Jermy

Wireless Temperature Monitoring for Oven Product Development

Background

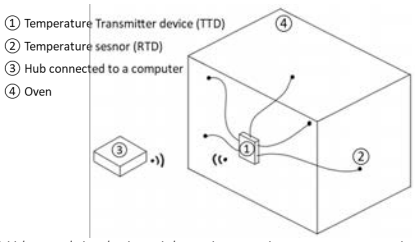
- Fisher & Paykel run tests to monitor the temperature of components within the oven electronic compartment.
- The current operation uses thermocouple sensors.
- Thermocouples provide an accurate temperature reading but become tangled and are time consuming to set-up.
- The focus of this project was to investigate and develop a wireless temperature monitoring system to remove the need for thermocouples and reduce set-up time.

Oven showing the electronics compartment at the top.

Project Specifications

Create a device that will:

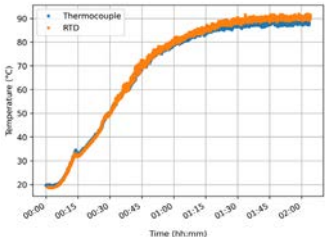
- Reduce set-up time for testing.
- Monitor up to 50 locations.
- Exist in the extreme temperatures of the oven.
- Monitor temperatures up to 250 °C.



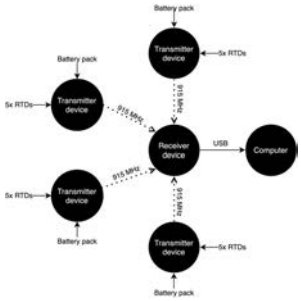
Initial concept design, showing a wireless receiver connecting to a temperature transmitter device on the oven.

Challenges

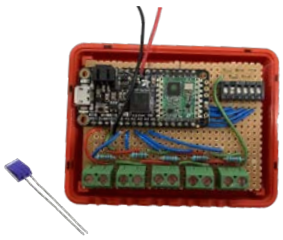
- Batteries were unable to operate at high temperatures.
- High temperatures deformed device casings.
- The sensors became less accurate at higher temperatures.



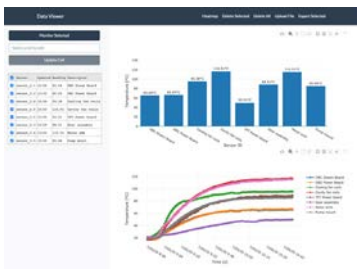
Comparison showing similarities between Fisher & Paykel's thermocouple based logger and the created device using RTDs.



Network map of how the devices interact with each other.



RTD sensor and Temperature Transmitter Device prototype (not to scale).



Screenshot of the user interface software created to pair with the created device.

Final Design

- Resistance Temperature Detector (RTD) sensors connect to a Temperature Transmitter Device (TTD).
- The TTD uses a development board that includes a 915MHz transceiver.
- The TTD transmits data to a receiver.
- Accuracy to ± 1 °C up to 75 °C.
- The receiving device exports the data as a CSV file.
- There can be multiple transmitters with one receiver.
- Integrates with a bespoke user interface which includes data visualisation.

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FISHER & PAYKEL

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Student projects: Mechanical Engineering and Mechatronics Engineering

Rotational Impact Protecting Rugby Headgear

Background

- 5 million concussions occur in sport annually.
- ACC spent $415 million dollars on treatment of concussion last year.
- Long term effects of concussion include: Depression, anxiety, Alzheimer's and Parkinson's Disease
- Linear and rotational accelerations experienced by the brain upon impact.
- Rotational accelerations cause shear-induced tissue damage.
- Shear deformation is the predominant mechanism of injury in concussion.

Aim

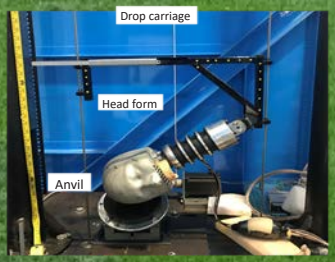
- Produce a test rig that can accurately measure and simulate rotational head impacts experienced in rugby.
- Investigate headgear materials that reduce the accelerations experienced by the head in a rotational impact.

Deliverables

- Testing methodology for rotational impacts.
- Design and build an instrument package.
- Testing to validate instrument package.
- Investigate and test existing head protection devices.
- 3D printed samples for new head gear material.

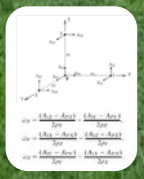
Rotational Impact Simulation

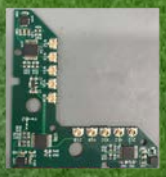
Head form is dropped onto a 30/45 degree platform which induces an oblique impact in 5 rugby-like impact scenarios. These produces angular accelerations up to 3200rad/s which are comparable to those experienced in a game of rugby. Accelerations of the head form are measured by an instrument pack located in the head form.

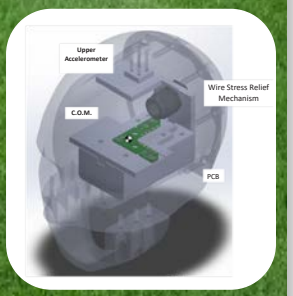


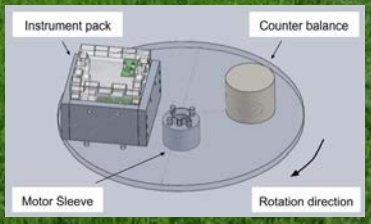
Instrument Pack Development

The instrument pack uses four linear accelerometers to find angular accelerations. The layout has one accelerometer is sitting in the centre of mass then the other three are place on the x, y, and z axis. This allows the angular accelerations to be calculated from the linear accelerations.









Sensor Validation

Validation of the instrument pack ensures that the accelerations are measured accurately. Validation was accomplished by spinning the accelerometer testing assembly at a known velocity and then calculating the centripetal acceleration which will then be compared to the produced accelerometer readings.

Material Investigation

Investigating the application of Fluid Inside and MIPS helmet slip mechanisms in soft shelled rugby headgear. Development of 3D printed elastomeric lattice to provide slim-line slip capability and reduce rotational accelerations experienced by the head.

P19

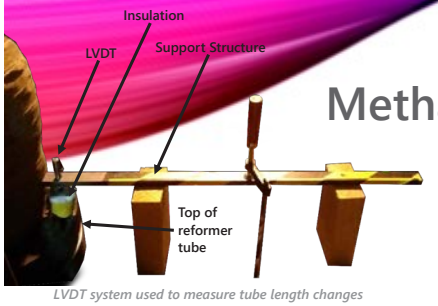
Margot Willis, Jonty McMillan, Jack Brough, Romke Hoogstra

Supervisor: Dr. Natalia Kabaliuk

Clients: Prof. Nick Draper, UC School of Sport and Physical Education

UC University of Canterbury

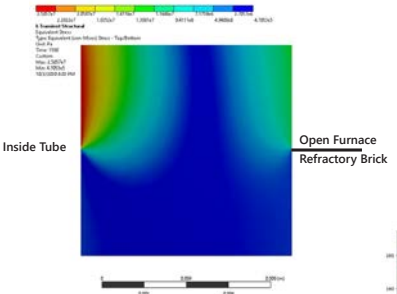
Methanex Reformer Tube Investigation



LVDT system used to measure tube length changes

Data Analysis and FEA

Length and spot temperature measurements were taken of the tubes using a linear variable differential transducer (LVDT) system and an infra red pyrometer, respectively, which identified exaggerated thermal cycles of the suspect tubes. This suggests a failure mechanism of cyclic fatigue damage. This theory was supported through development of a finite element analysis model, which demonstrated that thermal cycles could create fluctuating stress gradients at the intersection of open furnace and refractory brick layer, and metallurgy that showed creep void concentrations on the suspected principle stress planes.

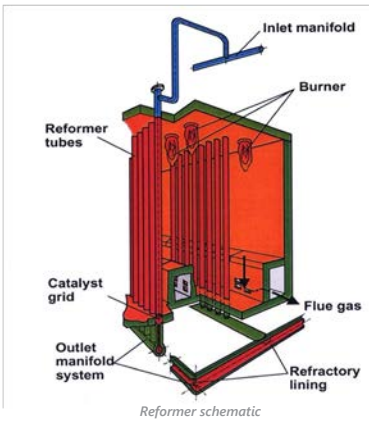


FEA of the tube as it enters the refractory brick layer

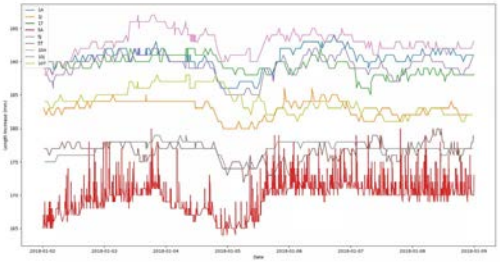
Section of tube crack

Problem

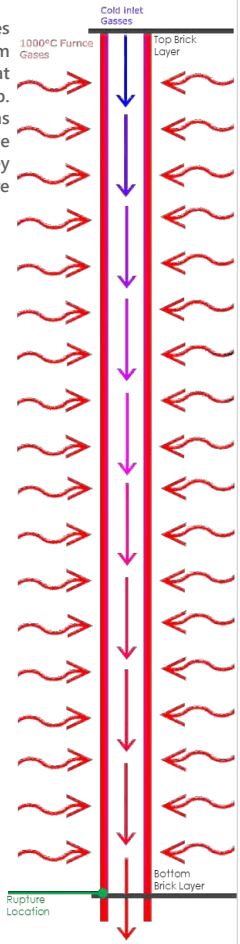
The Methanex steam methane reformer furnaces contain multiple tubes that convert natural gas and steam to reformed gas. High operating temperatures mean that the tubes have a finite life, ultimately failing by creep. However another failure mechanism could be involved as the tubes in the coldest furnace regions experience the most creep. If the tubes are not replaced in time then they will fail with large cracks. The significance of temperature fluctuations were investigated for tube life consumption.



Reformer schematic



Thermal cycles influencing the tube length



Schematic of one of the 680 tubes in the refomer furnace

Leading Theory and Next Steps

All evidence to date supports the leading theory of creep fatigue as the primary cause of the failures in the coldest tubes. The next steps are to apply this concept to the analysis that determines the optimal tube thickness relative to a creep-fatigue interaction, rather that steady state creep alone. The cause of the thermal cycles also needs to be identified to eliminate or mitigate the severity.

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Team:	Supervisor:	Special thanks:
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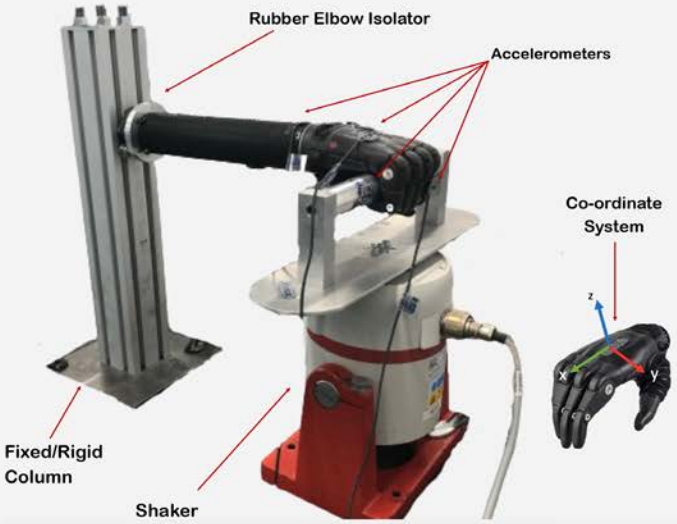
Hannah Lilley	Methanex:	Alice Young
Phillip Dain	Peter Tait	Matrix Engineering
Mitchel Couchman	Diego González	UC Workshop staff

Student projects: Mechanical Engineering and Mechatronics Engineering

TASKA PROSTHETIC WRIST-VIBRATION RESPONSE AND OPTIMISATION FOR USER COMFORT



BACKGROUND

- Robustness and versatility are defining qualities of the Taska prosthetic. An understanding of how the Taska Quick Disconnect Wrist reacts to everyday activities is crucial to guarantee customer satisfaction.

PROBLEM STATEMENT

- Analyse the vibrational response of three wrist systems; Taska's QDW, the standard QDW and a low profile option. From this we identified any possible areas for improvement in user experience with Taska's new model.

RESULTS

- Frequency sweep test measurements recorded below:

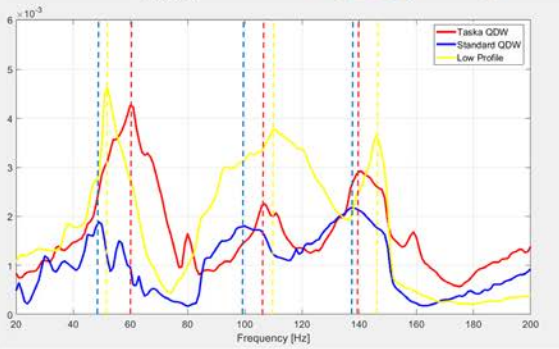


Figure 1—Highlight of the shifted resonant frequency peaks of each wrist recorded by the sensor on the wrist, subject to constant input acceleration in the Z direction.

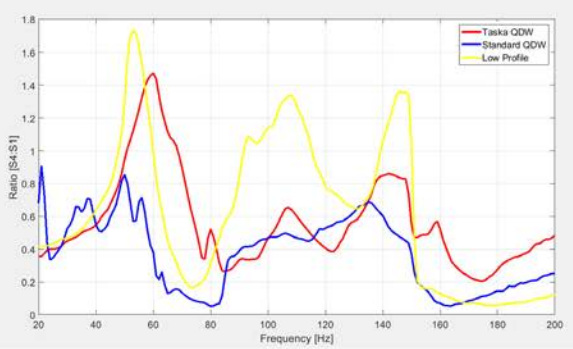


Figure 2—Ratio of amplification of the induced vibrations from the sensor on the input to the sensor on the wrist subject to constant input acceleration in the Z direction.

ANALYSIS

- We found that that the Standard QDW attenuates the input vibration at every frequency. Taska's QDW amplifies the response at the first resonant peak of 60 Hz and the low profile amplifies the response at each resonant frequency.
- Our recommendation is for the Taska team to alter the mass distribution in the new Taska QDW to shift the location of the resonant peaks or change the rigidity of the materials used to reduce the vibration perceived by the user.

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TASKA PROSTHETICS:
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ROSS DAWSON

TASKA

Student projects: Mechanical Engineering and Mechatronics Engineering

AUTOMATED SPRAYING OF WILDING PINES

Developing a more efficient system for aerial spraying of wilding pines by accurately and automatically controlling individual nozzles across a helicopter spray boom

ADVERSE EFFECTS OF WILDING PINES

- Overwhelming and eliminating native vegetation, wildlife and landscapes
- Already covering 1.8 million hectares of New Zealand
- 5% growth each year despite current control - 20% of NZ will be covered in 20 years without change

BENEFITS OF MORE EFFICIENT APPLICATION

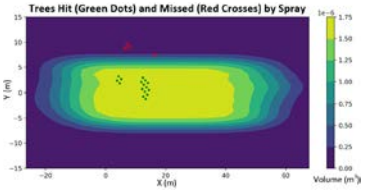
- Optimise fuel and herbicide utilization
- Reduced herbicide on untargeted foliage
- Decreased helicopter flight time and emissions
- Reduced ongoing operation costs for DOC
- Preservation of New Zealand's natural landscapes

SENSORS

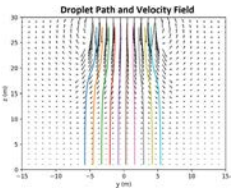
- GPS data
  - → Speed
  - → Altitude
  - → Bearing
- Meteorological data

SPRAY TRACKING MODEL

- Droplet tracked with current speed, velocity field and gravity
- Droplet position and volume recorded at ground
- Developed in Python then converted to C# for optimum speed
- Adapted key elements of helicopter airflow model from Continuum Dynamics' AGDISP



- The Velocity Field includes Helicopter Downwash, Rotor Tip Vortices, Forward Velocity and Wind



USER INTERFACE

- Interactive display for pilot
- Tree location input
- Low-clutter interface

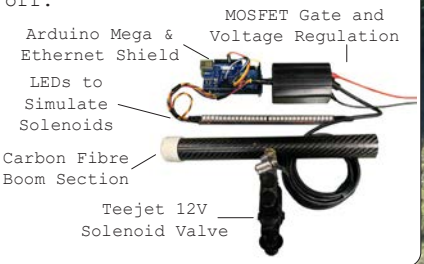
MAIN CONTROL UNIT

- Integration and operation of subsystems
- Summary reports and data storage
- Receiving/processing meteorological data

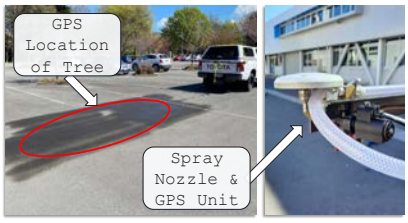
ON/OFF signals and timing

ACTUATION SYSTEM

- Arduino receives on/off times for each nozzle via an Ethernet cable connected to the NUC.
- MOSFETs gate the 12V supply that turns the solenoid valves on and off.



PROTOTYPING



- Successfully tested a 5-nozzle spray boom
- Nozzles turned on automatically above pre-set GPS points representing target trees

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Mechatronics Students:
Jack Taylor
Liam Hunn
Software Students:
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Sponsors:
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Supervisors:
Mark Jermy Mechanical
Andreas Willig Software

SCION FORESTS • PRODUCTS • INNOVATION

Department of Conservation Te Papa Atawhai

FREIGHTFISH

P26: CAVITATION ON HYDROFOILING SHIPS

Problem - Cavitation

Cavitation is a phenomenon in which a fluid experiences a rapid change in pressure, leading to the formation of small vapor-filled cavities. When cavitation occurs on a hydrofoil, it causes a sudden and dramatic loss in lift causing the vehicle to fall off its foils.

Figures 1-3: (Left) Tip vortex cavitation (TVC), (middle) travelling cavitation, (right) sheet cavitation.
Images courtesy of: YAMAGUCHI, H., & MIYANAGA, M. from http://www.1.k.u-tokyo.ac.jp/yama/fluidlab/Research/CavPictures/index_e.html

Our Solution - Computational Fluid Dynamics (CFD) Simulations

1. Developed an accurate CFD model to determine a region of safe operation

2. Started with 2D simulations and built a workflow for 3D simulations

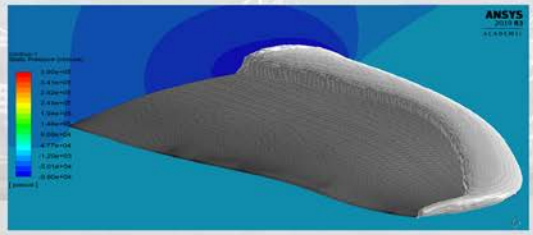

Figure 5: 10% volume fraction of water vapour at 14 degrees angle of attack and 14m/s velocity (3D simulation)

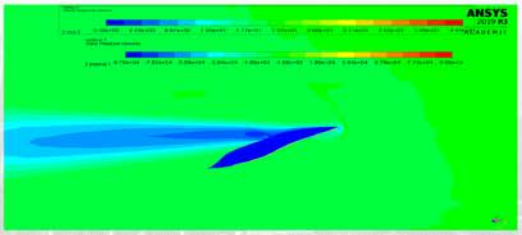

Figure 4: Static pressure and velocity magnitude contour plots at 10 degrees angle of attack (2D simulation)

3. Ran extensive CFD simulations using ANSYS to characterize cavitation over a hydrofoil

4. Modified FreightFish's internal control system to constrain angle of attack on foils to operate in this safe region

Integrating the CFD Results Into the Control System

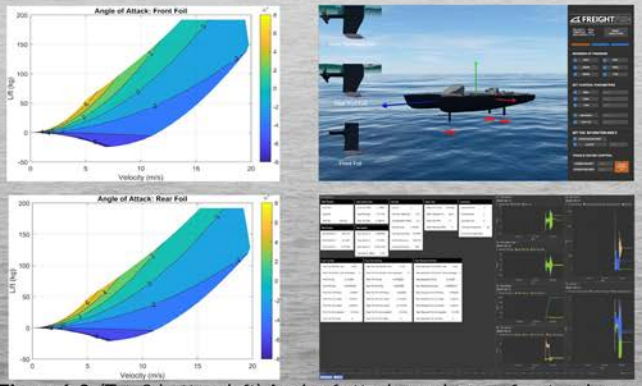

Figure 6-9: (Top & bottom left) Angle of attack envelope on front and rear foils, (top right) Unity 3D simulator, (bottom right) OpenMCT dashboard

1. FreightFish provided the safe operating region envelope (seen in figure 6 and 7). Outside this safe operating region cavitation, stalling and spindle failure occurs

2. Developed a higher resolution envelope using 3D simulations

3. The vehicle's actuators are clamped to operate at the minimum and maximum angle of attack that lies within the safe operating region.

4. Integrated this into FreightFish's simulator and data dashboard.

5. Full visual control via a modern user interface

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Juan Robertson
Dr Sam Harding
Richard Young
Jack Beagley

Supervisor
Dr. Dan Zhao

Technologies used
unity
openMCT
Ansys

FreightFish's website

P27: ULTRA-LOW-COST SATELLITE PROPULSION MODULE

DAWN AEROSPACE

Project Brief:

Develop a propulsion module based on H2O2 monopropellant thrusters capable of delivering 150m/s dV to a 16U CubeSat for less than USD 2000 in component cost.

In-space transportation of satellites is a crucial part of harnessing space. Satellite propulsion modules allow for orbital positioning and manoeuvres. With this project, we aim to develop propulsion technology that uses non-toxic/safe propellants and is easy to mass-produce at a low cost.

Control

Control over the propulsion system is required to ensure that the thruster only fires when commanded, and for the right amount of time to achieve the commanded manoeuvre. A central control unit monitors and manages the state of various propulsion system components through an array of sensors. It controls the thruster using the pump and thrust vector control system.

Motors

Motors are required to drive the pump that delivers fuel to the thruster. Brushless motors provide high torque with low volume and simultaneously mitigates the risk of particulate matter from motor brushes, which could interfere with the satellite's electrical systems and payloads.

Sensors

Sensors are required to provide feedback on the operating state of the propulsion system. They must be high accuracy, low cost, and small. In space, radiation and temperature fluctuations dramatically reduce the reliability and lifespan of electrical components. Each component had to be selected to meet the demands of such an extreme environment.

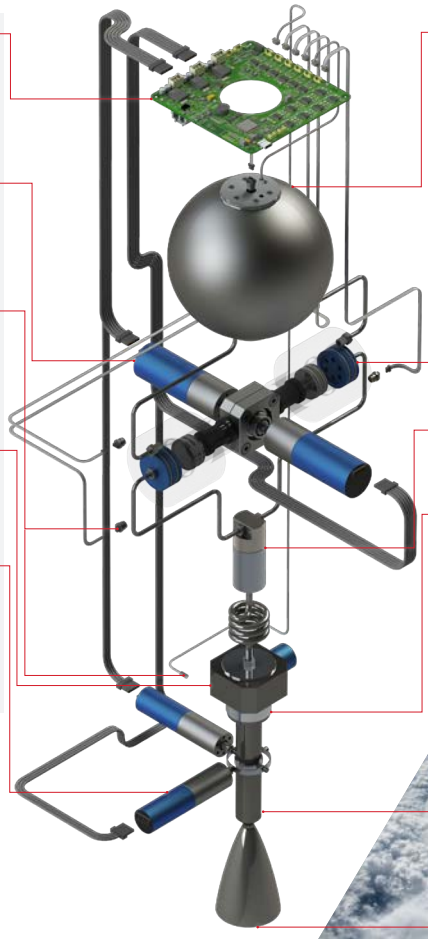
Valve

The feed system is isolated from the thruster assembly by the main valve. The valve determines the flow of propellent into the thruster. This valve is actuated by the control system to provide a specific delta-v to the satellite.

TVC

Thrust Vector Control is required to direct the satellite and provide torque compensation without using the reaction wheels in the main satellite unit. The module's design allows for future integration of a complete TVC system.

At present, motors have been specified, a PCB to monitor fuel consumption, thruster state, run the fuel pump and valves and monitor the orientation of the satellite has been designed and is in the testing process.



PMD

In the low gravity environment of space, liquid propellants form droplets which are free to float in the pressurant gas within a tank. The Propellant Management Device (PMD) controls the location of the propellant and pressurant gas bubble within the propellent tanks, providing a continuous supply of propellant to the pump. A conceptual design of the propellent tank and PMD system has been developed.

Pump

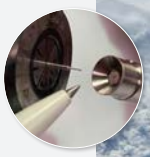
Propellent storage volume is extremely limited by the satellite build volume. To achieve the desired delta-v from the limited volume of propellent, the thruster requires propellant to be supplied at high pressure. The pump takes low pressure propellant from the tanks and increases the pressure as required.

The pump enables the entire system to have low standby pressures. This provides extremely low leak rates, which is required for a long operational life in orbit. A pump was designed for manufacture. The design is currently undergoing testing to determine performance characteristics.

Regulator

The output of the pump is regulated to provide a continuous feed of propellent to the thruster.

Injector

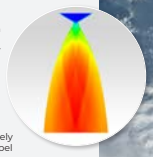


The injector regulates flow into the thruster to prevent flow instabilities during operation. Propellant is forced through a small orifice, which results in a pressure drop. This acts to physically separate the feed system and catalyst pack, stopping reverse gas flow back into the feed system during decomposition.

Catalyst pack

In the catalyst pack, liquid hydrogen peroxide decomposes into oxygen and steam, reaching temperatures of 800 degrees Celsius and expanding 100's of times in volume. The catalyst pack consists of many metal mesh disks coated with a thin layer of reactive material. Hydrogen peroxide is force through spaces within the mesh and decomposed on contact with the catalyst.

Nozzle



The nozzle is an energy conversion device designed to produce highly-efficient thrust. Low-velocity gas at high temperature and pressure enters the nozzle downstream of the catalyst pack. As the gas travels through the nozzle, thermal energy from decomposition converts to kinetic energy. At the nozzle exit, the exhaust is travelling at approximately 800 m/s, resulting in a force to propel the satellite.

Development of Thermal Characteristics

The thermal analysis provides insight into the required sub-system operating conditions. Thermal energy produced through peroxide decomposition is capable of reaching temperatures exceeding 700K. Exposure to these temperatures can easily result in sub-system failure, with potentially catastrophic consequences. The problem was tackled using thermal analysis of the thruster during the burn phase and reactor during the decomposition reaction. Results were used iteratively design thermal limitations, utilising flow and environmental characteristics. In conclusion, the system was determined to be able to be operated safely, with thermal risks sufficiently mitigated.

Thruster

The thruster produces a force to propel the satellite while in space. Hydrogen Peroxide decomposes within a catalyst pack before being accelerated through a nozzle at over 2500 km/h. The change in momentum from accelerating exhaust gasses through the nozzle is what produces the desired thrust.

Following the design phase, analysis of the flow through the combustion chamber and nozzle was completed using a combination of analytical and computational methods. Assessing isentropic flow through the nozzle, the performance and thrust capabilities were determined to verify with design requirements. Furthermore, CFD analysis was used to confirm and verify the isentropic flow calculations.

A mock-up thruster was produced and successfully fired on a test stand at Dawn Aerospace. Several sensors were used to collect key performance parameters such as chamber pressure and internal decomposition temperature. Comparison of the experimental data with the expected flow characteristics is the current focus in terms of flow and thermal analysis, and the final step in justifying an operational thruster. Testing is ongoing and presenting promising results.

SINGLE-USE ACETABULAR IMPLANT INSERTION TOOLS

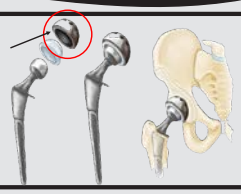
Motivation

Enztec wish to break into the single-use surgical tool market as this is becoming increasingly popular in the industry. Disposable tools would have the benefit of guaranteed sharpness of the tools every time, reduce risk of patient infection due to lack of cross contamination potential, decrease time and money required for sterilization

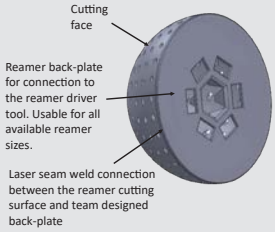
Scope

To design and analyse the three tools required for acetabular shell insertion:

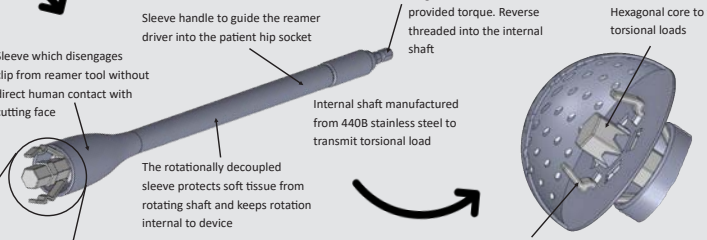
- Reamer
- Reamer driver
- Impactor

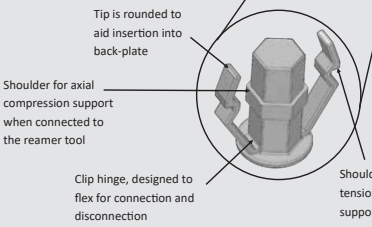


REAMER TOOL



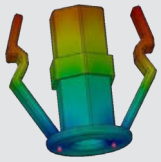
REAMER DRIVER TOOL





Clip

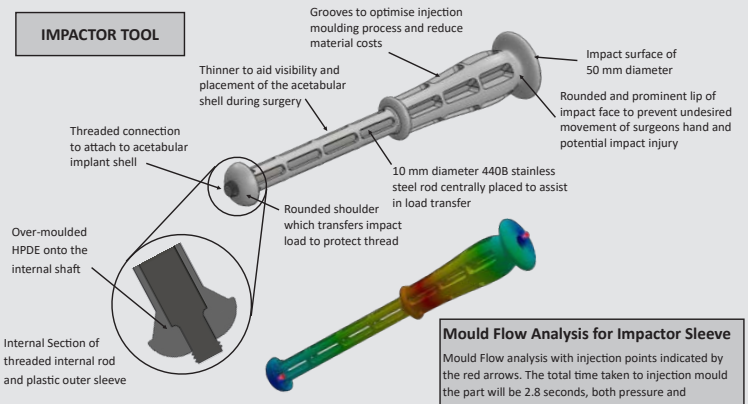
Clip which attaches to the back plate of reamer. Over-moulded onto the internal shaft. Core hexagon to transmit torsional load to reamer tool, external clips to constrain in axial direction



Mould Flow Analysis for the Clip

Injection points of 1 mm shown by red arrows, at clip base. Gave an overall fill time of 1.98 s for total fill using the HDPE material. Pressure and temperature were within allowable parameters

IMPACTOR TOOL

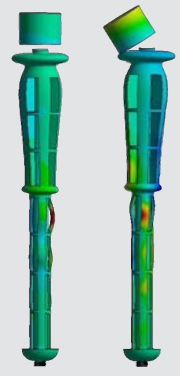


Mould Flow Analysis for Impactor Sleeve

Mould Flow analysis with injection points indicated by the red arrows. The total time taken to injection mould the part will be 2.8 seconds, both pressure and temperature are all within allowable parameters

Dynamic Impact FEA for Impactor

A dynamic impact FEA was conducted on the impactor tool. A 27.5 m/s velocity of the hammer head was applied as an initial condition over an impact time frame of 0.01 s. The bottom cup and thread were fixed supports to emulate conditions experienced in use. Concentric impact loading experienced a maximum deflection of 4.11 mm and a 10 mm eccentric impact loading experienced a maximum deflection of 2.78 mm.



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CHRISTCHURCH NEW ZEALAND

Team Number: P28 –2020
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Sponsor: Dr Iain McMillan
Special thanks to: Kenneth Brown, David Read, Tony Doyle, Bill Mohs , Dave Fanner and Julian Phillips

Department of Mechanical Engineering

Final Year Project

Team Members:
Rhys Broad
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enztec

ADVANCED MATERIAL DEVELOPMENT—C969

Introduction

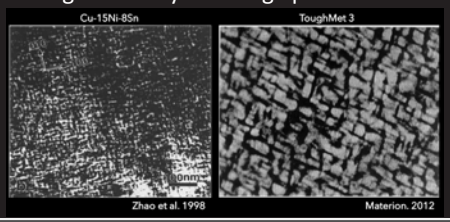
The goal for this project was to create a heat treatment process that would allow for the redevelopment of a bronze alloy known as C969. This alloy is currently made by only one company in the world. C969 is a high strength copper-nickel-tin alloy with applications in oil , mining and aerospace industries as bushings and bearings.

The project was sponsored by AW Fraser. AW Fraser is a world class Christchurch based producer and supplier of bronze alloys and brass extrusions.
AW Fraser manufactures with 99% recycled material and produces parts that can be found in every country in the world.

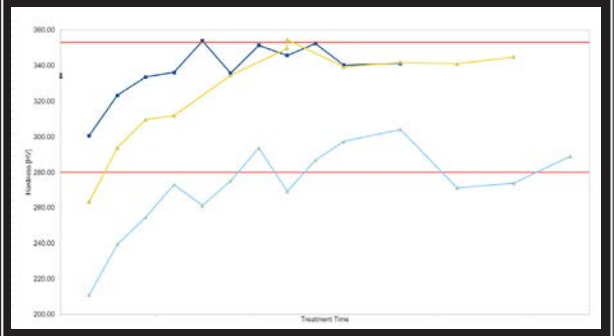
Literature Review

A literature review was completed and it was found that one of the reasons for C969's high strength and toughness is its spinodally decomposed structure, this is a very fine scale modulation in the composition of the alloy. Spinodally decomposed alloys are rare an d C969 is one of very few commercial alloys to have this structure. A transmission electron microscope (TEM) is required to view this structure. This research resulted in us having a better understanding of the alloy and allowed for a heat treatment plan to be created with specific time and temperature ranges identified as likely to give the desired mechanical properties.

TEM Images of Alloy Showing Spinodal Structure



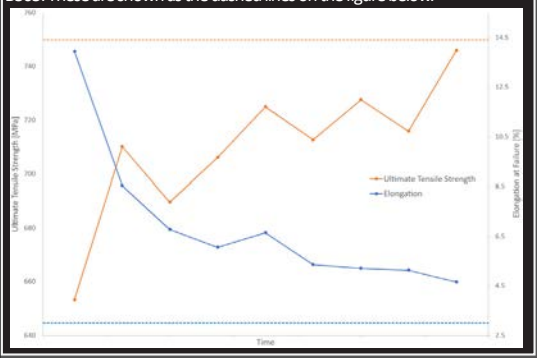
Hardness Testing



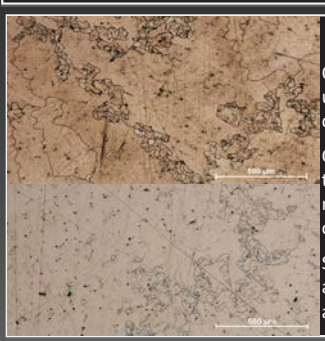
Hardness testing was done to find at what heat treatment time and temperature the peak hardness occurred. The red lines seen on the graph represent the upper and lower limit for hardness given by the ASTM standard. Points on the far left of the graph represent the competitor material and the each line represents a different temperature.

Tensile Testing

Using the hardness testing results we refined our heat treatments. Tensile tests were then used to determine if the mechanical property requirements for strength and elongation were met from the ASTM standard B505. These are shown as the dashed lines on the figure below.



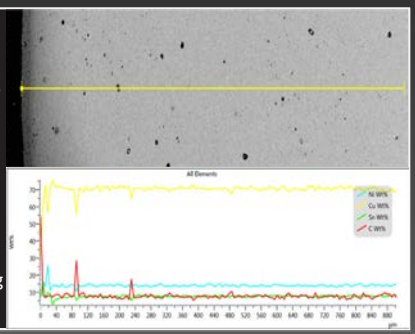
Microscopy



Optical and the Scanning Electron Microscope (SEM) were used to both characterise the alloy and further understand the chemical composition and microstructure.

Optical Images taken before (top) and after (bottom) heat treatment can be seen on the left. It can be seen that a similar microstructure to the competitor alloy was obtained following our heat treatment processes.

SEM line scans were used to map the composition of the alloy across the sample, the right image is an example of this looking at surface de-alloying as a result of heat treatments.



Conclusion

The conducted heat treatment processes have exceeded the minimum required mechanical properties set by the ASTM standard for hardness and elongation of the alloy. Further heat treatments and testing are being performed so that the final requirement of ultimate tensile strength is met. These tests are being conducted with cast AW Fraser material to confirm their capabilities of replicating the alloy.

FRASER engineered bronze

Team: Kyle Ryland, Thomas Wilkie, Hosea Watson

Supervisor: Professor Milo Kral

Sponsor: Philip Benson

Thanks to Kevin Stobbs, Shaun Mucalo and the Mechanical Workshop

UC UNIVERSITY OF CANTERBURY

Student projects: Mechanical Engineering and Mechatronics Engineering

CORROSION REMOVAL PROCEDURES ON AIR NEW ZEALAND AIRCRAFT

Fig 1: Corroded aircraft wing skin around fastener

Background

- Research conducted in 2018[1] concluded salt accumulation to be a contributing factor to Corrosion on Air New Zealand (Air NZ) aircraft; in particular, their Airbus A320 fleet.
- Corrosion has the potential to decrease the structural integrity of an aircraft, therefore must be repaired to maintain adequate aircraft safety.
- Current corrosion repair procedures are time consuming and expensive, it requires fastener removal to eliminate the possibility of dissimilar material cross-contamination.
  - Air NZ believe there is opportunity to increase the efficiency of this procedure.

Purpose

- Investigate and determine effective methods of corrosion removal whilst fastener remains installed:
  = *"Fastener Installed"* (F.I) procedure.
- Investigate and quantify the effects of dissimilar material cross-contamination between Aluminium Alloy 2024 (aircraft wing skin) and Titanium Alloy Ti-4Al-4V (fasteners).

Testing & Analysis

F.I Corrosion Removal Simulation

- Aircraft grade titanium alloy fasteners were media blasted, using a variety of different methods including; linear, swirl, and spot blasting, both with and without aluminium tape covering the exposed fastener heads. All testes were completed using industry-approved methods (glass-bead suction blasting) (see Fig 2).

Cross-Contamination Analysis

- Methods of Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Spectroscopy (EDS) (see Fig 3) were used to investigate cross-contaminated titanium present on the aluminium alloy (2024) base material.

Fig 2: Media blasting titanium alloy fastener using Nederman suction blaster with glass bead.

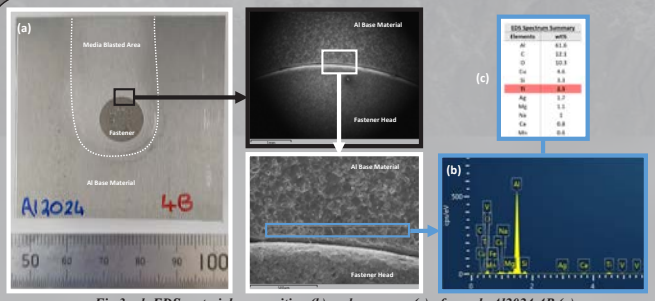


Fig 3a-d: EDS material composition (b) and summary (c) of sample Al2024-4B (a)

Results

- Dissimilar material cross-contamination can occur when using glass bead media blasting as a means of F.I corrosion removal.
- Data was used to determine:
  - Best technique for F.I corrosion removal to minimise cross-contamination:
    = 'Spot blasting' (see Fig 4).
  - Effectiveness of aluminium foil tape as a preventative technique to minimise cross-contamination:
    = Application drastically reduces cross-contamination by ~100 times (see Fig. 5).

Recommendations

- If undertaking F.I glass bead media blasting corrosion removal:
  - Use a 'Spot' blasting technique for 1 s intervals for up to a total of 10 s.
  - Use aluminium foil tape to cover the exposed fastener head to minimise material cross-contamination.

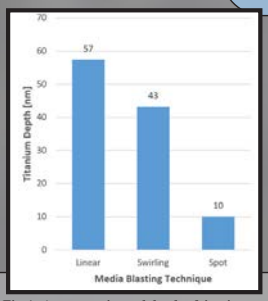


Fig 4: Average estimated depth of titanium on aluminium surface after 10 s media blasting

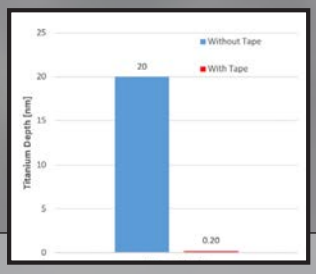


Fig.5: Average estimated depth of titanium on aluminium surface with and without Aluminium foil tape covering exposed fastener head during 10 s 'spot' blasting

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Special Acknowledgments:
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Zac Perston
Garry Cotton
Mechanical Engineering Department

[1] James, T. et al; (2018); *Elimination of Salt Corrosion on Air New Zealand Airframes;* (BE(Hons) Dissertation; University of Canterbury, Christchurch, New Zealand)

[Background] *Sommer, P. (2014, August 16). Airplane Air New Zealand take-off from Queenstown.*

AIR NEW ZEALAND

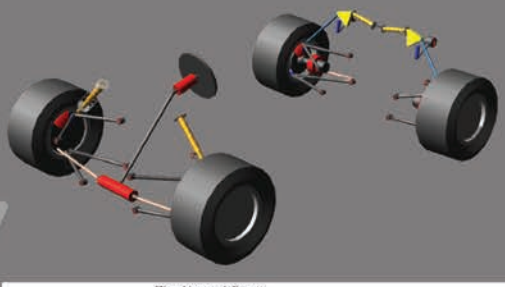
Student projects: Mechanical Engineering and Mechatronics Engineering

VEHICLE PERFORMANCE

UCM20

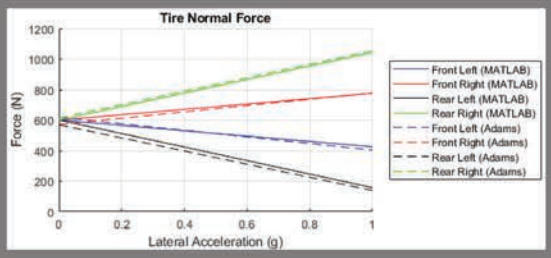
Objectives:

- Model and validate existing UCM2019 vehicle.
- Develop tools for validation of future designs.
- Produce documentation proposing vehicle design improvements that result in increased vehicle performance.

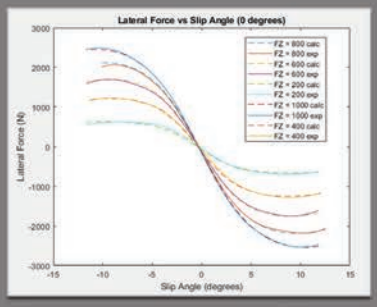


ADAMS MODELLING

- Modelling the vehicle in Adams Car allows suspension designs to be tested in a kinematic and dynamic environment.
- Justification of designs against lap time improvements.
- Model has been fully validated through the fundamentals of lateral load transfer using MATLAB.



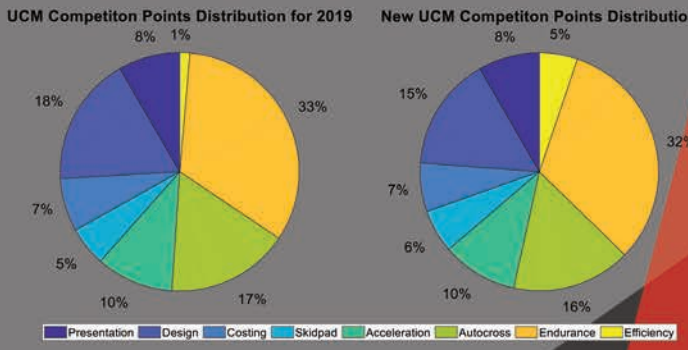
TIRE MODELLING



- Creating a dynamic tyre model helps to produce accurate vehicle modelling and suspension geometry optimisation in Adams Car.
- MATLAB least-squares curve fitting tools are used to best approximate the tyre's non-linear performance behaviour.
- Output tyre models have been validated against experimental datasets from Calspan International.

LAP SIM / COSTING

- A MATLAB program that computes the points UCM could theoretically gain at competition with different car configurations.
- Takes the cost of car components and the general vehicle performance properties and calculates its theoretical lap times and overall cost.
- Can be used to justify spending on car components and whether the team will see a gain in points from this at competition.



UNIVERSITY OF CANTERBURY MOTORSPORT

Client: University of Canterbury **Faculty Advisor:** Bruce Robertson
Supervisors: Digby Symons
Staff: Zac Perston, Kevin Stobbs
Students: Blake Parish, Jared Parker, Lachie Crawford

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Student projects: Mechanical Engineering and Mechatronics Engineering

Thermal Design

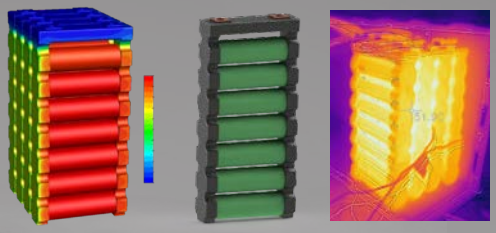
UCM20

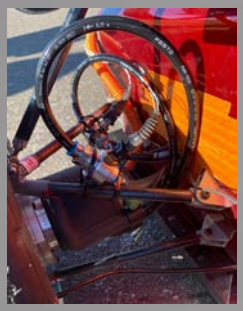
Objectives:

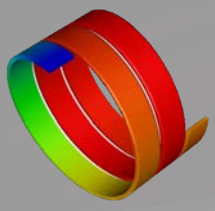
- Analyse the limitations of convective air cooling of lithium ion battery cells
- Motor cooling system and motor jacket analysis to increase liquid cooling effectiveness
- Optimise thermal dissipation of power inverters using a water cooled aluminium plate
- Wheel hub cooling system to reduce brake temperature

ACCUMULATOR COOLING

- CFD analysis to model lithium ion battery cell temperatures under race conditions, using experimental air velocities.
- Design of experimental test methods and apparatus
- Scaled physical testing conducted to validate the model





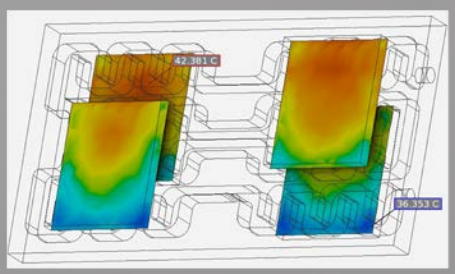


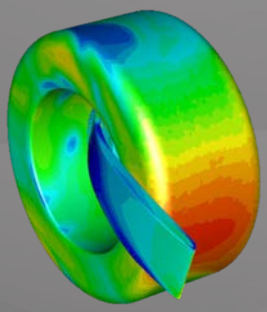
MOTOR COOLING

- Low voltage capacity constraints prevents increasing the jacket coolant flowrate
- CFD analysis conducted on water passage to assist in redesigning a more efficient package
- On track testing with sensors provided useful data
- Maximum allowable motor temperature: 80 °C

INVERTER COOLING

- Two inverters are mounted to each side of a water-cooled plate.
- Steady state CFD heat transfer on inverter heatsink
- Manufacture of aluminium prototype and physical testing





INNER HUB COOLING

- The area inside the wheel contains a planetary gearbox and brakes which have previously overheated (250 °C +)
- Design of a duct to divert air flow from the front wing into the wheel hub to convectively cool the hub.
- Aerofoil directs flow

UCM
UNIVERSITY OF CANTERBURY MOTORSPORT

Client: University of Canterbury **Faculty Advisor:** Bruce Robertson
Supervisor: John Pearse
Staff: Zac Perston, Julian Phillips, Bill Mohs, Natalia Kabaliuk
Students: Spencer, B. Shaun, H. Reid, W. Dylan, C. Emad, M

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P33

SHELL ECO-MARATHON

Elroy Lederman, Jacob Nelson, Grace Elliot, Josh McDougall, Ezra You

PURPOSE STATEMENT

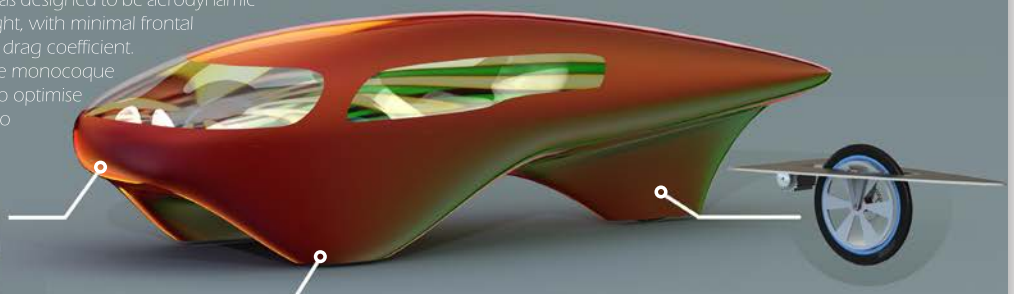
The purpose of the project is to represent both the University of Canterbury and New Zealand at the Shell Eco-Marathon competition in April 2021. This will be achieved through the design and manufacture of an energy efficient electric vehicle. The solution must be a 'Prototype' car that is robust and innovative in its design. Success for this project would be achieved by placing first in the Prototype Class of the 2021 Shell Eco-Marathon Asia competition.

WHAT IS THE SHELL ECO-MARATHON?

The Shell Eco-Marathon is one of the world's leading energy efficiency competitions, amalgamating all areas of STEM in a challenge to design and construct an innovative, ultra-energy efficient car. While there are two vehicle classes, Team P33 has opted to compete in the 'Prototype' class. This category is focussed on ultra-efficient, light-weight vehicles that are separated into three distinct energy sources, of which Team P33 has elected to compete in the 'Battery Electric' competition.

CHASSIS DESIGN

The chassis was designed to be aerodynamic and lightweight, with minimal frontal area and low drag coefficient. A carbon fibre monocoque was chosen to optimise the strength to weight ratio.



PEDAL BOX

The pedal box was developed though several iterations for optimal functionality, simplicity, and minimal weight.

STEERING SUB-ASSEMBLY

The steering design considered a number of factors, including maximum turning radii, camber, toe-in or toe-out, rolling resistance, and construction materials, in addition to conducting stability and Ackermann calculations. Three 20" BMX racing wheels have been selected for the vehicle.

REAR WHEEL SUB-ASSEMBLY AND POWERTRAIN

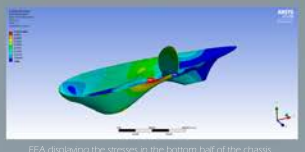
The rear sub-assembly has been designed to completely detach from the interior of the chassis for accessibility and ease of maintenance. The assembly is comprised of an 'ONYX Pro' rear hub, a drivetrain configuration using a 144-tooth single speed sprocket, a wide hub chain, and a BLDC motor.

MANUFACTURING

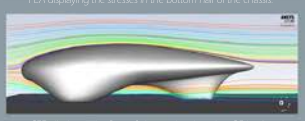
The manufacturing of the chassis consisted of creating carbon moulds in which high temperature pre-preg carbon will be layed with varying thicknesses of foam core.

COMPUTATIONAL ANALYSIS

Finite element analysis (FEA) and computational fluid dynamics (CFD) were conducted using ANSYS to analyse the monocoque strength and aerodynamics respectively.



FEA displaying the stresses in the bottom half of the chassis.



CFD displaying the flow of air over the chassss at 25 km/h

SPECIAL THANKS TO
Garry Cotton, Tony Doyle, Rodin Cars, UC Motorsport & Ben Eagle

UC UNIVERSITY OF CANTERBURY

SHAYNE GOOCH
Supervisor

BRUCE ROBERTSON
Client

Shell Eco-marathon ASIA

Take My Hands

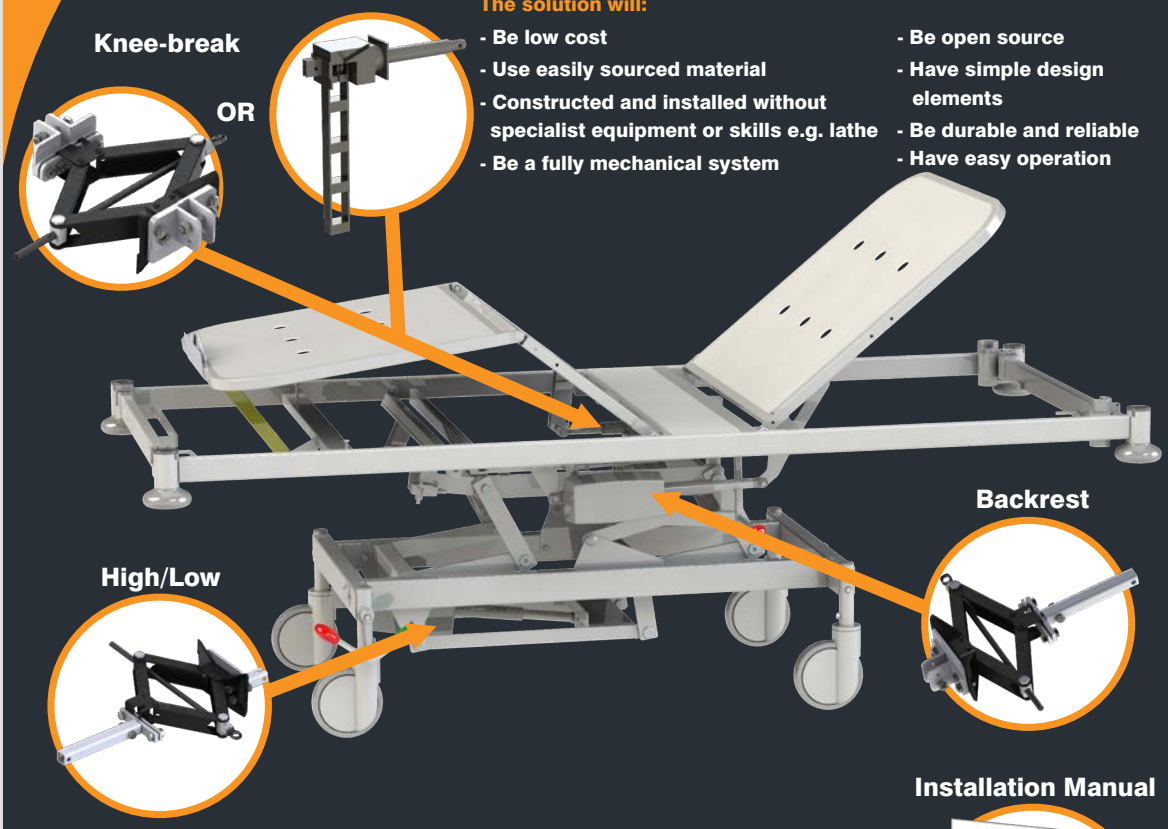
Hospital Bed Conversion Kit

Improving Health Conditions in the Pacific

Take My Hands are taking retired medical equipment to the Asia-Pacific. However, many electric hospital beds (including Howard Wright M6) are failing due to harsh environments and power conditions. Actuators are either broken or unable to be used. A solution is required to ensure a M6 bed can continue to be useful and can also be used on other bed

The solution will:

- Be low cost
- Use easily sourced material
- Constructed and installed without specialist equipment or skills e.g. lathe
- Be a fully mechanical system
- Be open source
- Have simple design elements
- Be durable and reliable
- Have easy operation



Car Jacks

- Readily available
- Low cost and easy to source
- High load rating
- Provide mechanical advantage

Custom Brackets and Ratchet

- No custom steel work
- Simple manufacturing
- Bolted construction

Installation Manual

- Universal language
- B/W print compatible
- Step-by-step format

Installation Manual

Results

- Actuation solutions for knee break, high/low and backrest (including additional ratchet design)
- Full fabrication drawings
- Installation manual
- Backrest freefall acceleration data
- Backrest force profile
- Backrest dynamic response
- Emergency CPR release design

Next Steps

- External manufacturing test
- Alternate bed compatibility
- CPR Designs testing
- Journal Article

P35

Students: Simon Holden, Stephen Pitts, Daniel Poskitt, Matt Wong-Kam
Supervisor: Dr Deborah Munro **Client:** Take My Hands
Special Thanks: Jeff Liddicoat, Howard Wright Beds

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Heavy Trailer Drawbar

Background

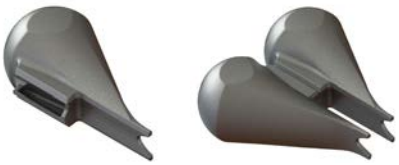
- Heavy trailer drawbars are currently manufactured using rectangular hollow section (RHS) and off the shelf components including the towing eye and cast hinges
- Current drawbars have not seen any development in over 20 years
- A range of different length and width drawbars are required based on different customers' needs
- Manufacturing the different length and width drawbars with RHS is time intensive resulting in high labour costs
- The aim of this project is to decrease the drawbar manufacturing time to one hour and reduce the overall mass while remaining under the fatigue endurance limit

Hinge

- The two hollow hinges connect the truck to the pipes
- Spherical joints to allow for changes in drawbar length
- Constant wall thickness used for reliable casting results
- Allowable cross member widths between 940 mm and 980 mm
- Finite element analysis has been used to reduce peak stresses and optimise the design

Toweye Mount

- The towing eye mount connects the pipes to the towing eye
- Two identical cast components fit together when one is inverted
- Spherical surfaces on the towing eye allow for various drawbar lengths
- Components fit together with a self-aligning feature for ease of manufacture
- Weld preparation built into the cast components

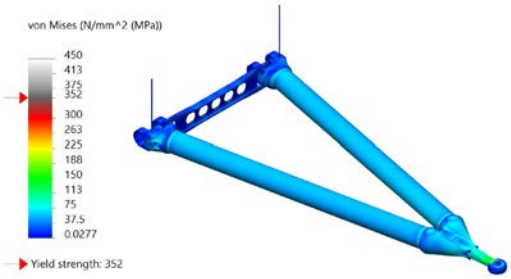


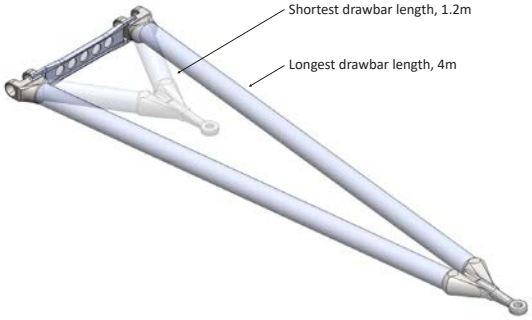
Manufacturing Jig

- Circumferential welds around the spherical surfaces allow for quick and accurate welds.
- Throughout the design process, future automation of the draw bar manufacturing has been considered and welding procedures kept simple and accessible.
- Manufacturing aim of 1 hour assembly time
- Component loaded into a single jig for all welding processes

Final Design

- The final design achieves the project goal by reducing peak stresses below the fatigue endurance limit in each of the components
- The cast hinges and towing eye mounts have spherical faces allowing for the different length and width drawbars to be achieved by only changing the length of the pipe used
- One cross member design is adequate for all width drawbars





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TransTech Dynamics Ltd
Consulting Engineers

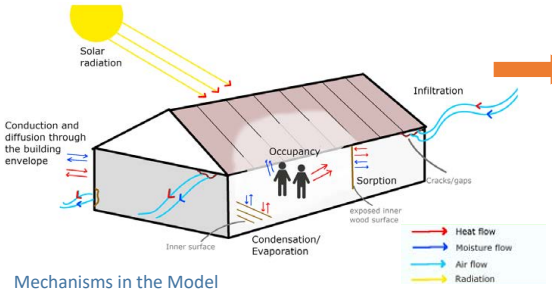
P36

Student projects: Mechanical Engineering and Mechatronics Engineering

Humidity in Antarctic Huts

Determining the effect of visitation on humidity in Scott's Terra Nova hut

Scott's Terra Nova hut and the artefacts within suffer from degradation due to humidity in the air. The heat and moisture introduced by visitors may worsen the effect. By using Finite Element Analysis to model the heat and moisture distribution in the hut, the effect of occupancy and other key factors can be determined.



Mechanisms in the Model

Methodology: COMSOL Finite Element Analysis modelling

Mechanisms represented in the model:

- Occupancy - A constant release of heat and moisture
- Sorption - Moisture absorbed or released by porous materials
- Condensation and Evaporation - Moist interior surfaces
- Heat Transfer - Solar radiation, convection & conduction
- Infiltration - Air penetration through cracks in the walls
  - Estimated using CFD

Challenges:

- **Extreme climate and weather conditions, Incomplete visitation data**

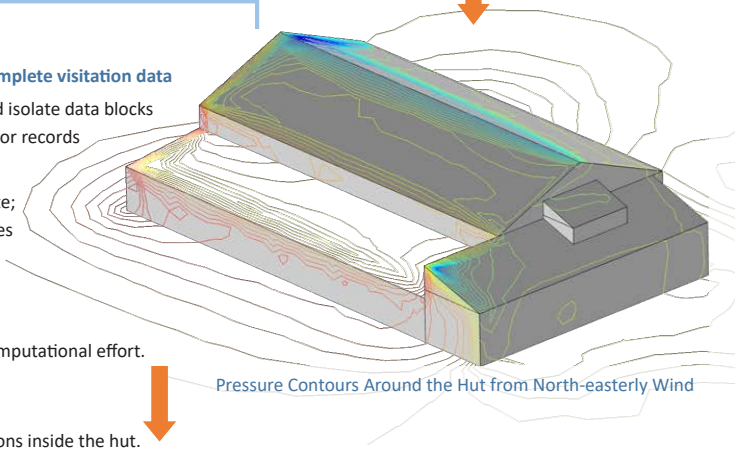
This required us to focus on Summer months, and isolate data blocks with both consistent weather conditions and visitor records

- **Lack of precise measurements**

Testing on the building is outdated and incomplete; material properties were found from other sources and infiltration estimated with a simulation of exterior pressure distributions.

- **Computational limit**

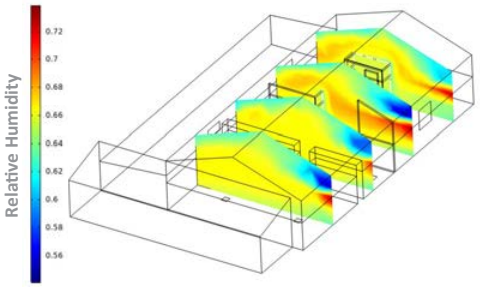
A simplified geometry with thin walls reduced computational effort.



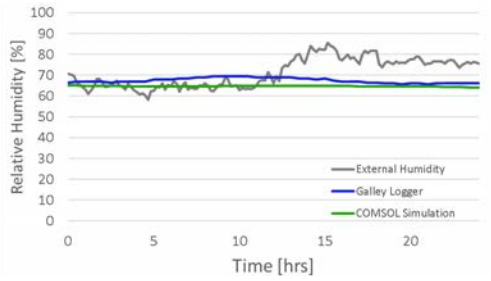
Pressure Contours Around the Hut from North-easterly Wind

Results: Temperature and humidity distributions inside the hut.

The effects of each mechanism will be determined, and visitation policies will be advised based on the simulations.



Humidity Distribution in the Hut



Relative Humidity In the Hut 01/02/13

ANTARCTIC HERITAGE TRUST

Team members:
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Tung Ming So Gabriel Jacobs Corban

Supervisor: Prof. Mathieu Sellier
Client: Antarctic Heritage Trust

Thanks to Glen Mason and Gordon Macdonald for their assistance

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Circuband E-Sports Project

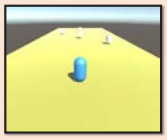
UC PRODUCT DESIGN

Supervisors
Adrian Clark & Mark Rickerby
Industry Collaborator
Daniel Thomson

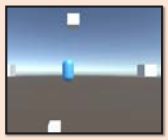
The Circuband ESports Project aims to design a game experience around an experimental piece of sports technology. The technology involved, currently known as the Circuband Sensor, is a resistance band designed to measure the amount of force a user exerts when wearing the band during exercise.

Prototype

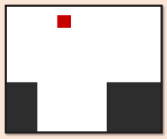
We identified various "single input" mechanics commonly used across multiple gaming platforms and categorised them into six mechanics, which we developed into prototypes.


3D Behind-View Endless Runner


Gravity Switching


3D Side-View Lane Changing


World Rotation


2d Side-View Reaction Runner


Crouch Jump

Explore

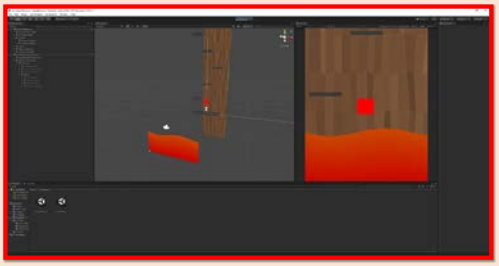
After choosing from the mechanics prototypes, we explored different ways of physically controlling the mechanic. Two projects were created from this initial mechanic prototype.

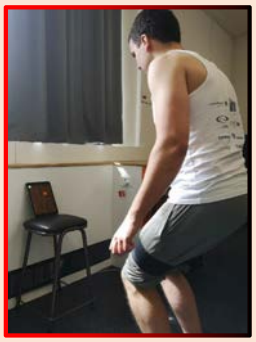
Crouch Jump
The player is required to perform a full squat in order to power up the character's jump. As the player releases the squat, the character jumps.

Horizontal Bounce
The player is able to control the horizontal movement of the character while they continuously bounce. Performing a squat will move right while releasing moves left.

Polish

Through user testing, we identified the preferred way of controlling the mechanic, The Horizontal Bounce project. Alongside fixing programming bugs, the final project involved creating graphics, animations, and audio.





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Student projects: Product Design - Applied Immersive Game Design

Communicating The Swallow

Swallowing is a huge part of day to day life. We all swallow without really thinking about. But what if one day you woke up and you couldn't anymore? Many faces this everyday often going to rehabilitation to learn such a vital part of living most not really thinking about it. This process is often a boring, frustrating and confusing at times. This Project looks at different ways to try and communicate what is happening inside the throat as it swallows

Research

What is Dysphagia?

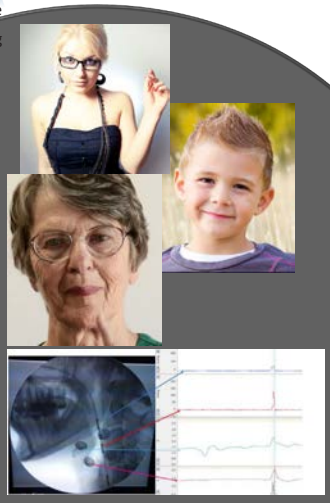
Dysphagia is the medical term for a swallowing impairment. This condition can span across the persons lifespan starting at times from birth injuries, accidents in childhood that involve the head, neck and brain, as well as stroke and neurodegenerative diseases in adults. The type of dysphagia we are looking at is a type that closes the throat all at once meaning food will get stuck in the throat.

Who is Affected?

People Affected by Dysphagia can range from childhood to older adults. Personas were created ranging from 6 years old to 50 years old seeing how different types of people would handle the effects of dysphagia.

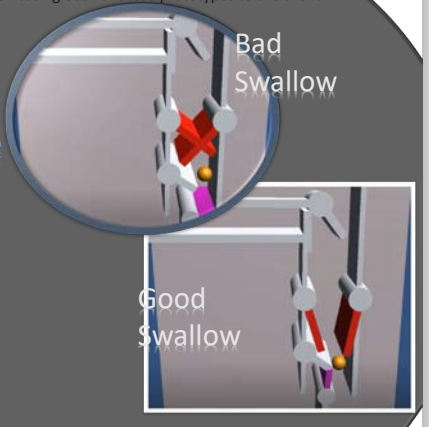
How Do People Communicate?

People Communicate Through a range of ways, some of the common ways are visual media such as photos, art, movies. Verbal/Sound ques such as talking, music, sounds, Body language, as well as feel/touch which can include tactile(vibration) input. Looking into other ways to showcase that information that has just been shown in graphs and points in other places



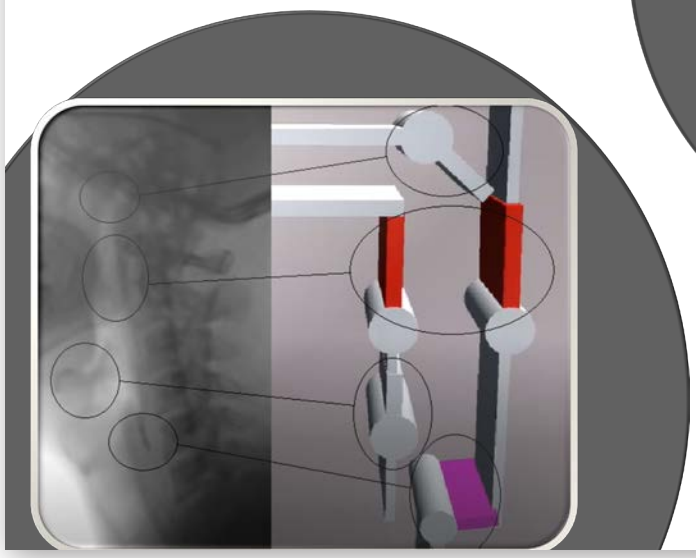
Develop

Considering the research found I choose to focus on the more visual side of communication seeing as one of the common methods of showing something to someone. Brainstorming a few ideas that were later turned into small prototypes. One prototype was chosen to move forward this being a simulated throat. The throat tries to replicate what is happening inside a person throat the first prototype using two levers to open and close sections of the throat that found would travel down letting the food fall when it is pushed in. This prototype was followed by two others which squeezed and pushed the food down in a more realistic but simpler way then a real throat. Showcasing both of these prototypes to the client



Validate

After looking at both of the two prototype decided to use Prototype One as the final product choosing this as I feel it shows what food does in the simulated throat without crowding the view of what is happening inside the throat as in prototype two where the walls squeeze in pushing the food down in a more realistic way but doesn't show what is really happening inside the throat. The levers in prototype one still push the food downwards but



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Project Title: Communicating The Swallow
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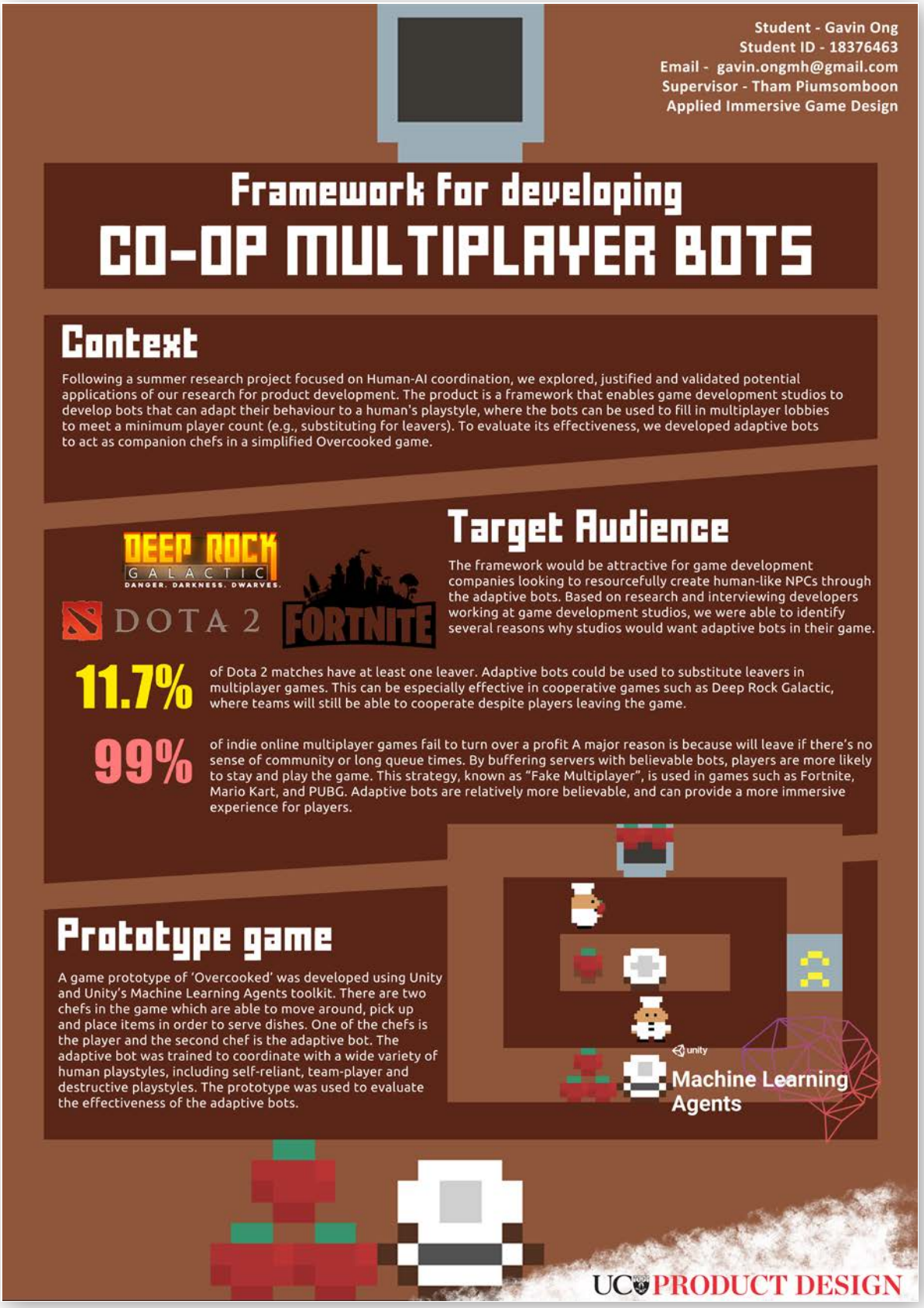
Supervisor: Adrian Clark

UC PRODUCT DESIGN

Student projects: Product Design - Applied Immersive Game Design



Student projects: Product Design - Applied Immersive Game Design

James Cameron 26623127
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Supervisor: Adrian Clark

Does a smart and helpful AI Agent need to be more reactive, suggestive, or passive, in order to be perceived as helpful by a participant?

UC PRODUCT DESIGN

Bachelor of Product Design, major Applied Immersive Game Design
PROD322—Gaming Studio 2

Overview

I created a small prototype to show create a Smart and Helpful Nurse AI. This was done by making a small surgery game, performing an upper leg surgery, seeking to test 3 different AI nurse agents for their perceived usefulness in a virtual surgical situation. One nurse is passive, waiting for instruction before doing anything. One nurse is suggestive, only giving suggestions on how the surgery should work. The third nurse is reactive, having the next tool ready for you before you ask for it.

The participants will participate in a Virtual Reality (VR) surgery in a virtual environment with one of three different AI nurses. These nurse's behaviour will be following a script prompted by the accessor. There will be one passive nurse, one reactive, and one suggestive. The participants then scored the nurse they tested out of 7, on how much they felt the nurse helped them through the surgery.

The outcome was not as clear as was expected. All the participants gave high scores to all the different nurses, which made conclusions difficult to make out.

Made inside of Unity 2019.2.15f1

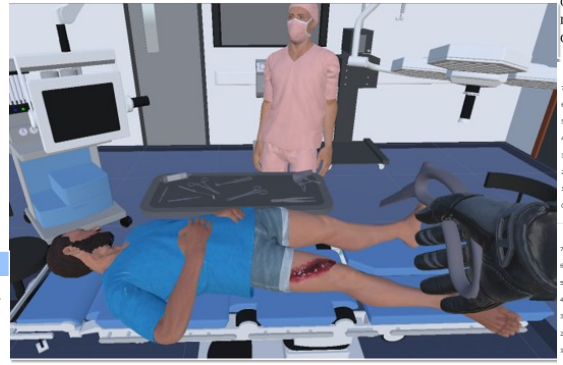
How this project was made:

This project was comprised of 3 sprints of 3 weeks long. However, the way I organised the project was much more waterfall in its process, rather then Agile

Sprint 1: Create the area inside of Unity with nurses and VR controls
This sprint went well over time due to complacency from my part, as well as NZ going back into Level 2 lockdown

Sprint 2: Implement the nurses into the environment, as well as add the tools and cutting the patient.
This sprint went much better for me, only needing to get approval for testing by the end of this sprint

Sprint 3: Begin testing on classmates and colleagues recording what nurse people preferred
This sprint only really went on for 1 week, instead of the 3 planned, due to approval taking *much* longer then expected

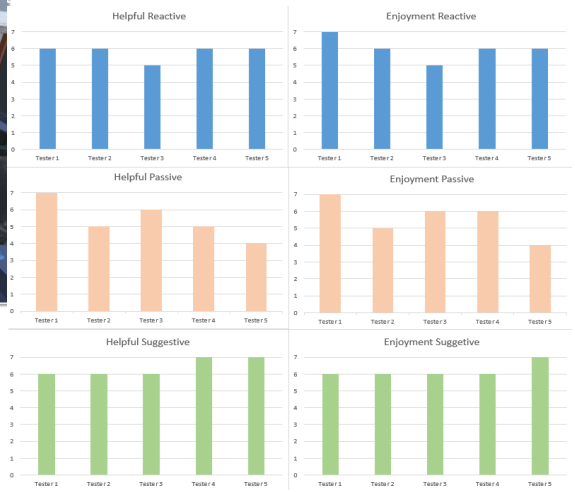


The steps of the surgery were:
- Apply sedative to the patient via a syringe,
- Cut open the upper leg with a scalpel,
- Pick out a ball like object out of the leg with tweezers,
- Put the ball in the bin beside the user
- Sew the wound back up with a large needle.

Results

The Passive nurse had an average helpful score of 5.4, while the Suggestive had a score of 6.4, and 5.8 for the Reactive nurse. With the median, only the Passive nurse had 5, while the other two nurses had medians of 6. So, from looking at the scores from a helpful point of view, going with a more suggestive nurse is a better approach. Looking at the enjoyment of the surgery, the same trend arises. The Passive nurse had an average score of 5.6, the Suggestive a score of 6.2 and the Reactive an average of 6. The medians for all three nurses was also 6. What does that mean for the enjoyment then? Really, there wasn't too much difference between all three of them, as also the data shows. The suggestive nurse scores the highest average due to a couple of bad tests for the other two nurses.

This can be seen by a couple of the comments made by the testers. For the passive nurse a tester said they scored the nurse low because the tester "…forgot what step I was up too, and the nurse didn't want to remind me where I was" This was also shown in another of the comments I received from the passive nurse from another tester: "Didn't say much, would have been bad if forgot what was doing or longer surgery" This shows that the low score for the passive nurse makes sense, as people were unhappy or unsure about the lack of comments the nurse makes. The comments on the other nurses were sparse, however, one tester made a comment about the Reactive nurse, stating that "the nurse's comments may get annoying if repeating the sim, otherwise fine"



Student projects: Product Design - Applied Immersive Game Design

Antarctic Centre Project

Background

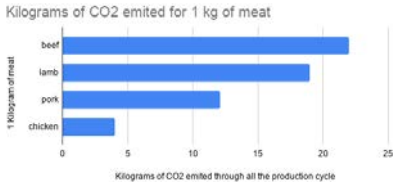
The International Antarctic Centre (IAC) in Christchurch is an interactive exhibition space with the aim to educate people about Antarctica. While the IAC has exhibitions which highlight how Antarctica is being affected by climate change and why it's important to take action, there is no further information on how to take action to combat climate change after you leave the International Antarctic Centre.

Project

This project focuses on making people aware of how they impact the environment and to empower people in making more eco-friendly decisions by showing them alternative options.

1 Research

We researched climate change and, since we were focusing on the impact individuals make on the environment, we focused on how groceries, transport and daily activities affect climate change.
An example is the graph below, which shows how many Kg of CO2 are emitted to make 1 Kg of meat.



2 Design

After researching, we designed a game to display the information to the users so they could understand how their decisions make an impact.
We used wireframing at the start to decide how the game should be played and made some UI mockups to guide our UI development.

We decided to make a simulation game with a focus on the environment. The game will show the CO2 emissions of everyday choices. The player will be given a monthly budget which they can spend on food, rent, petrol, plants, and so on. They will be encouraged to make environmentally friendly choices by rewarding them for low emissions, which will help them to unlock new things to buy. They can also get extra rewards by completing daily tasks, unlocking achievements and reading tips.

3 Prototype

We created the UI art by ourselves using Photoshop and made the prototype for the game using Unity, coding it in C#.

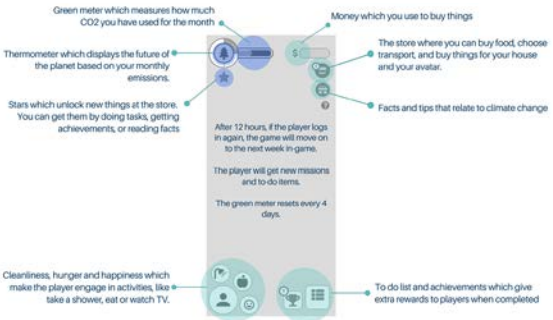
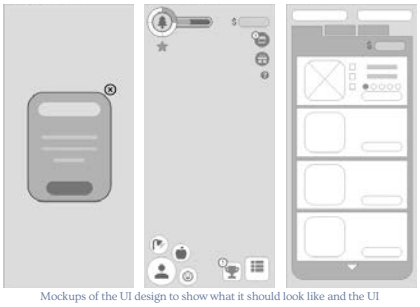


Image explaining the icons and their purpose in the main page of the game.



Mockups of the UI design to show what it should look like and the UI arrangements for the game.

Screenshots of the final prototype of the game.

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UC Product Design

Industry Partner:
INTERNATIONAL ANTARCTIC CENTRE

Student projects: Product Design - Applied Immersive Game Design

Development of a Patient User Interface for Measures of Pharyngeal Swallowing

Brief

Patients with swallowing impairment due to neurological illness require continuous swallowing therapy to strengthen their throat muscles. These therapy sessions are generally carried out in clinics where the clinician's role is motivating the patient's activity during swallowing sessions while providing them with feedback.

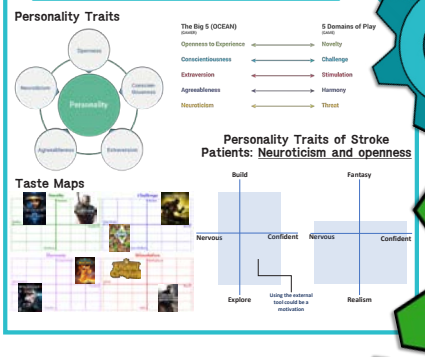
Biofeedback equipment that the patient can take home and practice swallowing makes the process much more convenient for them. This project designs a game in which the patient can actively engage in a mobile game while performing the swallowing task.

Goal

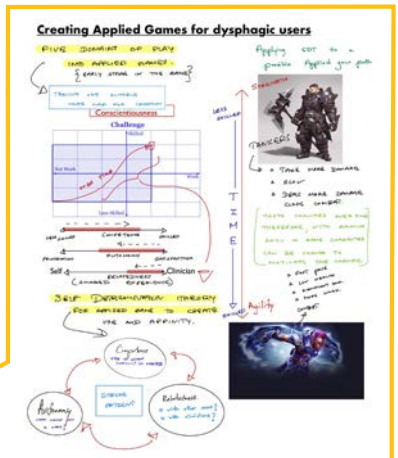
Engage the patient with the game and ensure regular training, i.e. swallowing sessions.

Research

Stroke Patients ¦ Motivation ¦ Video Games



Brainstorm



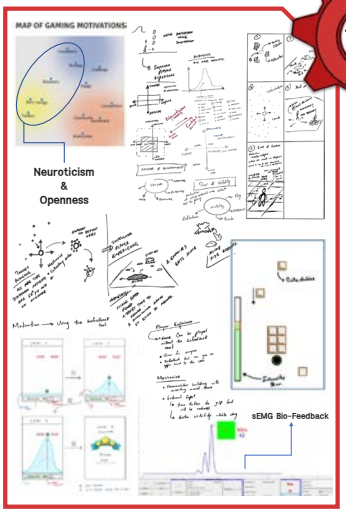
What:
Motivating user's engagement for Visual Bio-Feedback Treatment

Why:
Clinicians cite low motivation as the most common reason patients do not continue dysphagia therapy beyond sessions at clinics.

Who:
Dysphagic patients of all age groups that have undergone treatments in the clinic

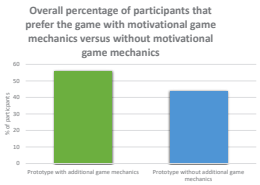
DESIGN PROCESS

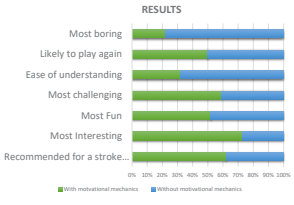
Sketch



Validate

Based on research conducted via questionnaires, the results indicate that majority of the participants prefer having motivational game mechanics to ensure engagement in the game.





Prototype

Two prototypes were designed to test the engagement of the users; Prototype 1 (left) contains additional game mechanics whereas prototype 2 (right) contains no additional game mechanics.

Motivational game mechanics are elements of the game that keep the user entertained. These elements in Prototype 1 include: catching chocolate pieces in the game while moving the player's character, avoiding obstacles etc. These additional elements are not implemented in Prototype 2.

PROTOTYPE ONE

PROTOTYPE TWO

Conclusion

Motivational game mechanics enhance the overall user experience and allow the patients to be more engaged. These additional features add an element of challenge and make the game more interesting. This in turn ensures the patient will continue to practice swallowing exercises even without clinical supervision; the patients can therefore practice swallowing at home.

UC PRODUCT DESIGN
Bachelor of Product Design, Applied Immersive Game Design

Student	-	Ashan Perera
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Supervisor	-	Dr. Adrian Clark
Sponsor	-	UC Rose Centre

Chills

Winter Skincare

By Georgia McBride

The Skin Screen and Lip Balm products are designed to prevent the damaging effects of winter conditions on the skin. These products have specific ingredients that prevent sun damage, moisture loss and wind burn. I have designed unique packaging that allows the products to be applied with one hand making it easy to use during winter activities. I have also created the marketing, branding and business model for this product.

UC PRODUCT DESIGN

Student Number: 56503270
Major: Chemical Formulation Design
Title: Chills Winter Skincare Line
Email: Georgiamcbride22@gmail.com
Supervisor: Conan Fee

Student projects: Product Design - Chemical Formulation Design

Spur

Recovery range for trampers

Erin Chisnall
33209922

Supervisor: Sarah Kessans

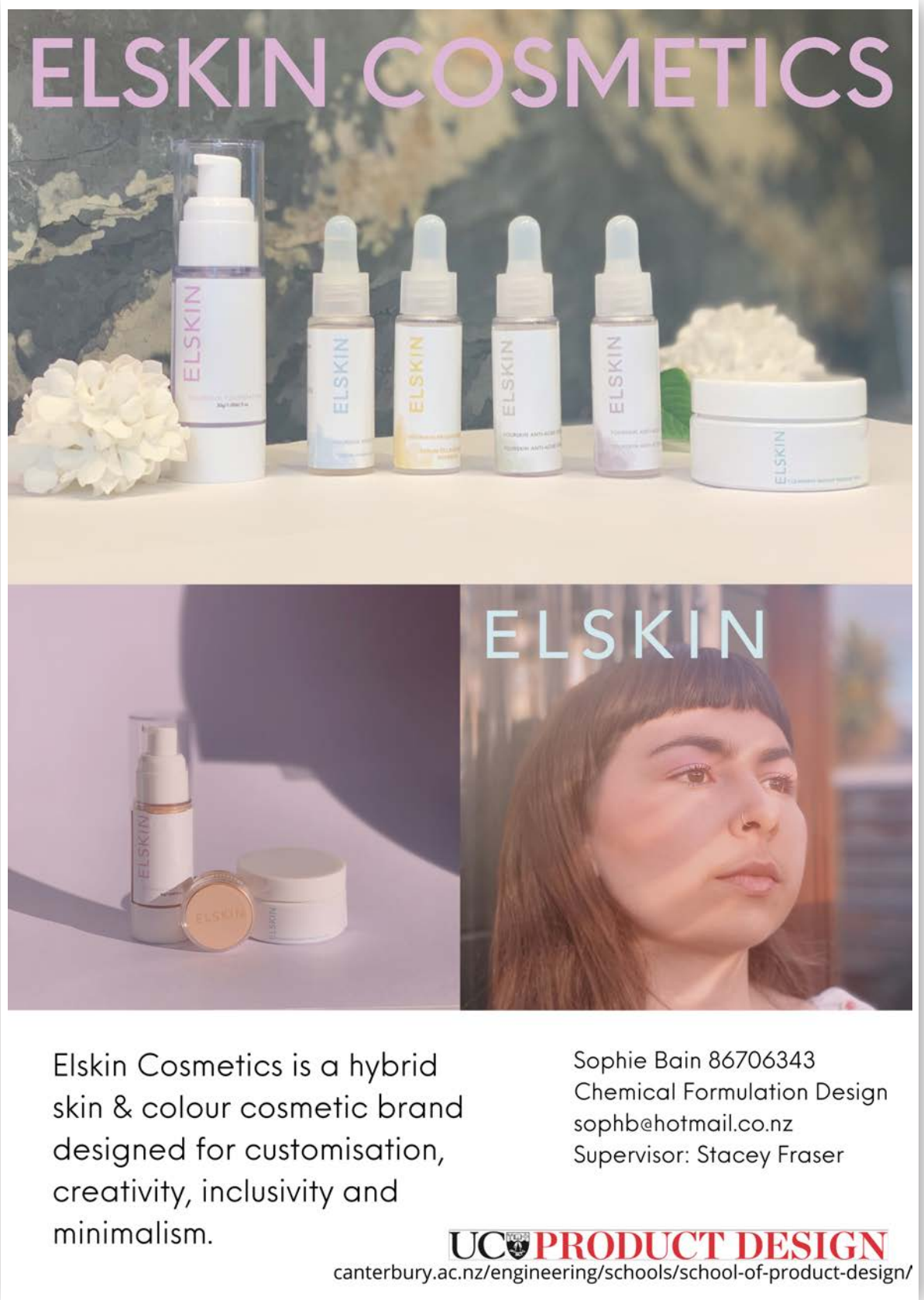
Bachelor of Product Design in Chemical Formulation Design

UC PRODUCT DESIGN

Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Chemical Formulation Design



Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Chemical Formulation Design

FAUX GLOW

COMBINING SELF-TAN, SKINCARE, AND SUN PROTECTION

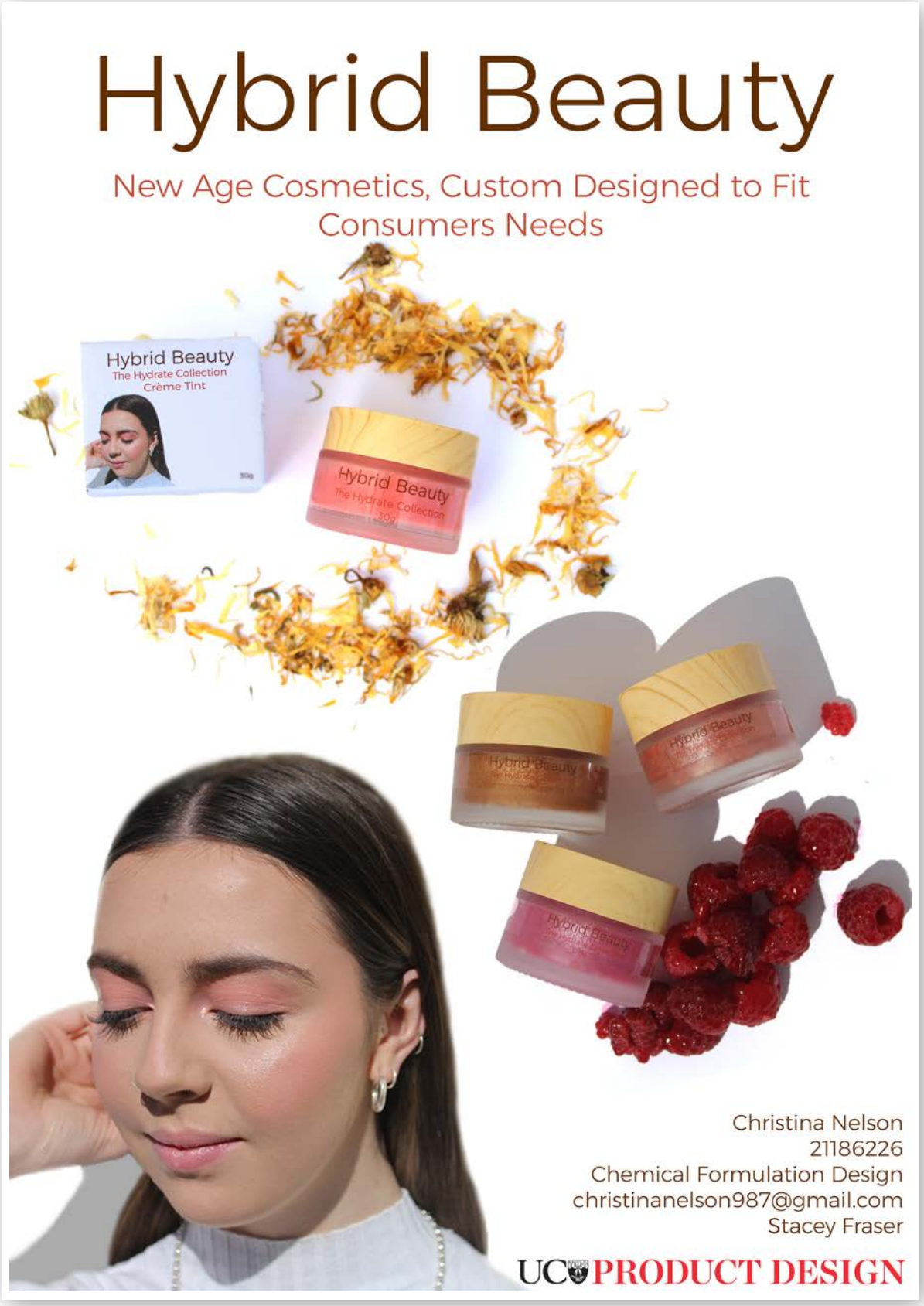
FAUX GLOW IS A PRODUCT LINE CURATED FOR YOUNG ADULTS THAT LIVE ACTIVE, SOCIAL LIFESTYLES THAT ARE WANTING TO ENHANCE THEIR NATURAL FEATURES WITH GLOWY, DEWY, AND BRONZED SKIN. FAUX GLOW NOT ONLY GIVES INDIVIDUALS A HYDRATED, AND HEALTHY GLOW, BUT ALSO ENSURES THE INDIVIDUAL IS PROTECTED WITH BROAD SPECTRUM SUN PROTECTION. MEN AND WOMEN CAN BOTH EQUALLY ENJOY THIS PRODUCT, WITH THE LINE DESIGNED TO BE A VERSATILE PRODUCT BETWEEN ALL GENDERS.

THE CURRENT SELF-TANNING PRODUCTS MARKET IS CURRENTLY MISSING PRODUCTS THAT OFFER SELF-TANNING PROPERTIES WITH SUN PROTECTION. THIS IS APPARENT NOT ONLY IN NEW ZEALAND, BUT GLOBALLY. WITH THE TANNED COMPLEXION TREND BEING VERY APPARENT ACROSS THE WORLD TODAY, INDIVIDUALS ARE WANTING TO ACHIEVE THIS LOOK IN ANY WAY POSSIBLE. THIS MEANS THE USE OF SUN TANNING AND SUN-BED TANNING IS RISING, CAUSING PROBLEMS IN THE STATISTICS OF SKIN CANCERS. FAUX GLOW'S PRODUCTS IS THE SOLUTION TO THIS SPIKE IN SKIN CANCERS GLOBALLY, AS INDIVIDUALS CAN EASILY ACHIEVE THE SAME DESIRED LOOK, ALL YEAR ROUND, WITH THE ADDED BENEFIT OF EXTRA SUN PROTECTION.

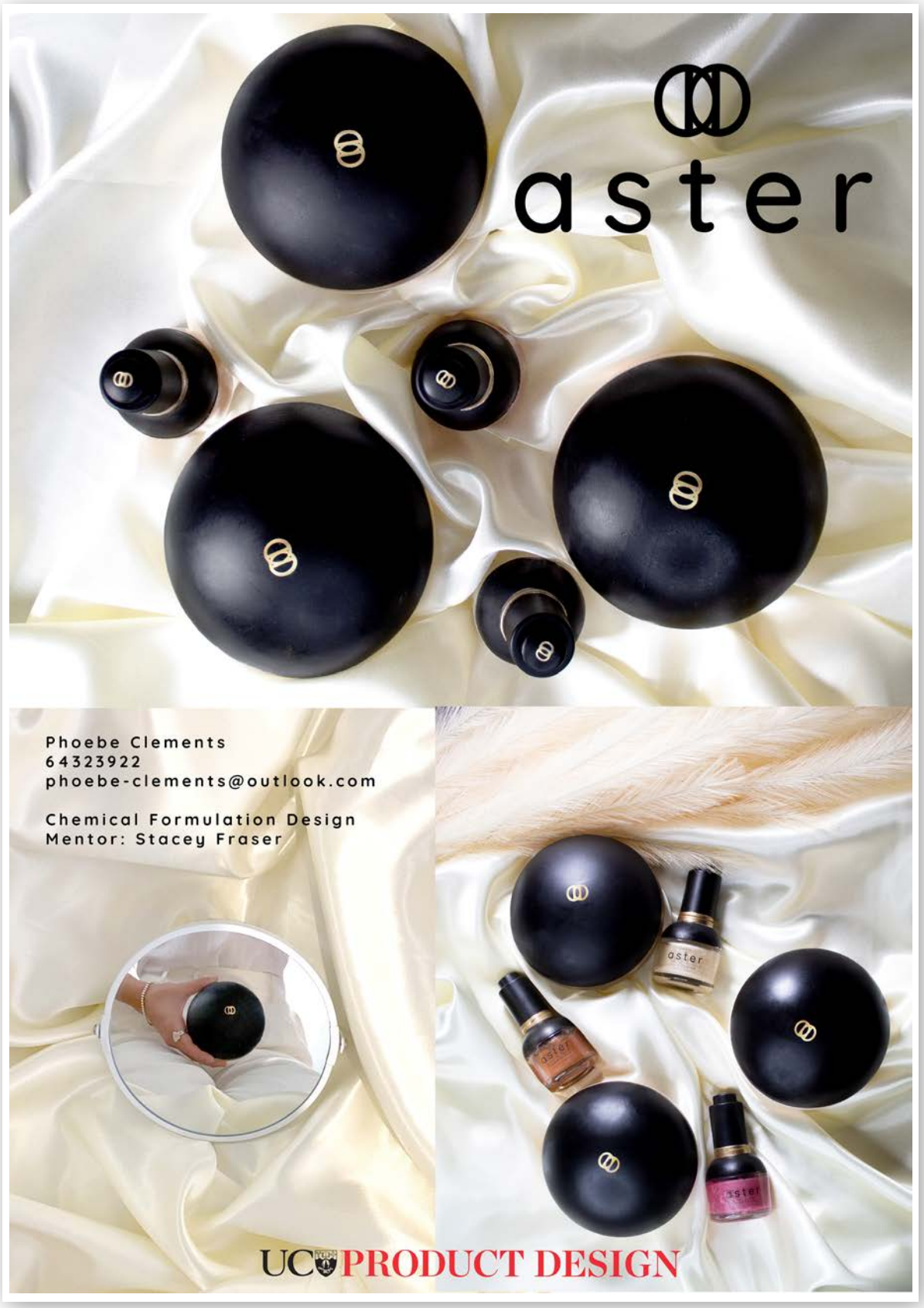
UC PRODUCT DESIGN

PROJECT BY GEORGIA JURASOVICH [86019072] GEORGIAJURASOVICH@GMAIL.COM
CHEMICAL FORMULATION DESIGN SUPERVISED BY PROFESSOR CONAN FEE

Student projects: Product Design - Chemical Formulation Design



Student projects: Product Design - Chemical Formulation Design



Student projects: Product Design - Chemical Formulation Design

JESSICA GOSLING

FRANK'S FIXES

FRANK'S FIXES AIMS TO SIMPLIFY THE LABELS OF SPORTS SUPPLEMENTS; DELIVERING DELICIOUS, NUTRITIOUS PRODUCTS IN SUSTAINABLE PACKAGING.

UC PRODUCT DESIGN

Student projects: Product Design - Chemical Formulation Design

Létta

Relieves stress symptoms

Chemical Formulation Design
Supervisor: Pram Abhayawardhana

Gemma Thompson
gth55@uclive.ac.nz
42739420

UC PRODUCT DESIGN

Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Chemical Formulation Design

Atmos body care was developed for a spa company in Christchurch. The line was designed to give customers an at home spa experience and uses key New Zealand ingredients to provide naturally effective results, backed by scientific research. The line consists of an AHA body lotion featuring glycolic acid and an antioxidant bioactve extract blend, a luxury body oil that contains harakeke oil, macadamia oil and apricot kernel oil, and the last product is a himalayan salt scrub combining himalayan salt with green tea extract and harakeke oil.

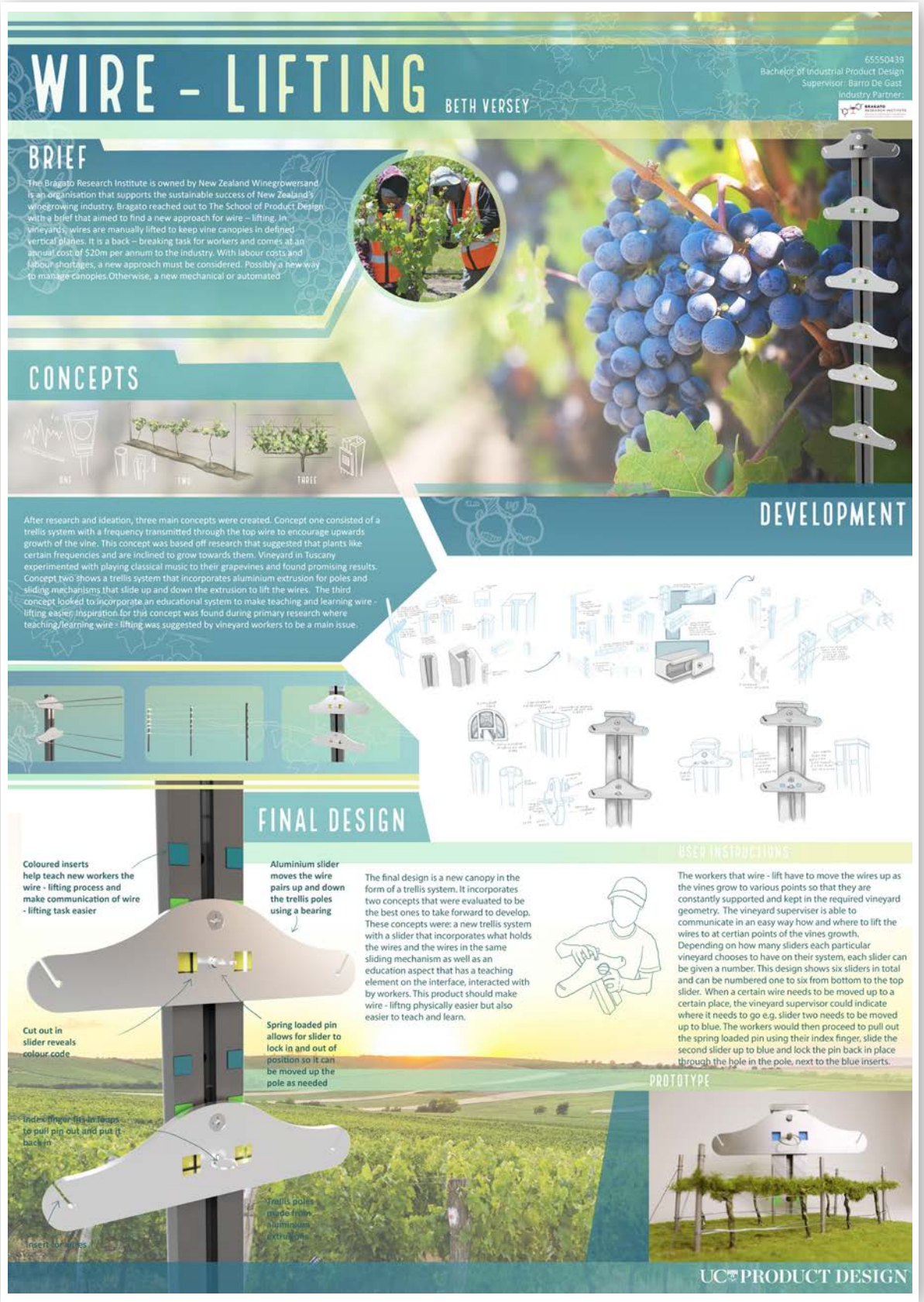
Natasha Milton 82942238
Bachelor of Product Design Major Chemical Formulation Design
Supervisor: Pram Abhayawardhana
natashalmilton@gmail.com

UC PRODUCT DESIGN

Student projects: Product Design - Chemical Formulation Design

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



Single Use Instrument Packaging

enztec

UC PRODUCT DESIGN

Concept

The design concept is based on creating packaging for single use surgical instruments for hip replacements. This brief was provided by Enztec, who are an orthopaedic device manufacturer in Christchurch. It is reflecting on an experimental process that was undertaken in order to find a solution to export the instruments securely and affordably while maintaining a sterile barrier. The design development was initially focused on creating a mechanism to fix three acetabular reamers, which then needed to be embedded into a thermoformed tray used to store the remaining instruments (reamer driver and cup impactor). Afterwards, a box was designed for the tray along with graphics for it and the peelable lid on the thermoforming (DuPont Tyvek). The collection of different prototypes were produced with 3D printing. The renderings and 1:1 scale prototype represent how thermoforming and blister packaging could be applied to safely and cost-effectively deliver disposable hip replacement sets to cutomers.

Process

RESEARCH
Examined packaging examples and conducted meetings with Enztec, Burwood Hospital and the CDHB.

IDEATION
Sketched mechanisms to secure the reamers and instrument layouts for the thermoformed tray.

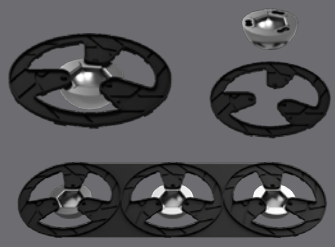
CONCEPTS
Catergorised the sketches then developed models that were later 3D printed to determine validity.

PROTOTYPE
Developed a CAD model of the packaging then 3D printed and laser cut a 1:1 scale prototype.

SOLUTION
The final outcome of the experimental design process with manufacturing and cost estimates.

Aesthetics

- Thermoforming was emulated with CAD by creating a solid model then removing some exterior surfaces and thickening the remainder.
- The prototypes were fabricated with 3D printing utilising flexible and non-flexible filaments situationally.
- Ribbing was applied to the reamer tray to retain visual consistency with the driver and impactor.
- Finger grooves and indentations were embedded into the main tray to improve instrument removal and peelability.
- A beveled extrusion was formed around the tray's rim to approximate where the Tyvek would adhere.
- Graphics were designed for the box and Tyvek lid making it simple yet intuitive for customers to use.



Materials & Solutions

- The final outcome represent the development of how thermformed blister packaging could be implented to safely house disposable instrument set while being transported to and stored by the customer.
- The reamers are attached to the thermforming with a simple keyhole mechanism:
  - Where thermoformed cylinders are pushed into the larger hole on the reamer's backplate.
  - Afterwards the reamers are rotated clockwise on top of the cylinders to tighten them down.
  - The cylinders are slightly wider at the tips and are squashed by the smaller holes locking the reamers in place.
  - The reamers can be dropped backed into their original packaging for disposal or reuese.
- In Enztec's case 99% of their sales come from overseas meaning it will need to be rugged to survive the journey.
- That is why the devices will be transported in a three layer packaging scheme:
  - The outer layer will be a 10kg cardboard FedEx box accomadated with suffcient internal padding.
  - The secondary box is made from card and will use graphics that will make the packaging simple yet inuitive.
  - The blister pack consists of a 0.6mm thermoformed transparent PVC tray and a Dupont Tyvek peealable lid that has branding and instructions printed on it.
  * The scale prototype was 3D printed with 1mm walls to improve printability and approximate thermoforming.
  * The reamer holders are printed in a flexible filament at 1mm to emulate how the holder will distort once the reamer and driver are pulled through it.

Goalkeeper Left Hand Protector (LHP)

Scott Sommer
ID: 16100120 Idustrial Product Design

Introduction

The aim of the project is to redesign a Left-Hand Protector (LHP) for field hockey goalkeepers, that improves its usability and effectiveness.

OBO's LHP hasn't been redesigned for approximately 7 years.

Goalkeeper equipment requires constant redesigning as the game is continuously changing. Technology development also provides new design possibilities.

The redesign of the LHP was strongly influenced by OBO's customer base, as they have shared their views and opinions of current products, through social media.

Iterations of the new LHP were developed by testing the product with a limited group of goalkeepers.

Background

Field hockey is a sport that has been around since 1908 but the game has changed dramatically, from the surface it is played on, to the equipment that is used. Goalkeepers used to wear limited protection, that was generally made of leather. Now, goalkeepers are protected from head to toe with advanced closed cell foam. This doesn't just protect the goalkeeper; it also maximises the deflection speed of the ball.

OBO are the leaders in the market for Goalkeeper equipment with a market share of 65-70%. OBO have a set of values that make them unique and drive them to be the best goalkeeper brand in the world. They are known for valuing their customer base and using it to help drive their innovation for new products.

User's Feedback

The Facebook comments is the most useful resource for this project.

From the comments there are some that only apply to a small population of the users. The sizes for the current LHP is based around the average hand size. The feedback from the users waw used to define the product design specifications.

Each stage of the design process goes to the users for feedback. This is how OBO designs all of their equipment, with a large number of product testers all over the world.

The Old LHP

- Only comes in 1 size
- Not tight enough on the hand, can fall off or twist when struck
- Hand is 2 dimensional so can slip inside glove
- Finger seperators are week and tend to break
- Elastic strap on back good for keeping tongue down
- Comes in Multiple colours
- Different manufacturing method to competitors
- All round good LHP but still room for redesign

Product Design Specifications

Design a LHP that can last at least 4 years.

Design a LHP that can deflect a ball travelling 160km/h and have no damage to users hand.

Design a LHP that feels secure on the users hand so they feel like it wont fall off when hit.

The LHP must be no wider than 228 mm and lo longer than 355mm.
This a requirement from the FIH hockey rulebook 2019 (latest version).

Design a LHP that feel comfortable on the user's hand when not being used.

Design a LHP that can accurately deflect a ball in the user's desired direction.

Design a LHP that doesn't restrict the movement of the users hand.

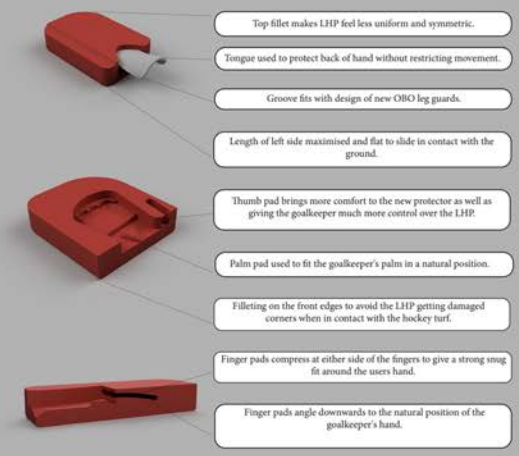
Prototyping

Prototype 1:
This prototype was used to test multiple pads and fittings.

Prototype 2:
Prototype 2 was an alpha prototype of the final LHP testing the dimensions

This figure shows the different pads seen in the second prototype. These pads include the thumb pad, palm pad and finger

Product Breakdown



The New LHP

The main changes in the new LHP are related to fitting. No other LHP on the market accommodates to different sized hands like the new LHP.
The new LHP is designed as a one size fits all.
The thumb pad gives the goalkeeper more control over their protector and the finger pads compress around the fingers to give a snug fit.
The parlm pad is shaped to fit many different sizes of hands and is used to hold the user's hand in a 3D state giving the goalkeeper more comfort and control over the LHP.

Colour and Material

The LHP is made from multiple layers of Closed Cell Polyurethane foam that is heated and moulded together. Closed cell foam works well at deflecting the hockey ball at high speeds as well as protecting the user. Higher density foam is better at absorbing the force from the ball but doesn't deflect as well. Lower density foam deflects the ball faster but doesn't protect the goalkeeper as well. OBO has done lab research on using multiple densities together to get the best of both worlds. The material selection of the LHP was not in the project scope.

The colours used for the new LHP with be similar to the colours seen in most of OBO's products.

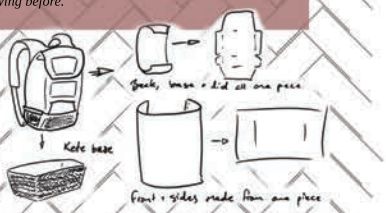
UC PRODUCT DESIGN

Supervisor: Euan Coutts

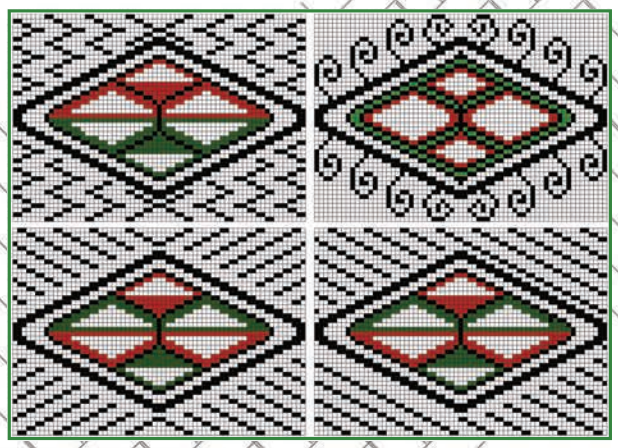
Project Sponsor: OBO

Harakeke School Bag
Pikau Kura

Ideation and sketching was relatively quick for this project, and the design simple. This is because I wanted to get prototyping quickly, and also because I had barely done any sewing before.



Sketches



Tāniko Designs

I began drawing different Taniko style patterns for a patch on the front of the bag. I explored a few different styles, looking at pure geometric patterns, korus, and literal patterns that bordered on being pixel art.
I decided to take inspiration from the double diamond design methodology that I used for my bag. A discussion with a well-known weaver, Aunty Doe, confirmed that this was the best looking one and so I developed it further. These were my best developments, and I settled for the design on the bottom left.

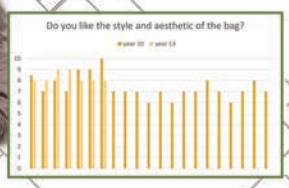
Prototyping

In this project, tangible outcomes such as the harakeke textile patch and the leaf woven kete base were really needed to give a full view of the design. Bags are also a very personal so a physical manifestation of the design was needed for users to interact with. These reasons meant the project was largely prototype based and I spent a long duration in this phase.

Final Model

User Feedback

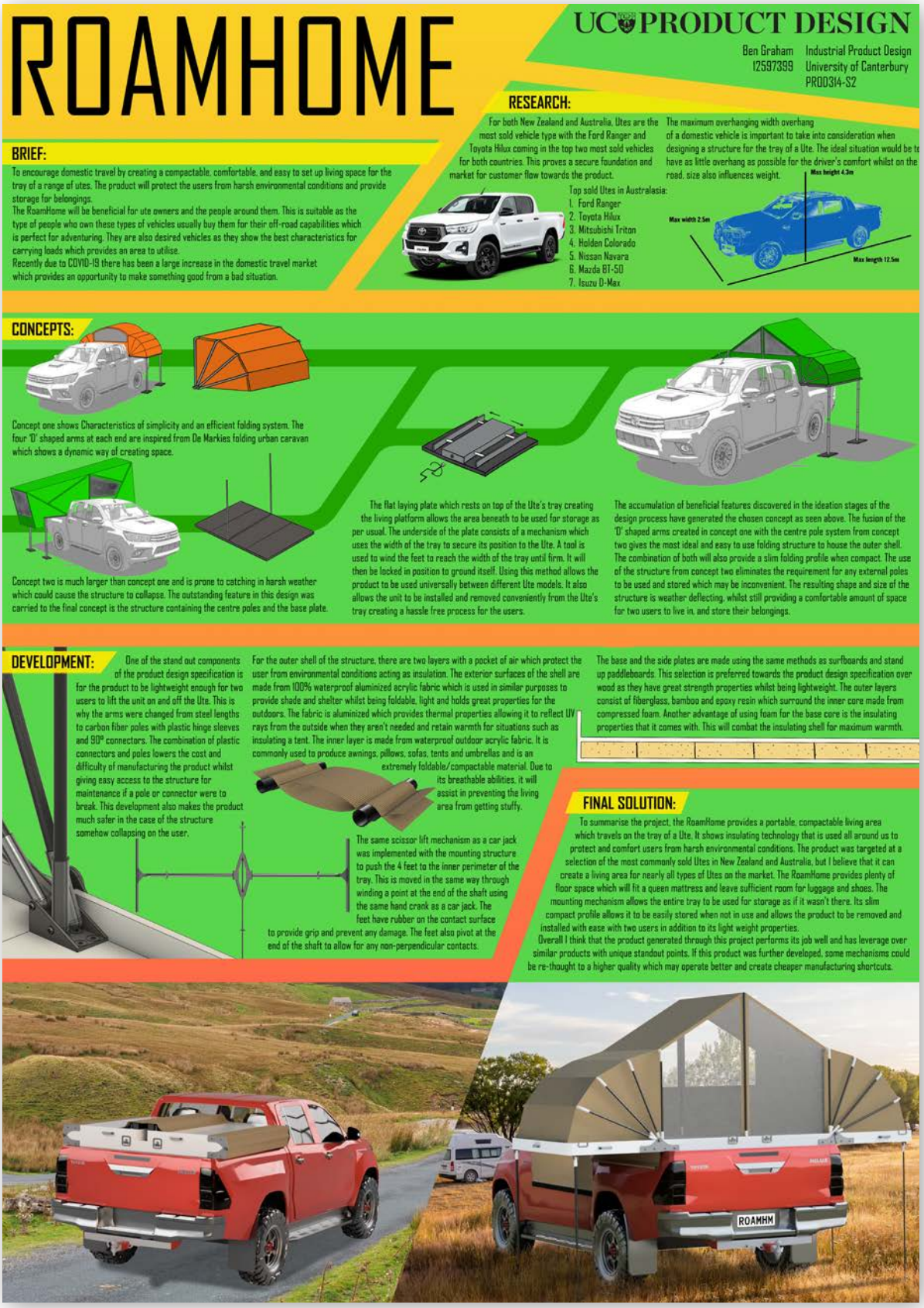
I wanted to get feedback from my target market, students aged 17-24. To do this I went to Cashmere High School and interviewed students. Their feedback was useful for further development of my design, most notably the addition of a front pocket.
The chart shows feedback from both year 10 students and year 13's. The year 13 feedback is generally more positive which reinforced my age range of target market being 17-24.



Caleb Philps - 78591837
Bachelor of Industrial Product Design
Supervised by Tim Huber
UC PRODUCT DESIGN

Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



Student projects: Product Design - Industrial Product Design

1. Discover

Three major ideas were discovered in this phase. These were child development, bike ergonomics and safety and standards. These being the building blocks of a set of product specifications which to drive the direction of the design process. Children's growth patterns are dynamic and can differ from child to child. This is why focusing on child development patterns and riding ergonomics is important. For the riders comfort and safety. The following specifications are refined from the original, but are all important considerations when creating the ONE bike.

P D S

Ergonomics
- The bike must be fit for change for children between the ages of 5 and 13.
- The bike must promote back posture of 15° from vertical.

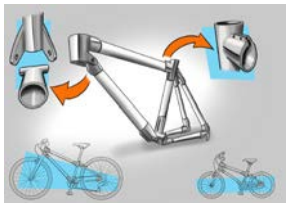
Mechanical
- The frame must fit wheel sizes of 12", 16", 20", 24" and 26" when increasing in size.
- Stack and reach of the bike must increase at different rates when increasing the overall bike size.

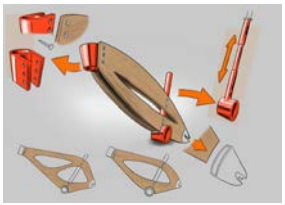
Safety
- Training wheels must be able to be attached for all bike sizes.
- Front and back brakes must be fixed on any bike equal or larger than wheel that are 16".

Standards
- All bikes must have brakes attached
- There must be 88mm of clearance between the front pedal and the tire.
- The frame and fork assembly must absorb no more than 40J when 900N is applied.

2. Select

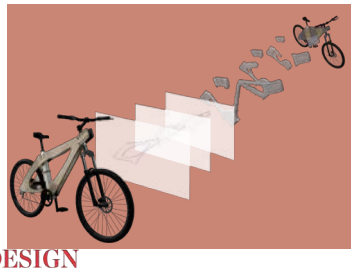
Driven from the PDS's concepts could be generated from methods such as brainstorming and morphological charts. Then Various iteration stages and development were undertaken to refine the list of concepts. Four concepts were formed at the end of this. A telescopic frame, a wire frame, a LUG concept and a timber panel bike concept. These were taken through two stages of evaluation. Peer evaluation and evaluation by criteria to deem the panel bike concept the strongest.





3. Develop

This was undertaken in various stages. First was conceptual development via sketching, second was prototyping by creating scaled models and prototypes and lastly was simulation studies and detailing to refine the whole bike. Finally stress testing simulations to test the material properties of the frame and components. This all making the following step in the process easier.



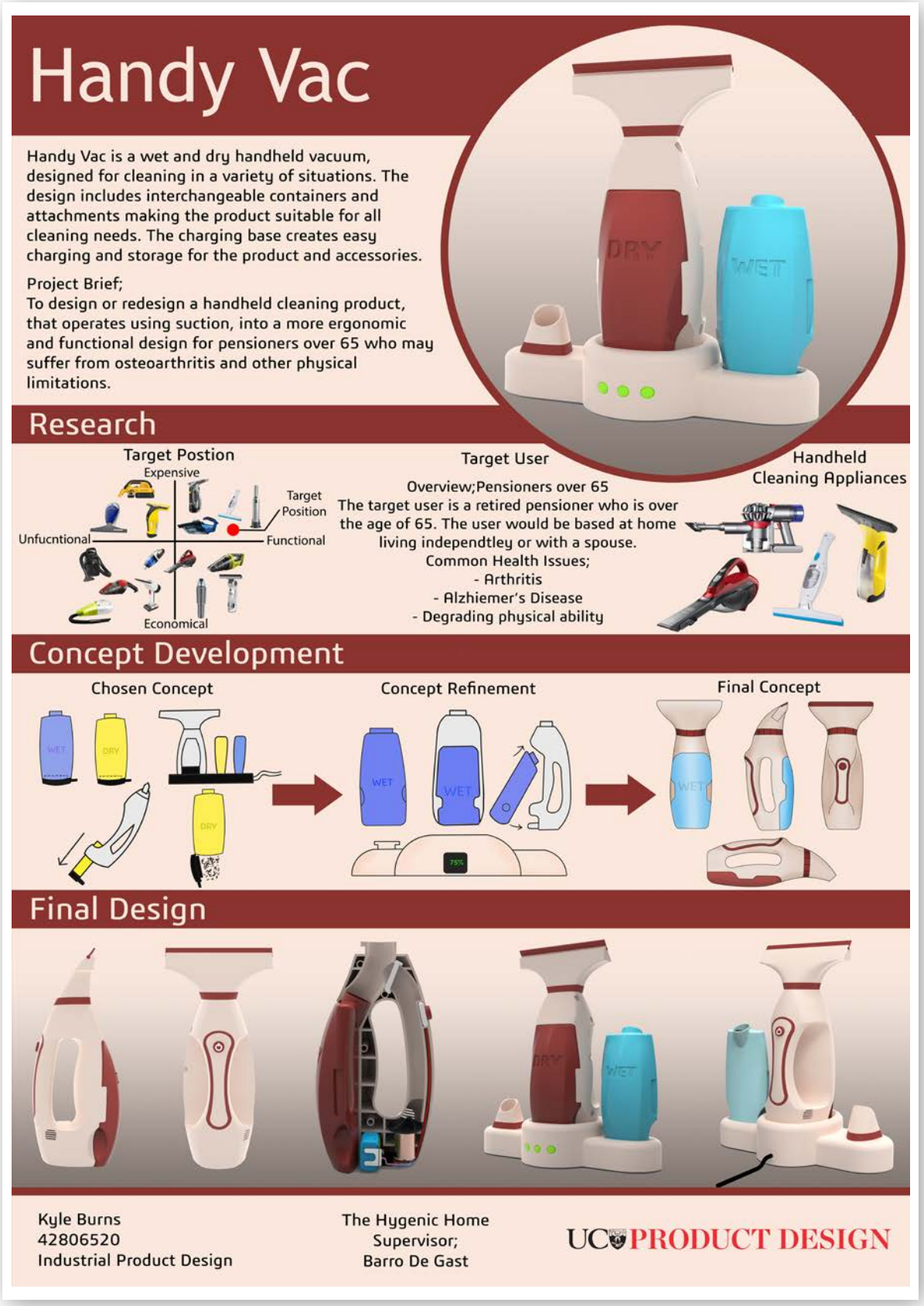
4. Embody

The last phase of the design process, where testing of manufacturing methods was undertaken. The testing of various manufacture methods were advised from technical staff and industry professionals. The frame of the bike incorporates a sweeping curve created from laminated timber. The accompanying components were manufactured by hand via welding and fabricating methods. The result is a prototype bike frame that would be suitable for riding.

UC PRODUCT DESIGN

Callum McGregor (73355539)

Student projects: Product Design - Industrial Product Design



Coach Mate

Tactics Made Simple

Design or redesign a football tactics board, that prevents the loss of accessories, and makes the coaching process more simple and effective

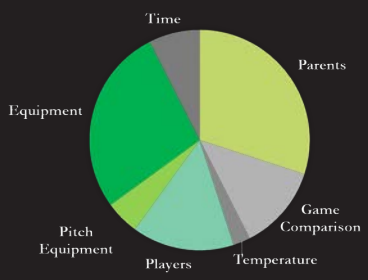
Materials:
Circular steel components enclosed within an acrylic body with natural rubber attachments

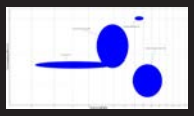
Product needs to be:
- **Simple**
- **Strong**
- **Reliable**

Liam Miller - 51144080
Industrial Product Design
PROD314
Supervisor: Euan Coutts

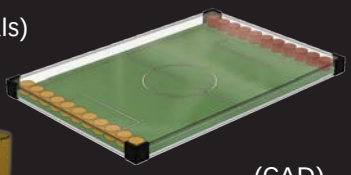
The project incorporates a user based approach, emphasising user feedback within the design process

Beginning with a coach (user) survey to establish and justify issues



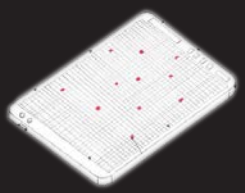


(Materials)



(CAD)

Product Research



Ideation

Prototyping
Testing
Finalisation

Product Development

Evaluation using concept comparison matrices

UC PRODUCT DESIGN

Student projects: Product Design - Industrial Product Design

POLAR - X SPECIAL

DESIGN BRIEF

The Antarctic heritage trust has been created with the charitable purpose to conserve the historic huts, share stories and experiences with others and encourage the spirit of exploration. My client wishes for me to create some unique and interesting merchandise that can be sold to raise funds to continue to maintain the huts. This merchandise will preferably either hold some sentimental value, represent the legacy of the explorers, inspire a new generation or even just successfully raise funds. It is required that manufacturing is well thought about **along with a budget to support an end to end product creation.**

CONCEPTS

I used methods such as a morphological chart, redefining my PDS, user personas and a meeting with a consultation with a different supervisor to help influence and guide my decisions heading into the concepts stage. Refering back to the user personas when making any drastic changes to my ideas was important as the product needs to be suited to my user, not my personal preference. The morphological chart helped me decide which aspects I would like to include in my designs for each concept.

FINAL DESIGN

Based on my concept reflection and project brief, I feel the final design was easily noticable among the three. This is due to the key points made in the concept reflection which was based of my user personas and PDS.

- The material of choice for the casing is a thermoplsatic hybrid polymer blend of PC and ABS as this was the most suited choice against the product design specifications along with being low inproduction costs.

- The product needed to be 'unique, compelling and interesting' which meant that the choice of addtional features, aestheics and overall case design took priority over function as we are using existing internals.

- Using any free space to 'brand' the merchandise with a tag line or logo would be highly beneficial as it is marketed for a charity to raise the necessary funds to continue operating.

- It was important to keep the manufacturing costs low as the point of the merchandise is to raise funds for their chartiable purpose, so keeping exspenses low increases the profit margin.

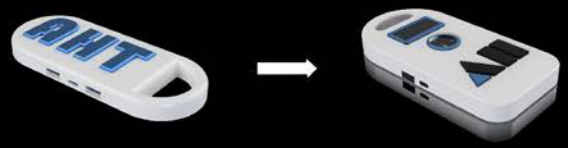
The design of this concept was developed by exploring the possibilities directed by these points and the redefined PDS.

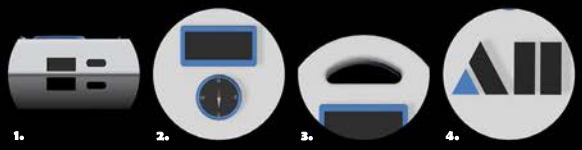
IDEATION

I used ideation methods such as brainstorms, moodboards and SCAMPER to help generate as many ideas as possible to present to my client. I used the SCAMPER method to approach the probelm from seven different key areas in hopes to inspire my thinking to unlock fresh, innovative ways to understand the problem and overcome creative blocks

CAD DEVELOPMENT

The model on the left is my intial cad prototype where I was exploring with the design of the power bank. This helped me visualise my concept to influence new ideas and improvements where necessary. The intial CAD model a rectangular shape with semi circle ends, a large in-built slot/handle and large branding on topof the casing, no extra features. This was a solid model, meaning it was not hollowed out with any internals modelled inside, it was more to visualise the overall concept rather than be technical. From this intial model I produced my second and final CAD model with a few changes to the handle/slot style, the overall shape of the case and the **branding on top of the case. Along with this development I added in the additonal features based** off the morphological chart and concept. The USB port design changed due to this being an actual component from Aliexpress in this model, whereas the one on the left was just a fake design for reference. The handle/slot design changed to increase the amount of free space inside of the casing for componentary, along with this design being stronger and more sleek. Using the offical logo of the trust seemed more approriate for this model as well as being visually more appealing. The new case shape was flowed a lot smoother and allowed for easier manufacturing, along with being able to **stand the power bank up vertically.**





1. USB port for external charging and a TYPE-C port for internal charging.

2. An LED display panel indicates battery level along with a custom analog compass.

3. A in-built handle/slot added into the case design for ease of portability.

4. The offical Antarctic Heritage Trust logo is 'branded' on top of the case for advertising and aesthetics.

JORDAN LLOYD - 27064964 - MARCUS WATERS - ANTARCTIC HERITAGE TRUST
'CREATE MERCHANDISE' - AHT PROJECT - BACHELOR of PRODUCT DESIGN
SUPERVISOR - WENDY ZHANG

UC PRODUCT DESIGN

SCSupport

School of Product Design
PROD314-S2 2020 Year 3
Tim Proctor - 29144639
Will Duncan

UC UNIVERSITY OF CANTERBURY

UC PRODUCT DESIGN

Abstract

This poster shows the creation of solutions for reducing the symptoms of incomplete spinal cord injuries (SCI). The main goal of this is to create independence and increase quality of life.Through research conducted, a few means could be done to help reduce it, through improving quality of life, through strengthening muscle groups and helping them to retain their independence through reminding them to upkeep their techniques learned during the rehabilitation stages.

The final result came to the product named SCSupport, which stands for spinal cord support.

Brief

To design or redesign a product to help the recovery of a person who has a spinal cord injury (SCI) to make life easier. The focus will be on reducing the symptoms, or making life more manageable through day to day life.

Some of the SCI symptoms are: migraines, back-pain, posture, nerve pinching, wellbeing, fatigue, spasticity, and other pains that can come with SCI. This could involve prevention, rehabilitation and or strengthening.

Define & Research

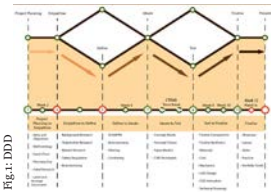


Fig.1: DDD

Fig.2: Moodboard

Firstly a timeline was created, and double diamond diagram (DDD) to create weekly goals. (Fig. 1)

The main research conducted was around the needs of people with SCI's. The findings were that exercise and stretching was important for progress in rehabilitation and recovery, as well as designing to allow the user to become independant is desirable. This can then help with quality of life for the user with a SCI. Research was conducted through using both primary and secondary sources, with interviews, journals and competitors products being the most helpful.

Ideation & Concepts

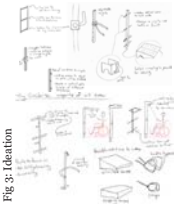


Fig.3: Ideation

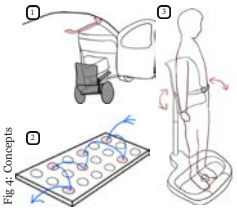


Fig.4: Concepts

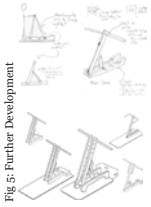


Fig.5: Further Development

Initial development included quick sketches to gain some ideas from the specifications created through research. This then led to concept generation, in which there were 3 main areas so 3 concepts were made with many iterations within them. The main concept selected was concept 2, which focussed on home exercise for people with SCI's to help them gain indepenence. This was selected through using a convergence control matrix. More detailed sketches were then made, to create a more defined concept profile. Once this was defined enough, CAD drawings and prototypes were included within the design process.

Prototype & Test

Fig.7: Prototype 2 Fig.6: Prototype 1

Fig.8: Progression of CAD Models

Fig.10: Exercise Fig.9: Final

The first prototypes were created using pine beams. These were low fidelity prototypes to test if the ideas were viable. Many participants tested out each prototype and a lot of improvements were made from their feedback. This was the most influential process of this project as it determined what changes needed to be made. During this process, CAD models were generated to give an idea of how each component will relate to each other. This then led to the final prototype which is a high fidelity product, using majorly 18mm plywood. Although not fully functional as the main bracket could not be created, but still gives the main shape and usability of what it could be.

Finalised Details

Stretch pole
Used on device for stability, removed for stretch pole.

Interchangable Bracket
Changes sizes in horizontal plane.

Counterweight
To help keep the product stable.

Footpad
Pins on inner sides help hold down device when user puts weight on pads. Comfortable ground to stand on.

Resistance Bands
Two sizes, longer for upper body and smaller for lower body workouts.

Carabiners
Used to connect resistance bands to device to be used while sitting.

Fig.11: Phone App for SCSupport

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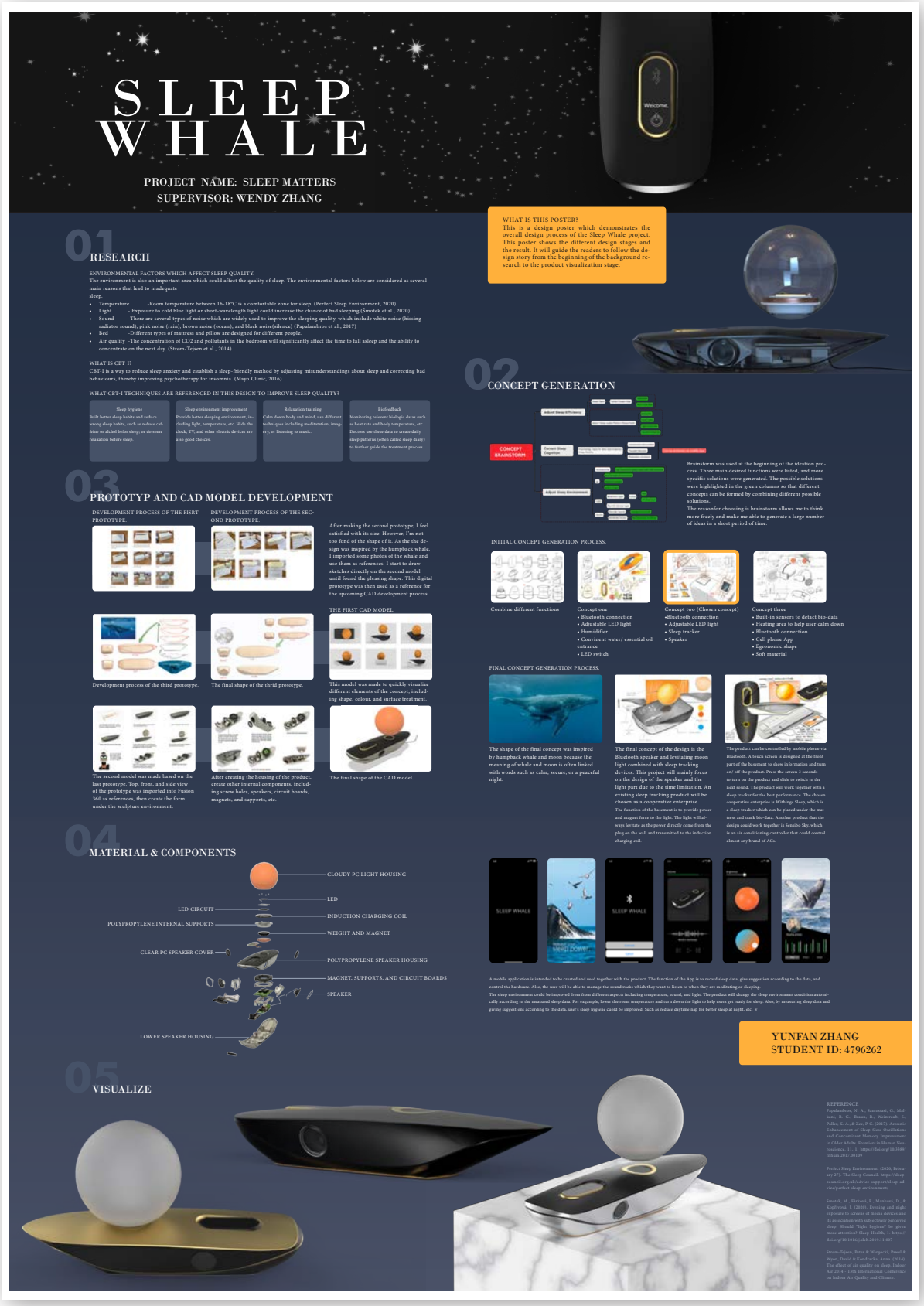

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UC PRODUCT DESIGN

https://www.canterbury.ac.nz/engineering/schools/school-of-product-design/

FRESH MINT

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PROD314 - INDUSTRIAL PRODUCT DESIGN 2B
CAPSTONE PROJECT
Supervisor - Bahareh Shahri

DISCOVER DEFINE DEVELOP DELIVER

Fresh Mint is a product designed for the RSA project titled '***Beyond the Kitchen***'. The brief was to design a *convivial* product that enabled people to come together and socialise around the dining table / kitchen.

STAGE 01 - **DISCOVER**

The beginning of the project involves researching topics that enable the designer to gain a better understanding of the brief at hand, and leads to defining where the project will lead to during the developing stage.

The initial themes researched for background information were barriers into why people are not cooking home cooked meals as often, and why socialisation is being impacted and is decreasing. The obesity statistics in New Zealand were also examined to see how Kiwi's eating habits are effecting the nation. It turns out that New Zealand was the third most obese country in the world (NZ Stats, 2020).

FIGURE 1 - Mint connected to runner

Throughout the process, more research was taken to understand the needs of herbs, and most importantly- how mint spreads. It was discovered a runner is attached to the roots of the mint, shown in Figure 1, which connects the mother herb to the other seedlings (Anna, 2015).

STAGE 02 - **DEFINE**

The aim to 'develop a convivial (social) product / solution that *motivates people to prepare and cook healthy meals, and come together to socialise*' was created, alongside a few objectives such as following a PDS and designing a final, tangible solution that is marketable for a low-income household, and is not complicated to use. Later in the process, a new brief was designed to fit the second lot of research undertaken. This new aim was to '*design a playful solution that allows for novice and beginner plant growers to produce their own herbs. This will enable them to learn new skills and grow foods to be used in healthy, home-made fresh meals.*
The Product Design Specifications included Customer, Function, Size, Aesthetics, appearance & finish, Materials, Product Cost and Quantity. I referred back to these specs' when choosing a final design during the develop stage.

STAGE 03 - **DEVELOP**

Concepts were developed based on the idea of connecting individual pots together in a playful manner, ultimately allowing the user to decide how the mint spreads. A controlled convergence matrix, as shown in Figure 2, was used to weigh the concepts against each other and a product that exists already. Fusion360, a CAD program, was then used to finalise the shape and form of the pot, and lead to the ability to create a laser cut prototype and negative mould used for the cement prototype which was made during the delivery stage.

FIGURE 2 - Controlled Convergence Matrix used to decide the final concept

STAGE 04 - **DELIVER**

The last stage in the design process is the delivery of the concept. This is mainly presented through a prototype, in this case an 'alpha' prototype which is meant to look and function as close to the real product as the designer can make.

During the last few weeks of the term, a laser cut pot was made to ensure the dimensions were accurate and would work for the concept. Once the form was correct, a negative mould was laser cut. This wooden mould was cut into quarters and was used to pour cement in to. More laser cutting was used to create the water containers, which sit under the pot.

The final prototype can be seen below in images 5 - 8, and in the final render, image 9.

REFERENCES

Anna (2015). *How to Plant Mint and Not Sob Uncontrollably.* Green Talk. Retrieved from https://www.green-talk.com/how-to-plant-mint/

Stats NZ. (2020). Obesity. NZ Social Indicators. Retrieved from: http://archive.stats.govt.nz/browse_for_stats/snapshots-of-nz/nz-social-indicators/Home/Health/obesity.aspx

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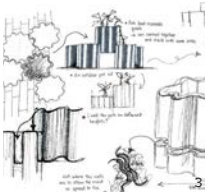
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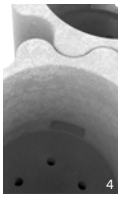
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PORTABLE AI BOX

DESIGN BRIEF

The ability to identify shellfish with desirable qualities quickly is critical for advancing high-value product markets. Current practices for gathering shellfish quality data are time consuming and labour-intensive, combining physical by hand and visual by eye, assessments on hundreds of individuals. Visual observations are especially problematic, as humans lack the ability to accurately quantify variable traits, such as differences in pigmentation.

The aim is to identify shellfish with desirable qualities from a single image and generate valuable data on characteristics such as uniformity of growth, shape, and colour. a system that can automatically measure the dimensions of mussels and oysters. Images can be used to determine whether mussels and oysters are good to eat, sell and breed from. NAI has the expertise to create software that can meet these requirements, and this is where a product designer is needed to design a fit-for-purpose hardware platform that can meet these requirments.

APPLICATION

Greenshell Mussel

The shellfish industry's current practices for gathering data are time consuming and labor-intensive, combining physical, by hand inspections and visual by eye assessment of hundreds of individuals to determine the quality of the shellfish. Visual observations are especially problematic as humans lack the ability to accurately quantify variable traits, such as differences in pigmentation that the clients product is aiming to resolve.

With this large market in conjuction with Nelson AI's software, this product has a large potential client base and room for growth.

With the average length of the mussel being 10-15cm, reaching 23cm

CONCEPT DEVELOPMENT

Initial Concept

The initial concept was a two piece design. The core of this design (shown in gray) is a simple container for a shellfish to be manually dropped into.

From this point the second component of this design, the sliding camera (shown in gold) is then manually pulled upwards.

This causes an internal camera that is facing the mussel, to be dragged upwards and past the mussel, capturing the required data.

After this scan has been achieved the mussel is then tipped out of the device and another specimen can take its place for another scan.

Developed Concept

The core design rationale behind this iteration of the initial concept was to adapt the design into an enclosed system that has a very high reliability and that can produce repeatable results.

This iteration achieved its core function by having the shellfish being dropped into a clear housing in the design and having cameras scan the mussel.

This design includes two internal cameras that face the shellfish at opposing angles to get a full 360 degree view.

This design included a light source, a detachable battery and rail system to allow the device to be attached to a fixture.

Final Iteration

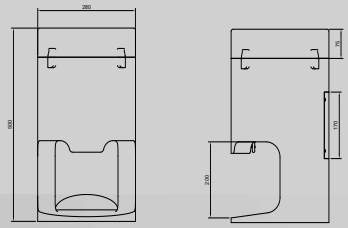
This final iteration shifted the design to being a more simple and time efficient product.
This was accomplished by reducing the number of components in the design and focusing on the important elements.

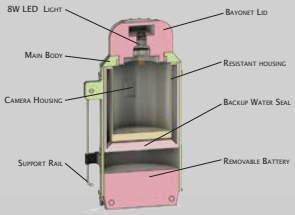
This design has the user drop the shellfish into the top of the device into a rotating clear insert inside the design. When a shellfish has completed a full 360 degree rotation a trapdoor ejects the shellfish out the bottom of the device and another one can be loaded for a second scan.

In this design a pre-built phone is performing the recording of data and processing the data through a custom app which is to be developed.
This phone is also responsible for the control of processes such as insert rotation and trapdoor actualization.

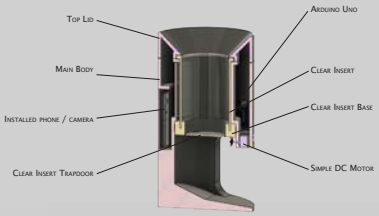
CAD DEVELOPMENT

DEVELOPED CONCEPT





FINAL DESIGN



FINAL DESIGN

UC PRODUCT DESIGN
ANDREW BANNOCK 29062944
BACHELOR OF PRODUCT DESIGN
PORTABLE AI BOX
SUPERVISOR: WENDY ZHANG
INDUSTRY PARTNER: NELSON AI INSTITUTE

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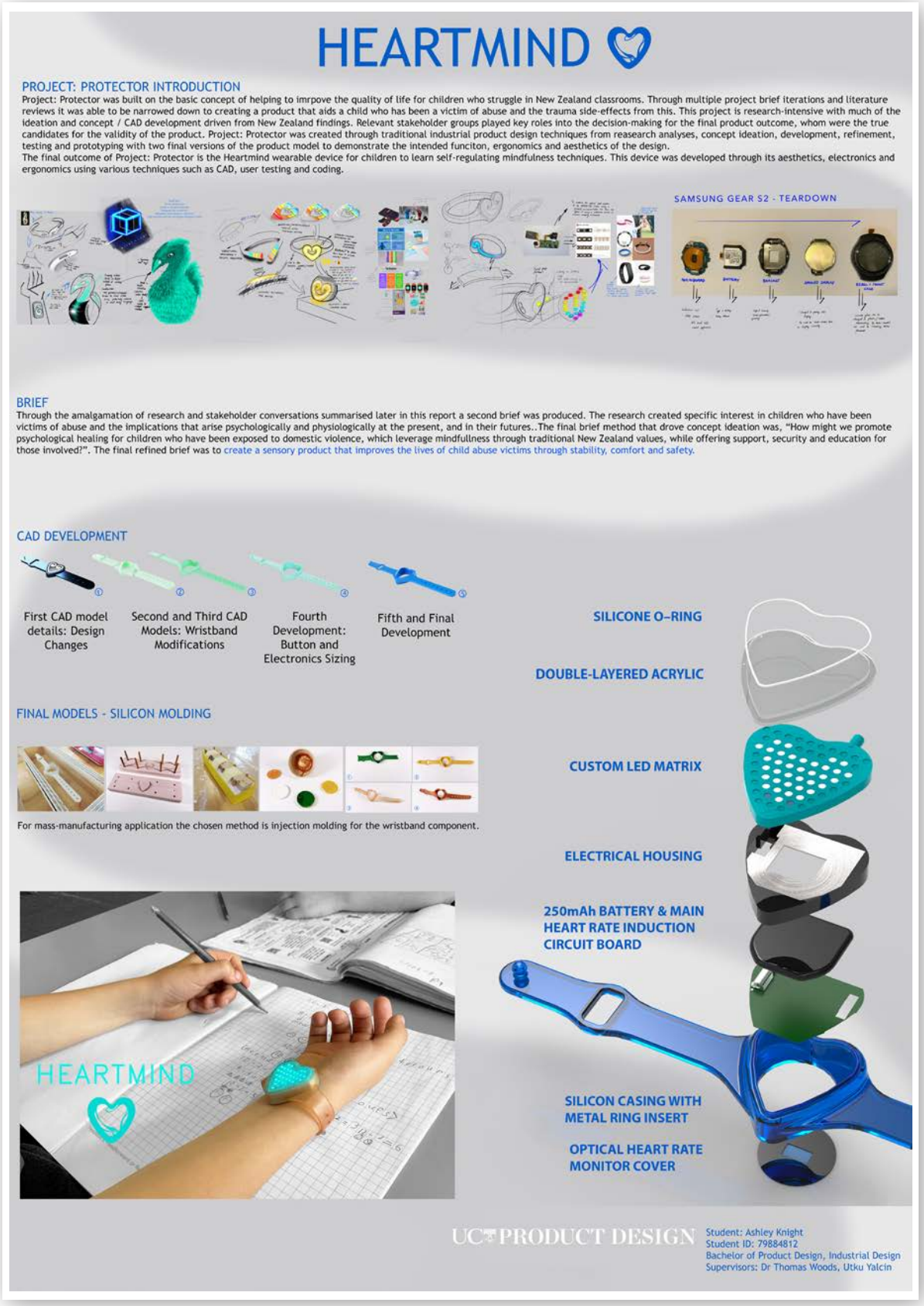

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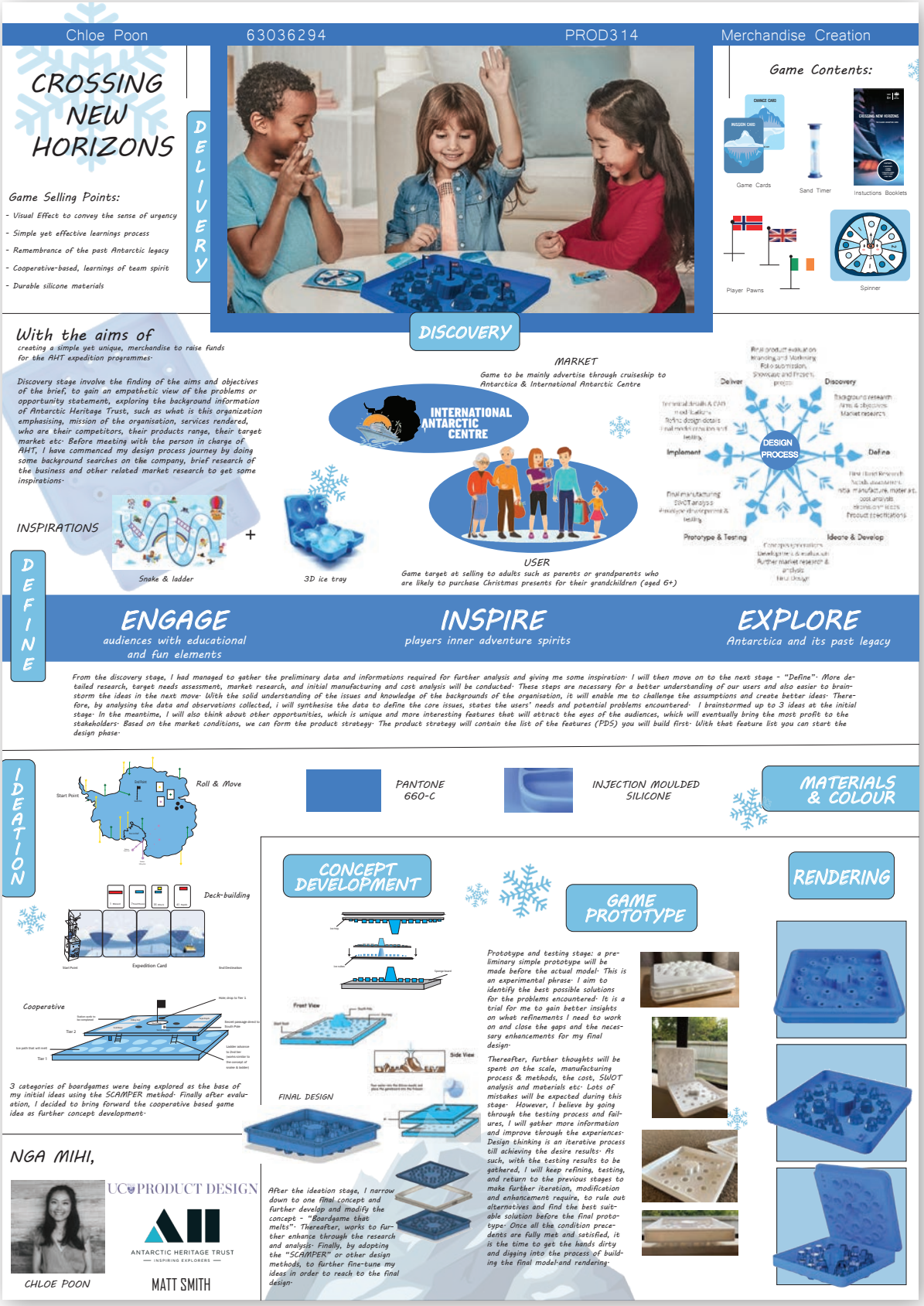

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MODULAR CARGO BIKE BOX PROJECT

Design Brief

"When people look at a cargo bike they look at the box, the rest of the bike is secondary"
- Pete Thornton

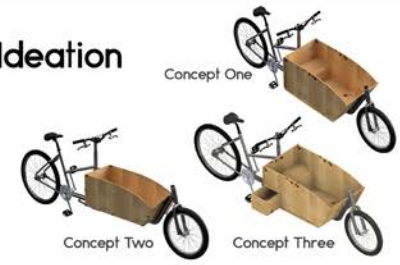
The Modular Cargo Bike Box project is an industry brief from Cargo Bike World Limited (CBW). The client is seeking a cargo box solution that will affix to their existing front-loading Cargo bike frame, the Big Long Thing (BLT). The box should carry a range of cargo dependent on the end user's needs. The end solution needs to follow CBW's locally and sustainably made ethos. The client wants a proof of concept prototype and manufacturing documentation for continued local production. The Client is planning to make multiple sized cargo bikes, therefore the cargo solution will need to work on different length frames. CBW want to sell cargo bikes to both recreational and commercial riders around New Zealand.

Concept One
-Base panel is bend twice, once at the front with a bend of 62° and the other at the back of 90°. The seat also has a 90° bend to reflect this bend feature.
-Removable high & low side panels. To allow box to carry different cargo.

Concept Two
- Five panel held together with steel brackets. The brackets can be unbolted to remove panels as needed.
- Tapered front panel allows sides to be lower while still covering the frame.
- Gap between panels allow for the box to drain.

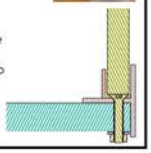
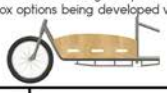
Concept Three
-Base panel has a single bend at front of 62°. This allows the box to follow the shape of the boom tube.
-This design has a small lockable storage box under the seat to hold electronics & small items.

Ideation



Development

This project went though three major development cycles.
- The first was developing on the chosen concept with the two plywood bends. In this cycle large amounts of testing where undertaken to explore the feasibility of having and making bends in plywood. It was subsequently found that producing bends in plywood sheets weakened the box and didn't allow for small adaptions between each custom made bike.
- The second development cycle was focused at making the side panels easily removable. The method explored was using off-the-shelf aluminium extrusions to provide end grain protection to the plywood and hold the side panels. This direction ultimately was seen as too expensive, heavy and prone to collecting moisture & dirt.
- The last development cycle was focused on making the cargo box easier to produce & changing from a modular solution to offering multiple sized bike options. This cycle resulted in three bike box options being developed which had common panel to simplify manufacture.


The final design consists of three box sizes, the high sided for long frame, the low side for the long frame and the low side for the short frame. These boxes share common parts such as the front and back panels for the low side options. The unique part of each design is the side panel. The reuse of parts allows the client to have to deal with less cut files. The high sided box can carry two children with the optional seating platform or large amounts of cargo, having 290 L of storage space and weighing only 11.7 kg. Being 600mm wide and 800mm long, this box can easily carry up to four Euro boxes each 600 x 400 x 250m (with the seat removed). The slots located on the top and bottom of the panels are tied down points for ropes and straps. As well as convenient handholds for children. The box has a large flat space on each side for companies to present their branding. The low side boxes are variations of the high side design focused more on at carrying the Euro boxes. Having lower side to making loading and unloading easier. The long low sided box has the same length and width as the high side. The shorter low side box is 400mm shorter but keeps the 600mm width to carry a single euro crates abreast. Both these low side designs have flat tops to allow oversized cargo to sit on top. The boxes only have one row of slots on the side panels due to their reduce height. The low sided long box has a storage capacity of 86.22 L and weighs 6.8 kg. The low side short box has a storage capacity of 45.4 L and weighs 4.2 kg.

Final Design

Prototype

A prototype of the high sided design was produced as part of this project in 1:1 scale. Unfortunately, the client was unable to provide a cargo bike frame for the submission. The chosen plywood for this particular prototype was BBI Redline Poplar Core Ply. Chosen due to its ability to take knocks and its high number of veneer layers with five plies. The prototype's panels were cut out individually on SOPD's CNC machine which has a relatively small workspace of X 650 mm, Y 1080mm, x Z 250 mm. all the cutting was done using a 4mm ball end mill. The panels were then sanded to give a smooth end grain and remove the 2mm radius corners in the slots and tabs. All the panels were sealed with polyurethane to bring out the grain and make the prototype more water-resistant. Once dry the panels were glued together and the seat and seat belt were installed.

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UC PRODUCT DESIGN

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BRUSH PATH

PRODUCT PURPOSE

Brush Path is a product designed to bring confidence and control back into the oral care routine of people impaired by degenerative diseases. Degenerative diseases are characterized by the progressive deterioration of organs and tissues of the body. This sees people losing cognitive functioning, dexterity, and muscle control. These impairments cause people to lose the ability to effectively brush their teeth, leaving them vulnerable to poor oral health. This has many health implications, both physically and mentally. Brush Path is designed to prevent poor oral health from occurring, to keep users away from pain and suffering, and expensive dental treatment.

PRODUCT DESCRIPTION

The four brush head designs give the user a choice, which allows them to use a toothbrush that fits their needs and is comfortable for them to use. The heads fits onto a sonic electric toothbrush body. Sonic technology vibrates at around 30,000 strokes per minute, and is highly effective in removing plaque from teeth. The toothbrush body has embedded speed and orientation tracking technology. The information from these components is send to the Brush Path app, via Bluetooth. The app is very easy to use, as it is run automatically by the toothbrush. It gives a visual guide to follow, showing where the user has and has not brushed. It also shows the brush head usage and gives audible cues to assist in brushing.

ACKNOWLEDGEMENT

Special thanks to Dr John Bridgman, Oral and Maxillofacial Surgeon (MBChB, MDS, FRACDS(OMS), for his collaboration in this project. His involvement included defining the problem and brief for the project, and ongoing input in research and concept evaluation. Dr Bridgman added great validity to the project, with his great experience in oral health and its effects on people.

PRODUCT BY

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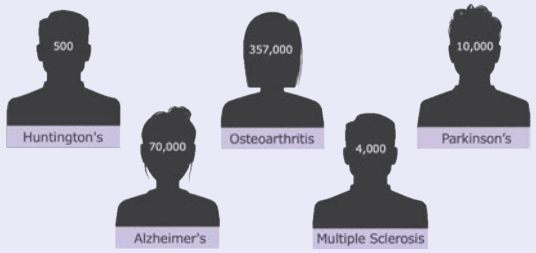
Student ID: 87764088
Supervisor: Euan Coutts
Course: PROD314
Institute: University of Canterbury
Department: School of Product Design

DISCOVER

Thousands of New Zealanders are currently living with degenerative diseases that impair them from effectively brushing their teeth. These diseases were investigated to discover the ways in which oral care is made difficult, and how it is currently being dealt with. This grounded the rest of the project with a good understanding of the potential users, the needs they have, and the ways that they will interact with a product. Relevant professionals were interviewed in this stage to bring validity to the research.



DEFINE

Product Design Specifications (PDS) were defined with the knowledge gained from research. These guided the project into well informed ideation and concept generation, and were helpful in evaluating potential designs. A better understanding of the PDS continued throughout the rest of the project.

Aspect	Objective	Criteria
1.0 Aesthetic		
1.1	Have an hygienic and clean appearance	Use white and colours associated with healthcare
1.3	Appear unobtrusive to the recipient	Curved edges, looks a comfortable size to have inside the mouth
1.4	Intuitive or familiar to the recipient	Draw design features from associated products
2.0 Reliability		
2.1	Give assurance that plaque is being removed	Test and obtain results
2.2	Function the same with each use	Test and obtain results
3.0 Ergonomics		
3.1	Cater for the grip a care person will have towards a recipient	Orientate the grip towards another person/ away from carer
3.2	Fit different mouth sizes and tooth layouts	Depending on the product, have different sizes/shapes
3.3	Have an easy to clean surface	Smooth surface finish, avoid small indented areas
4.0 Standards		
4.1	Keep within the electrical standards for oral products	Do not exceed 250 V
4.2	Consider standard recommendations	Comfortable voltage for a cognitively impaired recipient

5.0 Material		
5.1	Able to be cleaned and remain hygienic	Smooth and non-absorbant material
5.2	Practical and durable	Strong material, not brittle
6.0 Size/Weight		
6.1	Be a comfortable size in the hand of the user and mouth of recipient	Try it out, and get customer feedback
6.2	Be a comfortable weight for the user to hold for the duration of use	No heavier than an average electric toothbrush (350g)
7.0 Environment		
7.1	Functional for use in the bathroom	Water resistant and self standing or handheld
10.0 Safety	Keep the recipient free from harm	No sharp or obstructive edges, and prevent poor oral health
11.0 Testing	Test prototypes to gain insight into their value	Test against PDS 1 and 3
12.0 Service Life	Comparable to similar products	Compare materials and durability against existing products
13.0 Packaging		
13.1	Aligns with other oral health products packaging	Draw inspiration from existing successful packaging
13.2	Use sustainable packaging where possible	Assess carbon footprint of materials while meeting hygiene needs
14.0 Product Cost	Be financially beneficial (compared to getting more dental care)	Assess against prices of other products and dental care

DEVELOP

This development process went through many stages, and repeated stages. There was a loop of sketching, CAD, 3D printing and prototyping, and static stress simulations (2N load to represent brushing pressure). This allowed the design to be greatly improved from the original concept, and be a tested and valid product.

DELIVER

UC PRODUCT DESIGN

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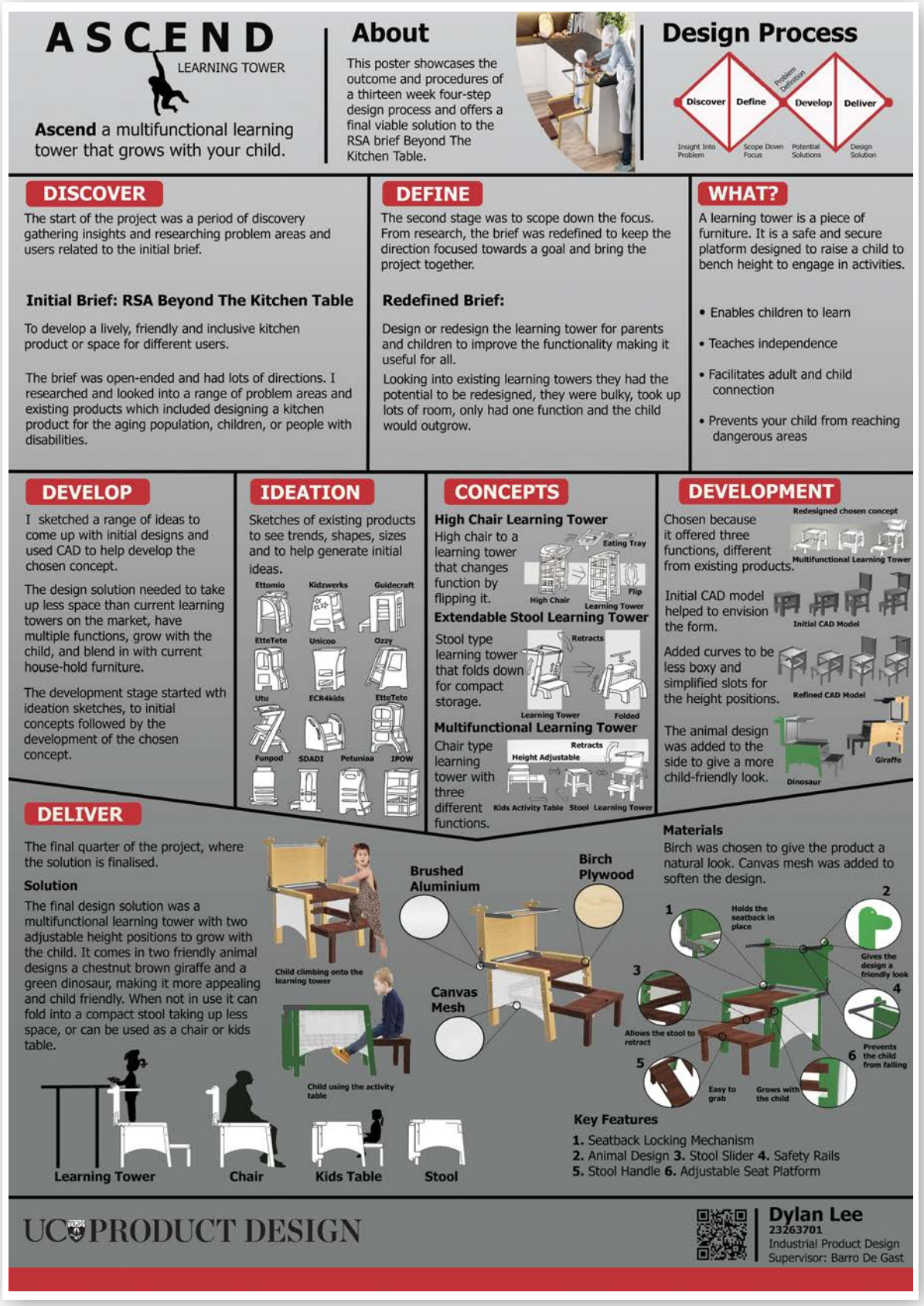

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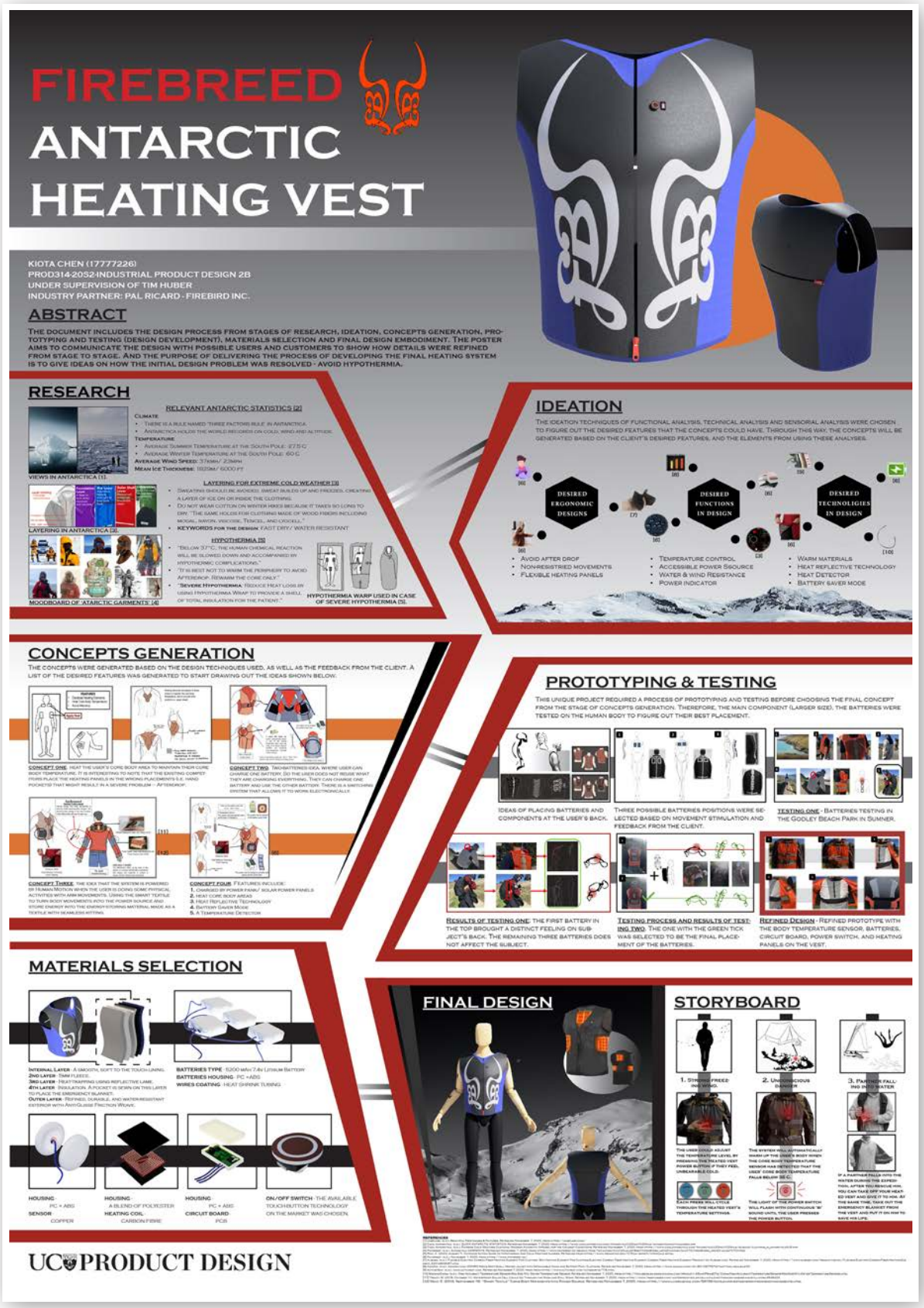

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Aquaponics for the Displaced

UC PRODUCT DESIGN

Designed by Orlando K.D. Woodcock - 69610339
Industrial Product Design Capstone Project PROD314 -2020
Supervised by Josh Campbell

INSPIRATION

Design Briefs

Dignity in Displacement
How might we support displaced individuals to find hope, dignity and safety to rebuild their lives?

This RSA brief was created as a way to find solutions to the current highest levels of human displacment on record. There are currently 79.5 million diplaced people around the world (1). As the brief is so broad - I focused specifically on supporting refugees physical and emotional needs. This led me to address the lack of food security often seen in refugee camps. I believed aquaponics would be a viable option to produce food in the harsh enviroments that refugee camps were often located. Thus, I changed the brief to;

Aquaponics for the Displaced
Design an inclusive aquaponics system that will help displaced individuals and communities to grow fresh organic food in order to provide hope, dignity and safety to rebuild their lives.

Target Audience

This venture is for refugees who are not receiving an adequate diet. The main target will be refugee mothers, as they are often in charge of sourcing and preparing meals. They are also the ones who look after the children, who in turn are often the most affected by the lack of a nutritional diet. Chronic malnutrition can often lead to irreversible impairment of a child's cognitive and physical development (2). This thereby further disadvantages them in life.

Current Environment

The global pandemic has caused "more than 3.2 million refugees across East Africa to receive reduced rations because of underfunding." (3) This has caused a recent hunger spike in West and Central Africa, where they are experiencing a 135% jump in the number of food insecure people (3).

Dadaab refugee camp was chosen as the location to design for as it's the largest refugee camp. It also has most challenging conditions to consider regarding the practical implementation of agriculture practices. These include: Low level of rainfall, high temperatures, erosion and poor soil quality, pests and diseases, lack of space, and funding. Dadaab is located on the border of Kenya. This area has been ravaged by a decade-long drought which has been followed by floods and now locust swarms.

Aquaponics

Aquaponics is a bio-integrated system that combines land-based aquaculture and hydroponics in a recirculating system. The fish produce ammonia-rich effluent, which is the used to fertigate the hydroponic production beds (4). The ammonia excreted by the fish is converted into nitrite then nitrate by micro-organisms present in the system. The plants then filter the nitrates - making the water habitable for the fish again.
Aquaponics serves as a viable, sustainable food production system for arid environments as it employs several key principles:

- The waste from one system acts as the nutrients for another system
- Water is re-used through biological filtration and recirculation. Aquaponics uses 90% less water than conventional farming.
- The integration of fish and plants in a polyculture increases diversity and yields.
- Stimulation of local food supply chains enhances local economy
- Provides healthy and nutrient-rich food to the community
- It is a soil-less system
- Small use of space

IDEATION

1st Initial Concept

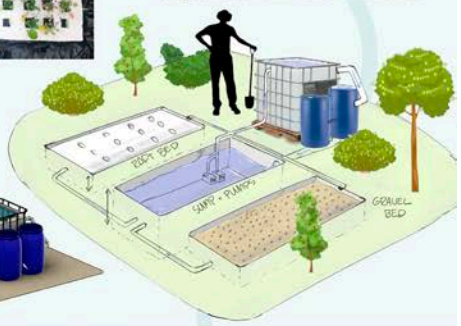
The first concept was inspired by easily accessible and inexpensive food safe materials and components. The concept utilises an IBC tank as a fish tank, blue barrels as mechanical filtration, and wood as the grow beds. It was also raised to make the sytem easier to use.

In-Ground Prototype

One of the main problems to overcome in my design was to verify if an in-ground grow bed was feasible. I developed a prototype to test if it was possible to plumb between two holes through the ground. I believe this issue is the reason this simple innovation has not been utilised as a growing method. To plumb between the two holes I used two bulk head fittings and secured them through the lining by using a pre cut board. The plumbing did not leak any water so I considered it to be feasible.

Final Concept

This concept was designed after a physical prototype of the in-ground grow-bed was demonstrated to be feasible. Previous aquaponics designs have grow beds that are constructed above ground, as well as large sump tanks that are placed under the ground. Thus, by simplifying the design so the earth acts a container for the water in the system - it significantly reduces the cost and makes the system easier and faster to implement.
Another unique feature in my design is the utilisation of universally accessible food safe components such as IBC tanks and blue barrels.

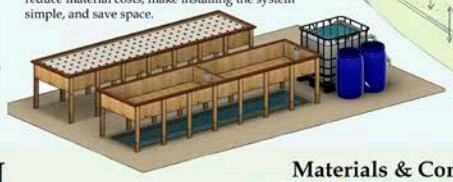


2nd Initial Concept

The second concept is a small scale aquaponics vertical tower garden. It was designed to provide herbs and leafy greens for families who have had to move to urban enviroments. The grow tower is intended to be made out of bamboo and the fish tank made out of clay. These materials were chosen as they are sustainable, easily accessible and cheap.

3rd Initial Concept

This concept is an adaptation of the first concept. It was designed to be able to provide food for a family of four for a year. It was calculated the area needed would be 23m². The difference to the first concept was the inclusion of an in-ground sump to hold all of the excess water. This idea would reduce material costs, make installing the system simple, and save space.



IMPLEMENTATION

Hero Shot

Materials & Components

LDPE Liner 2 x 20m | IBC Tank 1000L | Blue Barrel 200L | PVC Plumbing Parts | Water Pump 7000L/h | Air Pump 40Lpm | Solar Panels and Bateries 24V

Conclusive Venture

The final design contains a range of manufacturable parts that are easily accessible and cheap. Due to these factors - the overall sytem is able to be modular. This has several advantages as it means the design is robust to damages, it can be implemented anywhere around the world, it is simple to setup and put together, and as the venture grows the sytem is able to expand.

Buisness Model

The main role of the venture would be to design and manufacture modular aquaponics systems and supply them to refugee camps. The design will have modular parts that are outsourced to a manufacturer. These parts will be part of a kit set that can be sent to a refugee camp to be set up. The idea is that hosting governments, charities, or NGO's would pay for the initial investment. The system will then be sent to the location with several staff to set up and educate the refugee volunteers on how to operate it. This is so that the refugees can assume the responsibility and costs of operating the system on their own - thereby gaining skills and independence.

Once the system is operational, the business would provide ongoing support. This will consist of a helpline where volunteers can ask questions and order parts that have been broken. Routine checks from the ground staff would also be necessary to ensure that the aquaponics system has a long service life and that the volunteers are happy.

References:

(1) - UNHCR. (18 June 2020). Figures at a Glance. UNHCR The UN Refugee Agency.
(2) - Pernitez-Agan, S., Wickramage, K., Yen, C. et al. Nutritional profile of Syrian refugee children before resettlement. Confl Health
(3) - Kibego J. (9 July 2020) Refugees in Africa 'even more vulnerable than ever' amid COVID crisis.
(4) - Diver, S., & Rinehart, L. (2000). Aquaponics-Integration of hydroponics with aquaculture. Attra.

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https://www.canterbury.ac.nz/engineering/schools/school-of-product-design/

ROSE CENTRE

GULP GLOVE

MADISON TAIT : 84125582
SUPERVISOR: EUAN COUTTS
INDUSTRY PARTNER: The Rose Centre For Stroke Recovery and Research
BACHELOR OF PRODUCT DESIGN – INDUSTRIAL PRODUCT DESIGN

BRIEF – FROM THE ROSE CENTRE

"Explore avenues for optimally presenting waveform data for measures of pharyngeal swallowing"

AIM –

to develop the at-home app aspect of the GULP product, as well as the evidence-based feedback related to the system.

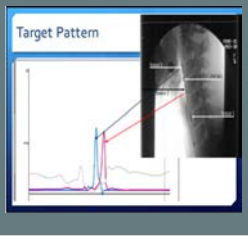


Image 1: graph showing waveform for a healthy swallow. Provided by The Rose Centre.

RESEARCH – PHARYNGEAL DYSPHAGIA

- Dysphagia is a swallowing impairment that occurs in patients who have suffered a neurological injury such as a stroke. Pharyngeal dysphagia prevents the brain from making the decision to transfer food or water from the mouth to the throat in an uninhibited manner.
- The Rose Centre have developed BiSSkiT and GULPS (Guided Utility in Latency of Pharyngeal Swallowing), which are both non-invasive, wireless, app-driven technology which uses surface electromyography (SEMG) to measure the electrical impulses of patient's swallows.
- The visual output is shown in a time v amplitude waveform graph which records the peak-to-peak latency between the two key pharyngeal muscles. When muscles contract individually and the swallow has been successful, the latency will be approximately 200ms. When the swallow has been unsuccessful the latency will be approximately 15ms. However, research has shown patients struggle to understand the waveform and convert the information from the waveform into a physical action for a more successful swallow.

CONCEPT GENERATION –

Concept generation was based off three main areas identified for growth in research: evidence-based feedback encouraging sensory stimulation, GULP as a take-home device, and developing the role of the in-app clinician.

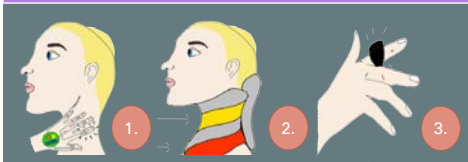


Image 2-4: Final concepts (smart glove, lightup neck device, pressure responsive ring)

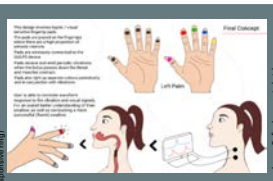


Image 5: final concept sketch

DESIGN –

The final design utilises GULPS technology and haptic / visual feedback. When the muscles contract individually, the finger pads light up / vibrate sequentially across the hand, indicating a successful swallow. When muscles contract with a short latency (or at the same time), pads activate simultaneously, indicating an unsuccessful swallow.

Image 6: stakeholder feedback

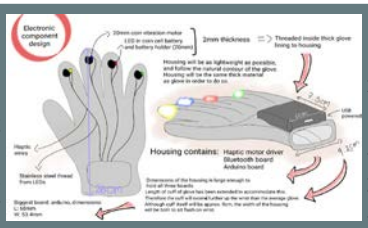
CONCEPT EVALUATION –

Stakeholder feedback and design evaluation matrices were used to evaluate the three final concepts. The final concept was a merge of two concepts (concept #1 and #3), based off stakeholder feedback and PDS requirements.

REDESIGN –

After initial prototyping and testing, it was decided that the finger pads were too small to house all the electronics. A wrist strap was designed, though ultimately the product was redesigned to a glove in order to retain the feeling of being disconnected that the PDS and stakeholders outlined, and to solve the issue of where to house the electrical boards.

Image 7: product design process



MATERIALS & MANUFACTURING METHOD-

A materials evaluation matrix based on product requirements decided that neoprene would be the material of choice. Manufacturing method was decided to be neoprene moulding.

Image 8: electronic component design

Image 10: testing LED's lights threaded in latex glove

PROTOTYPE & TESTING

Two prototypes were developed in order to test and communicate the product best. An aesthetic model was 3D printed at 0.8 scale to describe the outer body of the glove. A working prototype was developed to test and describe elements of the visual / haptic effect of the glove in 1:1 scale. The APP also went through prototyping and testing.

Major changes from testing included: LED colours and their order, haptic frequency, dimensions of glove and housing

CAD DEVELOPMENT

Image 13-16: CAD Development

RENDER

Image 14: CAD Rendered image

Image 9: haptic motor testing

Image 11: 3D printed glove, scale 0.8, PLA

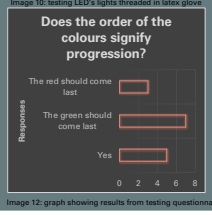


Image 12: graph showing results from testing questionnaire

FINAL DESIGN

Image 15: photograph of GULP GLOVE and front page of app

GULP GLOVE is a training device to assist patients with measures of pharyngeal swallowing, in collaboration with the GULP DEVICE (by The Rose Centre)

- Haptic coin motors and LED'S are threaded in the fingertips of the glove to harness the high proportion of sensory neurons in the fingertips.
- Glove Bluetooth connects to computer operating the GULP device.
- As patient swallows, and SEMG sensors record muscle activity, feedback is sent to the glove which is programmed to activate accordingly.
- When the muscles contract individually, the finger pads light up / vibrate sequentially across the hand, indicating a successful swallow. When muscles contract with a short latency (or at the same time), pads activate simultaneously, indicating an unsuccessful swallow.
- GULP GLOVE is based on promoting repetitive training and motor learning.

APP DESIGN

Image 16-23: APP content pages

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BLEND
Conversations Over Coffee

"Blend - Conversations Over Coffee" is the design solution to the brief that had been revised, refined and renamed since the original proposal *"A Conversation on Sustainable Design"*. The entirety of the project was structured around the awareness of sustainable design and worked in collaboration with industry partner; Frontal Lobe, a sustainable furniture design company based in Christchurch City Central. Research and industry collaboration focused the choice of material to center around the by-product waste of coffee, looking specifically at how this can reduce environmental impact and enhance emotionally sustainable design. The designer has developed Blend to communicate the sustainability theme of the project through every stage. The by-product is used as the leading story throughout the process. The final product output of the project is a coffee table made from coffee grounds and lids from a take away coffee cup. This product encourages and enables conversations on sustainability for the 'coffee drinker' and the 'coffee producer'; connecting with both cafes and their customers. Their is also further potential for expanding the material to a variety of products. The material and product design of Blend meets the criteria, aims, objectives and product design specifications set at the beginning of the project and is a marketable and effective solution to the design problem within this project.

The major stakeholders in this project will be The University of Canterbury, Frontal Lobe as an industry auditor, Matt Smith as a supervisor and Holly Rose Hunt as the lead designer. These stakeholders will support and resource the project and therefore are impacted by the outcome and success of the product.

For the empathize stage of this design project, research was undertaken in order to drive the understanding and decision making going forward. The beginning of this project was initiated by the issue of 'sustainable design' which was then focused within the cafe and coffee industry in New Zealand. Key areas for research were to discover the level of waste produced by cafe's in New Zealand and understand the impact of that waste by individually contacting cafes across New Zealand, and collecting statistics found through research already undertaken. The current market solution was also explored in order to understand what is already solving this problem, if there is a solution, and how the designer might create a point of difference from these current products. Initial research looked at product end of life, alternative materials, recycling, 'closed loop' sustainability and material sources. From that research, three key areas were realised as significant moving forward; by-products, environmental impact and emotional sustainability.

The Product Design Specifications were the driving metrics behind the design of Conversations Over Coffee. They were categorised by the three majors sections developed in the initial research and outlined in the project proposal. These were living specifications and were updated upon new research findings. Three iterations of the Product Design Specification were made before the final design output.

Ideation for this project focused primarily on creating a suitable material to meet the requirements of the PDS. There are less sketches and drawings of concepts, form and function, however there is a great focus on the prototyping and testing of the material as part of the ideation stage. Although the ideation phase was originally going to be an even double diamond, the material ended up being the focus and dictated the potential of the product concept. Ideation was fluid for this project. Brainstorms and seeking advice were the most significant techniques used, along with inspiration from the current market and coffee industry. Three concepts were generated and evaluated for the potential of the final design. The chosen concept was taken forward due to its ability to meet the PDS requirements.

There were four original methods explored for the formation of the material. The focus was to use the highest amount of coffee grounds possible, yet still create a material that was structurally sound and aesthetically pleasing. The first method explored was bio-resins, which was successful as seen if other market solutions. Long fibre binding was considered though difficult to execute. Clay was purchased with the intention of developing a potential mix however, a new direction was found before this was explored. Heat compression was also halted as the machine located in the School of Product Design was not yet set up for use. After understanding that PLA coffee lids would be the most relevant and effective way to blend the coffee together, samples were made to test and validate the concept. This took three iterations and methods in order to create the desired material. This was the most pivotal and crucial stage of the whole design project.

The testing and evaluation phase focused on the mechanical properties of the 'Blend' material created. Three physical tests were undertaken on the material samples, however the results from only two tests were successful and useful for the project. A deformation test was made but did not have the capacity for large enough weights, therefore was irrelevant. The other two tests were an impact test and a heat deformation test. Due to time restrictions only one sample of each material mix was tested which means future testing will be required for commercial use and justification of properties. Further simulation tests were run on Fusion 360 to understand deformation of PLA with 1000 N force of the center of the table design. This had a safety factor of 15. All tests showed the material and design are structurally sound. These tests determined the four Blends that are used for colour variation.

Holly Rose Hunt (86184992) Industrial Product Design

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frontal lobe

HRH

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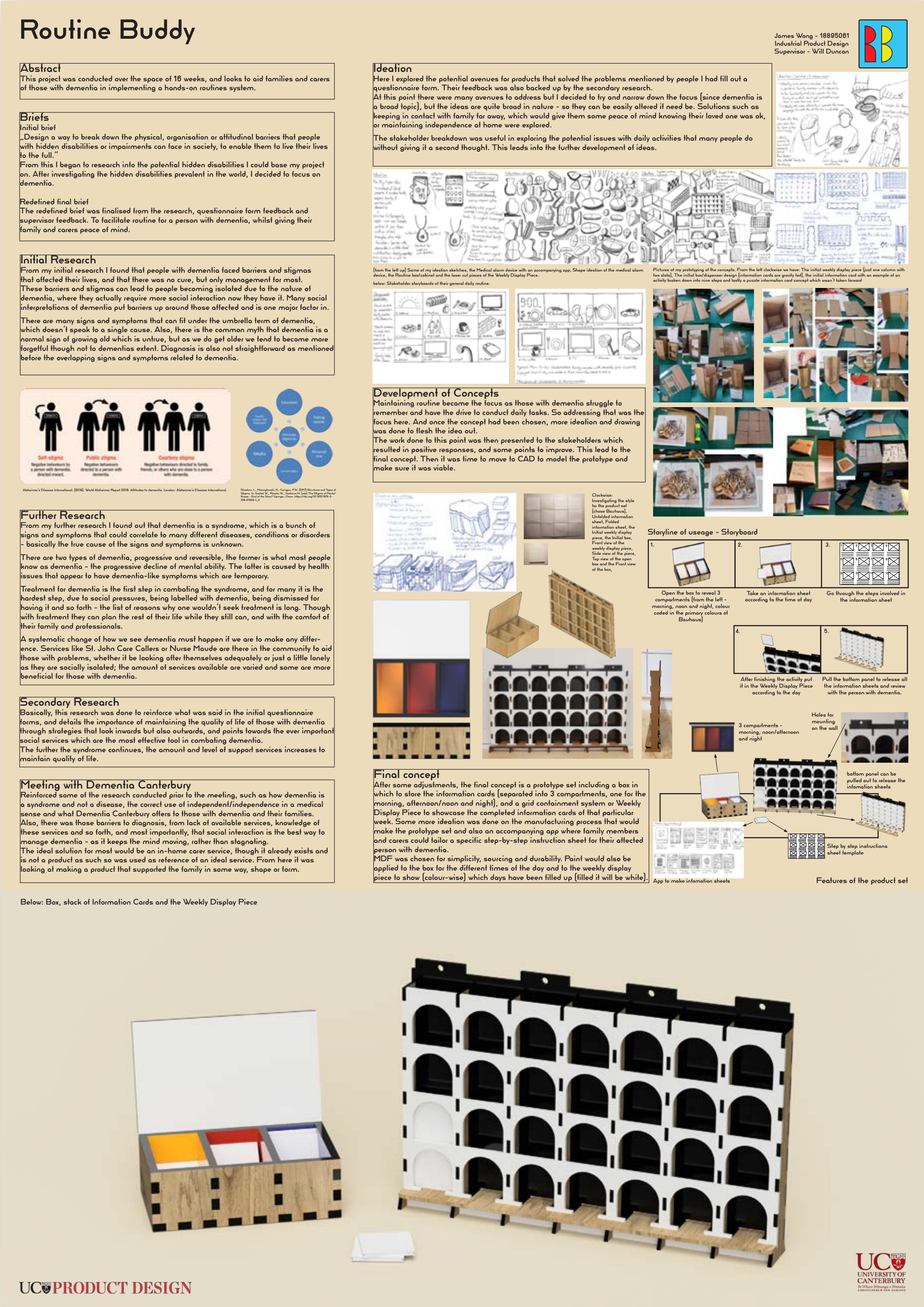
Routine Buddy
James Wong - 18895061
Industrial Product Design
Supervisor - Will Duncan
Abstract
This project was conducted over the space of 16 weeks, and looks to aid families and carers of those with dementia in implementing a hands-on routines system.
Briefs
Initial brief
„Design a way to break down the physical, organisation or attitudinal barriers that people with hidden disabilities or impairments can face in society, to enable them to live their lives to the full."
From this I began to research into the potential hidden disabilities I could base my project on. After investigating the hidden disabilities prevalent in the world, I decided to focus on dementia.
Redefined final brief
The redefined brief was finalised from the research, questionnaire form feedback and supervisor feedback. To facilitate routine for a person with dementia, whilst giving their family and carers peace of mind.
Initial Research
From my initial research I found that people with dementia faced barriers and stigmas that affected their lives, and that there was no cure, but only management for most. These barriers and stigmas can lead to people becoming isolated due to the nature of dementia, where they actually require more social interaction now they have it. Many social interpretations of dementia put barriers up around those affected and is one major factor in.
There are many signs and symptoms that can fit under the umbrella term of dementia, which doesn't speak to a single cause. Also, there is the common myth that dementia is a normal sign of growing old which is untrue, but as we do get older we tend to become more forgetful though not to dementias extent. Diagnosis is also not straightforward as mentioned before the overlapping signs and symptoms related to dementia.
Alzheimer's Disease International. (2019). World Alzheimer Report 2019: Attitudes to dementia. London: Alzheimer's Disease International.
Sheehan, L., Nieweglowski, K., Corrigan, P.W. (2017) Structures and Types of Stigma. In: Gaebel W., Rössler W., Sartorius N. (eds) The Stigma of Mental Illness - End of the Story? Springer, Cham. https://doi.org/10.1007/978-3-319-27839-1_3
Further Research
From my further research I found out that dementia is a syndrome, which is a bunch of signs and symptoms that could correlate to many different diseases, conditions or disorders - basically the true cause of the signs and symptoms is unknown.
There are two types of dementia, progressive and reversible, the former is what most people know as dementia - the progressive decline of mental ability. The latter is caused by health issues that appear to have dementia-like symptoms which are temporary.
Treatment for dementia is the first step in combating the syndrome, and for many it is the hardest step, due to social pressures, being labelled with dementia, being dismissed for having it and so forth - the list of reasons why one wouldn't seek treatment is long. Though with treatment they can plan the rest of their life while they still can, and with the comfort of their family and professionals.
A systematic change of how we see dementia must happen if we are to make any difference. Services like St. John Care Callers or Nurse Maude are there in the community to aid those with problems, whether it be looking after themselves adequately or just a little lonely as they are socially isolated; the amount of services available are varied and some are more beneficial for those with dementia.
Secondary Research
Basically, this research was done to reinforce what was said in the initial questionnaire forms, and details the importance of maintaining the quality of life of those with dementia through strategies that look inwards but also outwards, and points towards the ever important social services which are the most effective tool in combating dementia.
The further the syndrome continues, the amount and level of support services increases to maintain quality of life.
Meeting with Dementia Canterbury
Reinforced some of the research conducted prior to the meeting, such as how dementia is a syndrome and not a disease, the correct use of independent/independence in a medical sense and what Dementia Canterbury offers to those with dementia and their families. Also, there was those barriers to diagnosis, from lack of available services, knowledge of these services and so forth, and most importantly, that social interaction is the best way to manage dementia - as it keeps the mind moving, rather than stagnating.
The ideal solution for most would be an in-home carer service, though it already exists and is not a product as such so was used as reference of an ideal service. From here it was looking at making a product that supported the family in some way, shape or form.
Ideation
Here I explored the potential avenues for products that solved the problems mentioned by people I had fill out a questionnaire form. Their feedback was also backed up by the secondary research.
At this point there were many avenues to address but I decided to try and narrow down the focus (since dementia is a broad topic), but the ideas are quite broad in nature - so they can be easily altered if need be. Solutions such as keeping in contact with family far away, which would give them some peace of mind knowing their loved one was ok, or maintaining independence at home were explored.
The stakeholder breakdown was useful in exploring the potential issues with daily activities that many people do without giving it a second thought. This leads into the further development of ideas.
(from the left up) Some of my ideation sketches, the Medical alarm device with an accompanying app, Shape ideation of the medical alarm device, the Routine box/cabinet and the laser cut pieces of the Weekly Display Piece.
below: Stakeholder storyboards of their general daily routine.
Pictures of my prototyping of the concepts. From the left clockwise we have: The initial weekly display piece (just one column with two slots), The initial box/dispenser design (information cards are gravity fed), the initial information card with an example of an activity broken down into nine steps and lastly a puzzle information card concept which wasn't taken forward
Development of Concepts
Maintaining routine became the focus as those with dementia struggle to remember and have the drive to conduct daily tasks. So addressing that was the focus here. And once the concept had been chosen, more ideation and drawing was done to flesh the idea out.
The work done to this point was then presented to the stakeholders which resulted in positive responses, and some points to improve. This lead to the final concept. Then it was time to move to CAD to model the prototype and make sure it was viable.
Clockwise: Investigating the style for the product set (chose Bauhaus), Unfolded information sheet, Folded information sheet, the Initial weekly display piece, the Initial box, Front view of the weekly display piece, Side view of the piece, Top view of the open box and the Front view of the box,
Storyline of useage - Storyboard
1. Open the box to reveal 3 compartments (from the left - morning, noon and night, colour coded in the primary colours of Bauhaus)
2. Take an information sheet according to the time of day
3. Go through the steps involved in the information sheet
4. After finishing the activity put it in the Weekly Display Piece according to the day
5. Pull the bottom panel to release all the information sheets and review with the person with dementia.
Final concept
After some adjustments, the final concept is a prototype set including a box in which to store the information cards (separated into 3 compartments, one for the morning, afternoon/noon and night), and a grid containment system or Weekly Display Piece to showcase the completed information cards of that particular week. Some more ideation was done on the manufacturing process that would make the prototype set and also an accompanying app where family members and carers could tailor a specific step-by-step instruction sheet for their affected person with dementia.
MDF was chosen for simplicity, sourcing and durability. Paint would also be applied to the box for the different times of the day and to the weekly display piece to show (colour-wise) which days have been filled up (filled it will be white).
3 compartments - morning, noon/afternoon and night
Holes for mounting on the wall
bottom panel can be pulled out to release the infomation sheets
Step by step instructions sheet template
App to make infomation sheets
Features of the product set
Below: Box, stack of Information Cards and the Weekly Display Piece
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Abstract

Helpotus was a 16 week project aim to reinvent the aesthetics and functionality of mobility aid. The aim was to relive pressure/strain on injury while maximising user well-being and increase users mobility in their daily routines during their recovery phase.

The process of this project started with research to further understand followed by ideations. Then choose an idea to develop concepts. From there evaluate and identify conthe best concept for further development. Prototype development and design refinement was used to acheive a final design concept. Its able to support users and possed a sleek organic design improving human wellbeing.

Brief

Design a medical device of the future for the medical rehabilitation and recovery industry. Design a visionary, adjustable, customizable, suitable for all users (above the age of 18+) aiding device. Asked to conceive, design, and develop the product that broadly addresses the issues with standard crutches or walking aids. To design to overcome issues like body-raise aid, joint or muscle pain, does not cause injuries after use, affordability, mobility, and independence.

Research

A breadth of research was conducted including mobility aid experiments, social stigma, barriers, analysis, and limitations of current marketable products to have a better understanding of the project. There are issues with users being stigmatized as a cripple, old, broken for using a mobility aid. Thus, affecting their recovery and mental health as they prefer to stay at home. The currently available mobility aids are bulky and space-consuming. It causes inconvenience to other people in the public area. It also presents challenges, like picking up or carrying objects to the ordinary task of ascending stairs and getting up from a chair.

Fig 1: User isolated (left), User using stairs (middle), Crutches space consuming (right)

Ideation and Concept Development

Three main ideas were formed based on product design specifications: redesign ferrule tip (to provide a self-standing functionality), hands-free crutches (it allows users to accomplish daily task easier.), attachments kit (allows users to customize their crutches to meet their requirements.)

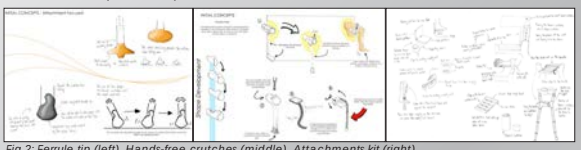

Fig 2: Ferrule tip (left), Hands-free crutches (middle), Attachments kit (right)

The chosen concept to develop further was the attachment kit. It received the best score from the control convergence matrix evaluation. An evaluation was conducted to decide which attachment to develop further. Elbow to forearm attachment was deem most beneficial to users and was chosen to develop further.

Fig 3: Types of attachments for exsisting mobility aid device

Prototype Development

Multiple refinements of the structure were completed to improve the ergonomic aspect and improve overall design functionality. Each iteration was formed using the feedback from users. The design got simpler and components were reduced.

Fig 4: Prototype 1 (left), Prototype 2 (middle), Prototype 3 (right)

As the design structure was finalised, the next phase was to refine the shape of the product. The goal was to create a sleek, organic, elegant design shape to stop discrimination against crutches and end social stigma. Thus, improving human wellbeing.

Fig 5: Types of design for platform (left), CAD model design for platform (right)

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Final Design

The final design was an organic, sleek shape with great functionality. A simple hinge mechanism that has four sets of angles at 0~90°. Different angles use to reduce stress and strain, ascending stairs. The key controls the angle of the platform. Pull the key to unlock and release to lock in the desired position. Extendable handle tube length for users with a lengthier forearm. The handle and platform have a slightly rough surface texture to increase grip. A conical geometric shape platform similar to the human forearm to increase support, stability, and comfort.

Fig 6: Final concept

Materials

The materials selected are Nylon 6/6 and 6061 Aluminium Alloy. Nylon 6/6 was used for the handle, forearm platform, and fix the tube. This material has high-abravise resistance, excellent durability against fresh and saltwater, and outdoor environment.

While the 6061 Aluminium alloy was used for the hinge and key. The material has great strength to weight ratio and excellent for outdoor environment use. Both materials are recyclable.

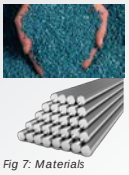
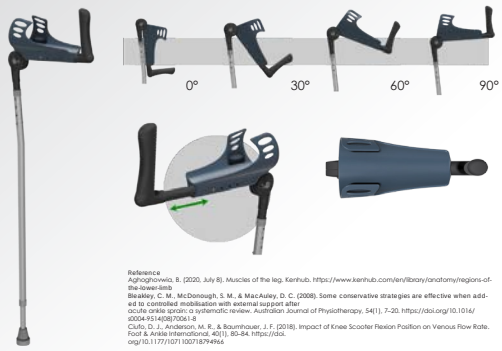


Fig 7: Materials



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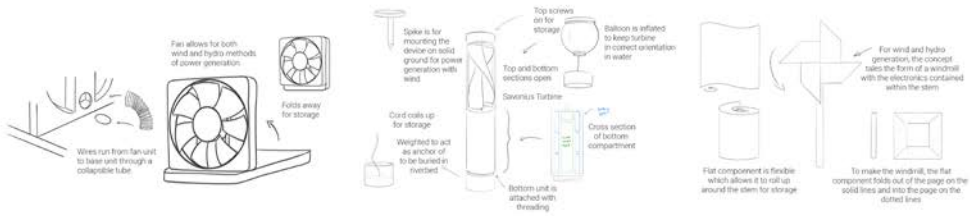
Student projects: Product Design - Industrial Product Design

MICRO-GENERATION OF POWER FOR THE OUTDOORS

DESIGN BRIEF

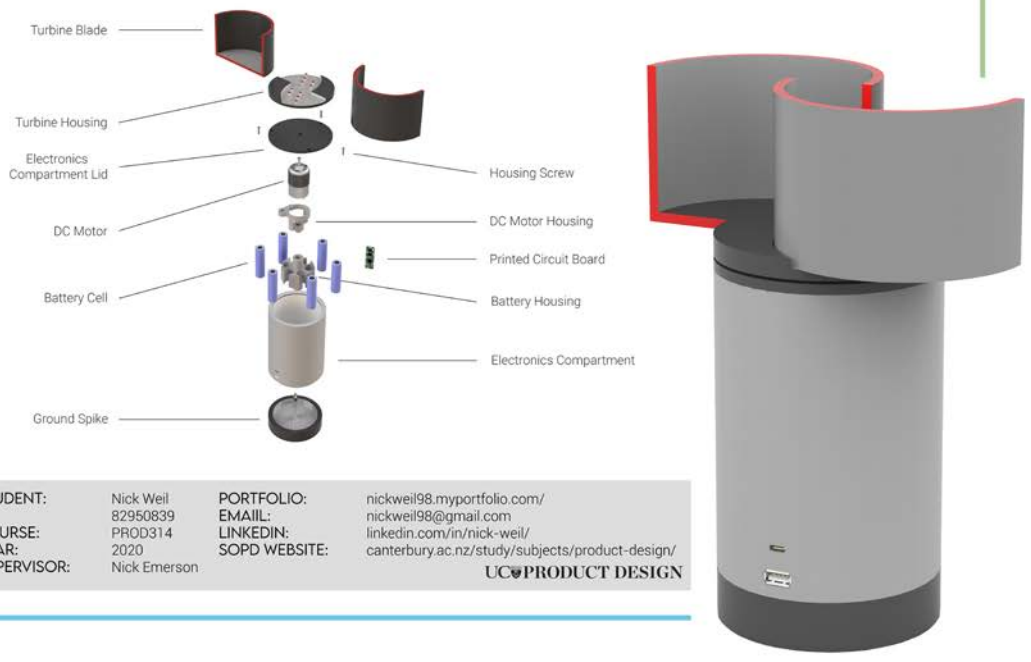
The aim of this project is to develop a product to aid with the micro-generation of power in the outdoors for use by hikers, hunters and other outdoorsmen. There is currently a gap in the market for a device which allows for the repeated charging of electrical devices without the use of traditional power supplies and this project will design a product to fill this gap. Such methods for generating power using this device could be through the means of solar, wind or hydro power on a small and portable scale to allow for the device to fit easily into a hiking pack.

IDEATION & CONCEPTS



CAD DEVELOPMENT

FINAL DESIGN



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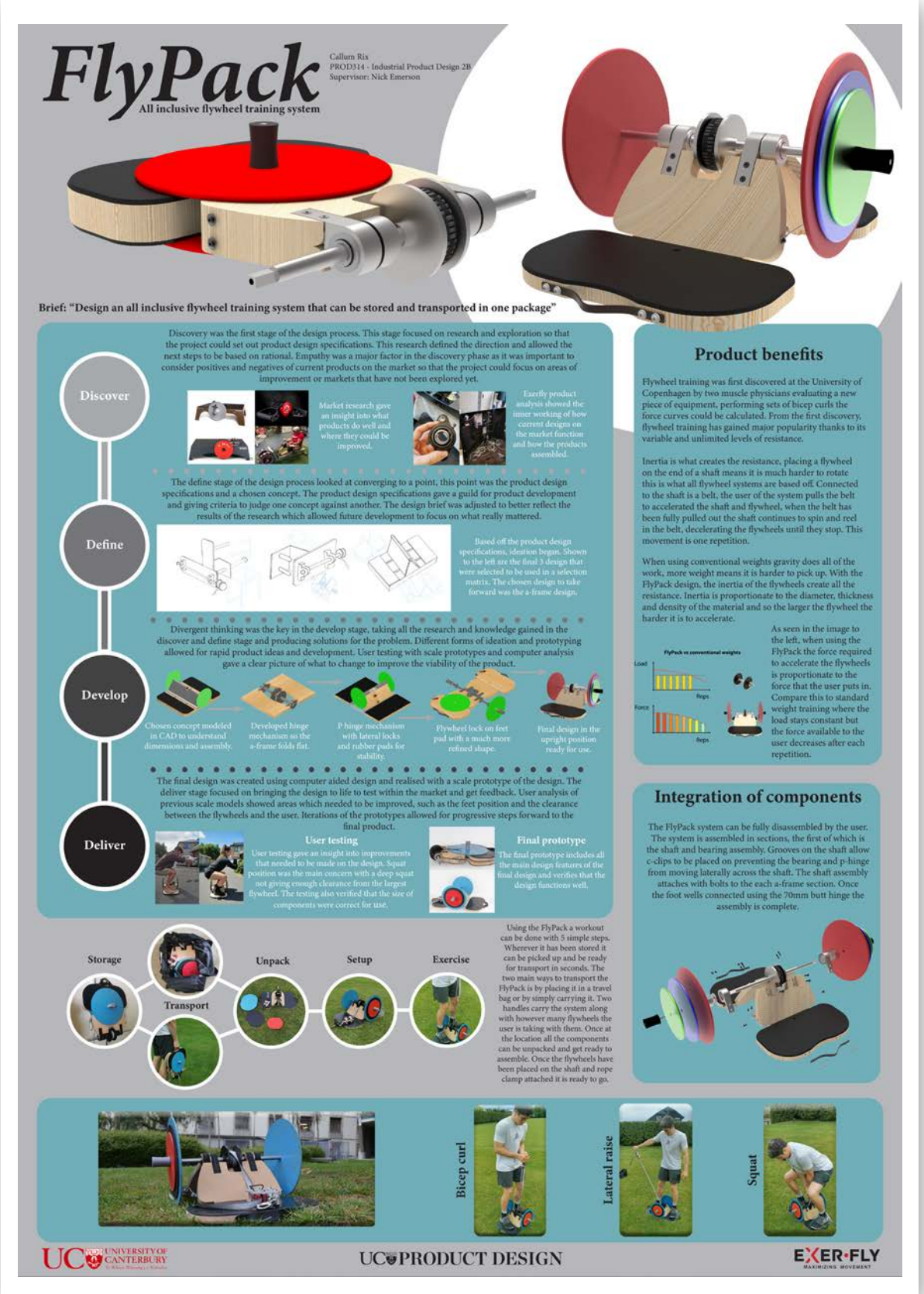

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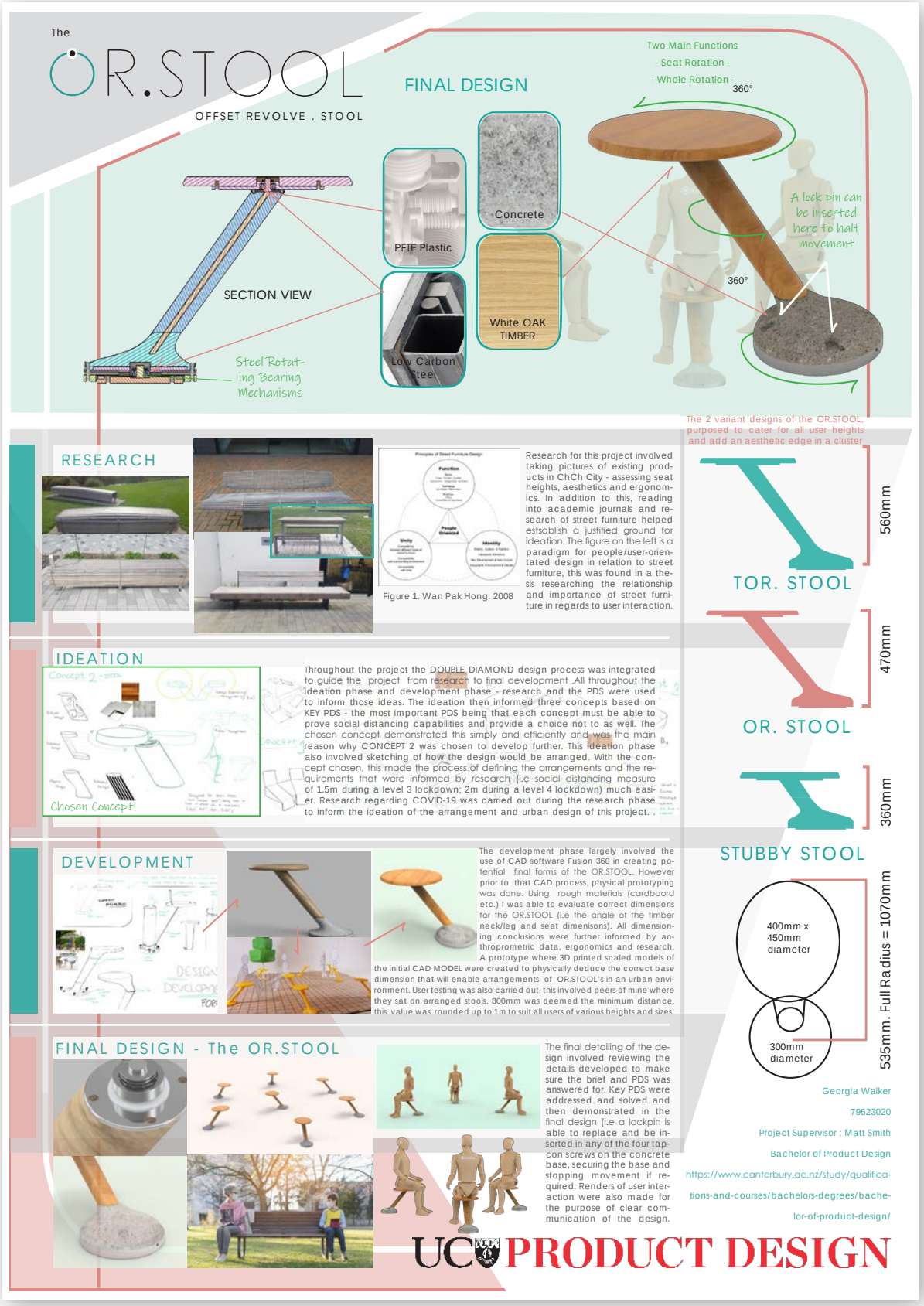

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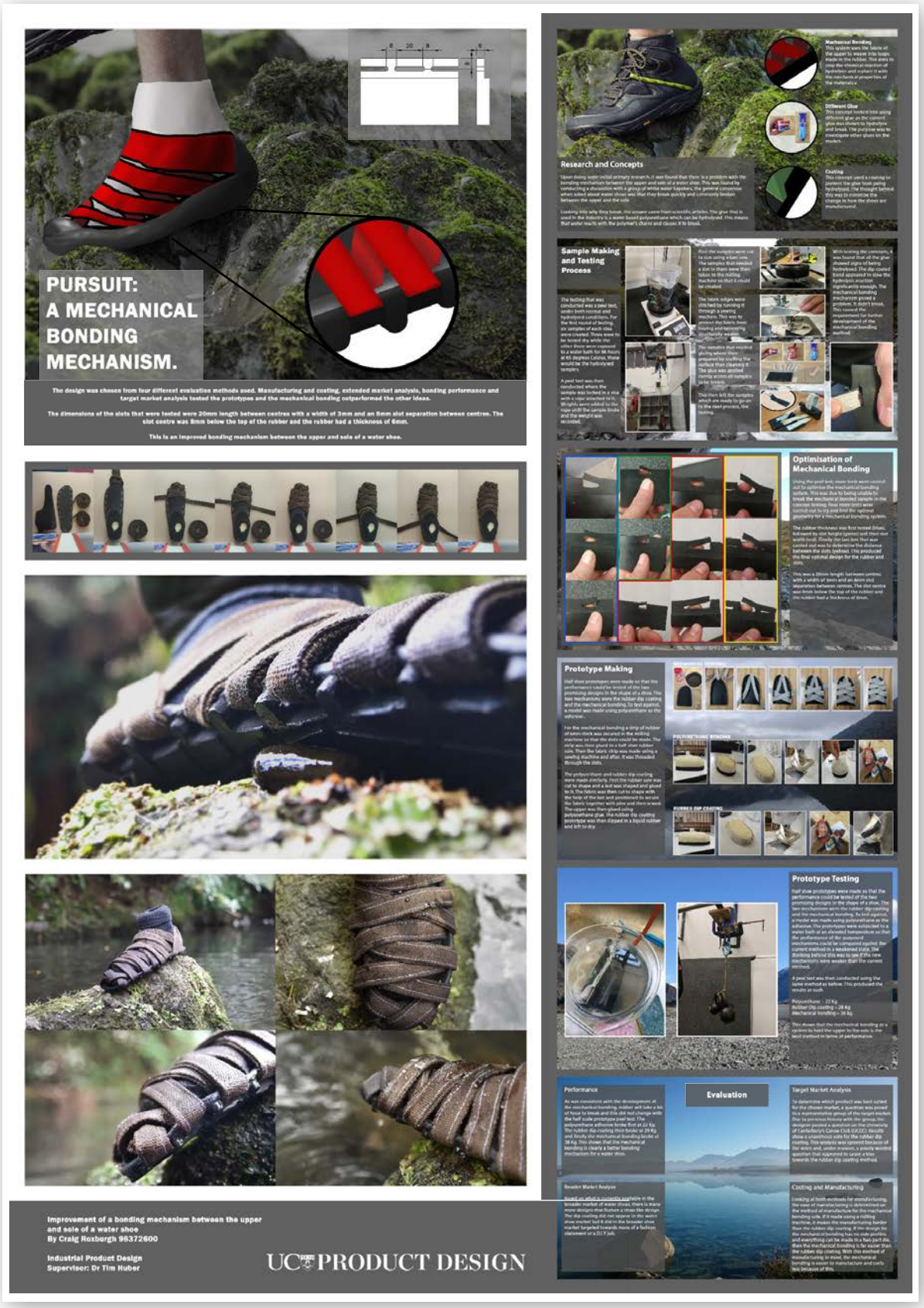

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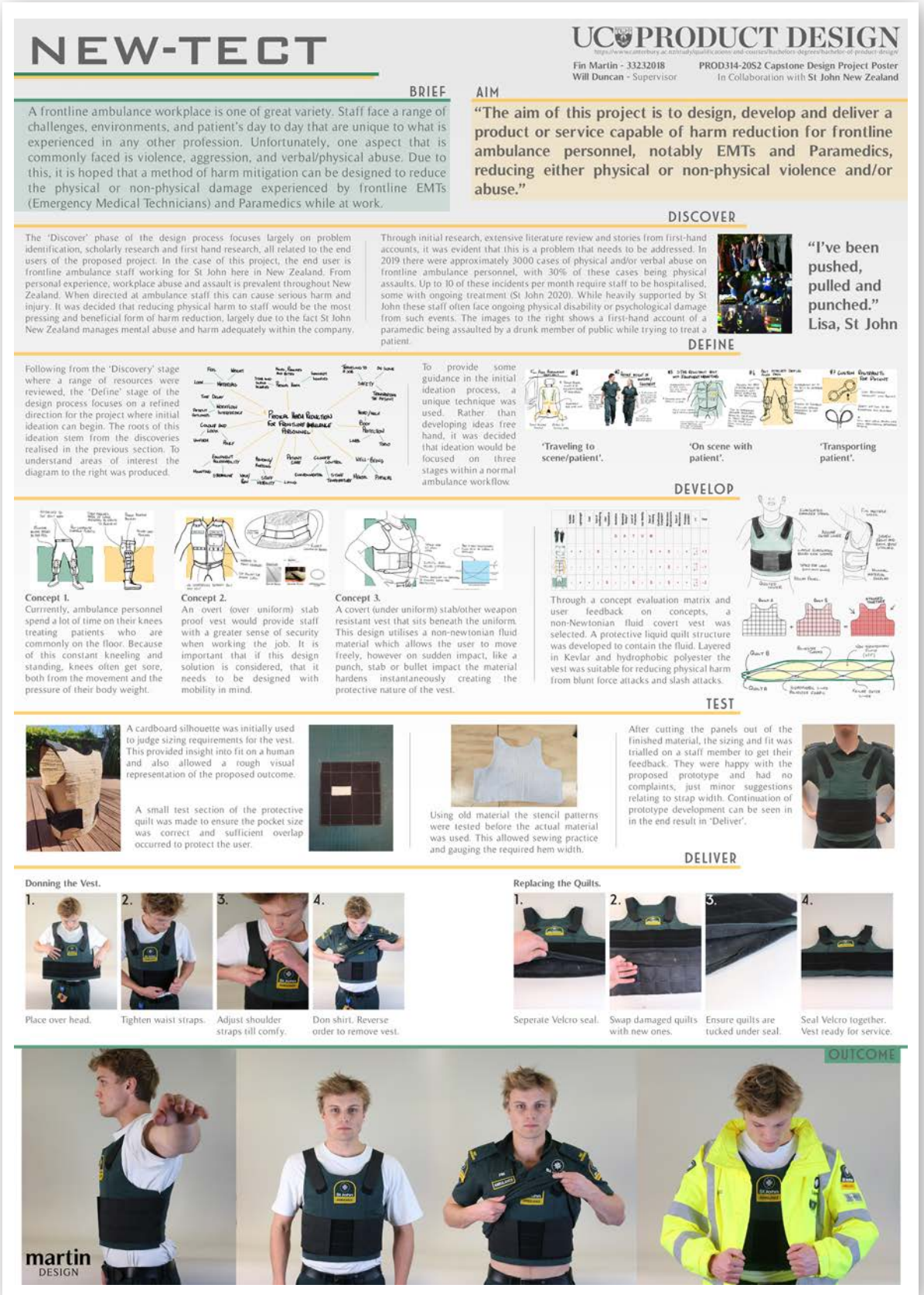

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Reminiscent

UC PRODUCT DESIGN

Florence Taylor
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Industrial Product Design
Agile Ageing
Supervisor- Bahareh Shahri

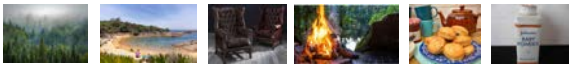
Smell is one of our most important and influential senses. It is one of the most effective ways of connecting individuals to memories through specific odours.

'Odors have an altogether peculiar force, in affecting us through association; a force differing essentially from that of objects addressing the touch, the taste, the sight or the hearing.' - Edgar Allan Poe

The sense of smell is more closely tied to memories and reminiscence than any of the other senses and is processed in the brain differently to the other senses. The sense of smell can deteriorate over time so it has been suggested that exercising this can slow down this process. In an article by Susan Reimer (The Baltimore Sun, February 18, 2013) she suggested that
"We might be able to stem the tide of this particular loss. According to the (report), there are the equivalent of puzzle books for your nose—exercises that sharpen the olfactory function the way crosswords exercise your brain. We are supposed to put aside small jars of spices, pencil shavings and even the leaves of plants and sniff them regularly to kick start the receptors in the brain. Experts recommend 30 minutes a day"

From the research I have found I have discovered that the use of scent as a reminiscent method is becoming more and more popular and there is growing knowledge and science surrounding it. This method of stimulating memories through the use of senses is very effective and can be effective and beneficial a wide range of people. The simple act of using the nose to smell scents has the ability to have a great impact for individuals and is a way of reminiscing that can be done by oneself.

Form and Scent Development



The scent selection was important to get right as these had to have a reminiscent aspect for most uses. After researching different types of sense and popular scents from the era of the individuals, eight different scents were selected. These are vague enough to spark reminiscent memories for all users however specific enough that it was clear on what those scents were. These scents stem from a variety of things such as the outdoors, homelife, family and work, all of which are likely to have been experienced by the user.
These scents all come together to spark memories spent with family and friends or memories they associate with particular people and places.
The physical forms of these were based around these scents in order to enhance the overall experience for the user. This gives the user something physical to hold and interact with, while they experience the scent. These all vary in material, shape, size and weight to give each scent its own individualised experience and encourage the user to interact with each one. The decision to make each form different adds an element of interest to each item and sparks a moment of interest for each scent.

Pine a strong natural aroma which could transport anyone back into a time of outdoor adventures such as hiking and camping. The scent is also strongly associated with Christmas and the memories surrounding that time of year

Rain The smell of fresh rain is a very familiar smell and one most people can recognise. The smell of rain sparks memories of outdoor adventures through its fresh tones, as well as cosy days spent inside sheltering from the rain. The rain scent is reasonably vague, however offers scope for the individual to connect to it with their own stories and associations.

Beach The beach is a big part of any New Zealander life and summer memories are often associated with the beach. This scent offers a light and fresh feeling and associate with summer days and holidays spent with family and friends at the beach.

Perfume Perfume is also a strong way of connecting directly to a significant other, mother or grandmother. Many individuals have a specific perfume scent that they would wear and therefore always smell of. Mother and grandmothers scents often offer a sense of comfort to an individual and spark kind memories shared with these special people.

Baby Powder Baby powder is one of those smells that people can instantly recognise. It is a familiar, clean and fresh scent that most people have warm feelings about. This scent could be associated with the individuals children and caring for their young family.

Campfire
The campfire scent is associated with outdoor activities such as camping or tramping, as well as outdoor social events like barbeques. The scent offers a sense of comfort and warmth.

Leather leather was a commonly used material during the eras of the target market, with things such as clothing, furniture and products being made from it. It was a materials that was unsexed and therefore will offer a wide range of individuals a connection to it.

Baking The sweet and vanilla undertones of the baking smell offer a familiar smell which are often associated with family baking with children and grandchildren. Baking is a very traditional activity which most individuals have done at some point in their life, or been around.

Tactile Development

To enhance the overall experience for the user it was important to target not the one smell sense but to try to cater to that of touch, sight and noise as well. The physical forms and the material choices surround these were all carefully designed and selected in order to achieve this. The material choices played major part in the end result as each material selected is able to offer the user a different tactile experience with varying textures, weights, plasticity, temperature and sound.

1. Leather The leather form is made directly of leather material, therefore is fully reflective of the texture and feel of true leather forms. The softness of the leather is reflective of many leather forms such as bags, shoes and furniture. This material was a commonly used material from the era of the target market, therefore it is a familiar texture.
2. Perfume The perfume form is made of glass. The glass offers a luxury feel that is an important trait of perfume. Perfume is seen as a luxurious product which holds special memories, therefore, creating a form to follow this was important. The addition of the crystal like knob at the top, offers the individual another tactile point to contrast the smoothness of the bottle but still follow the luxury form.
3. Campfire The campfire form is made of a rough piece of wood. This form offers a rustic form which is solid to touch. These aspects are reflective of that of real wood. The rustic texture has been smoothed to make it safe for the user. Using actual wood was important as it directly linked back to the scent and offered a strong tactile element.
4. Rain The rain form was based around rain clouds by using a soft Dacron to reflect the fluffy soft clouds. The softness of the form reflects the softness of the scent and the rain itself. It offers a good contrast to the harder elements in the kit and is more freeform than the other elements
5. Pine The pine form is made from a wooden base form however has an additional strip of a grass like texture to draw on the feel of pine needles. The two materials together have a natural look and the combination of the smoothed and rough textures add contrasting elements which are reflective of nature itself.
6. Beach The beach form follows the free form of the beach and waves. The three different fabric materials offer three different material textures, each with different tactile elements and varying stiffness, softness and sound elements involved. These are held together with a solid wood base which grounds these together and mimics that of the harder aspects of the beach elements such as driftwood
7. Baby Powder The Baby powder form reflects directly back to the tin container that baby powder traditionally was sold in. The tin is cold to touch which offers a great contrast to that of the other components. The tin is lightweight but sturdy to touch and has a great sound effect when tapped with something hard. This offers a well-rounded sensory effect for the individual, playing with sight, smell, touch and noise.
8. Baking The baking form was designed to be reflective of that of a soft cake. The spongy form adds a new texture to the range of forms and the softness contrast the hardness of the other forms nicely and is very fitting to the softness the scent offers.

Scent Application

The scent is applied directly to each form though a spray bottle design. This allows for the carer to apply it to each design with ease. The spray bottle is precise and disperses the scent across a large area of the design. The spray allows for the scent to dry quickly as it is applied in such a fine mist. This also means that it does not cause any damage to the form itself.

Each bottle contains a different scent which is associated with a particular form. The name of each scent is on the bottom of the bottle to ensure that the carer can apply these to the correct form every time.

The scent is created from an essential oil mixture. The essential oils have a strong scent, therefore they have been diluted to ensure that the scent is not overpowering for the user. The essential oil smell lasts strongly on the designs for 1 to 2 weeks and then begins to fade, therefore this scent will have to be reapplied every use or every couple of uses, depending on how often it is used.

Student projects: Product Design - Industrial Product Design

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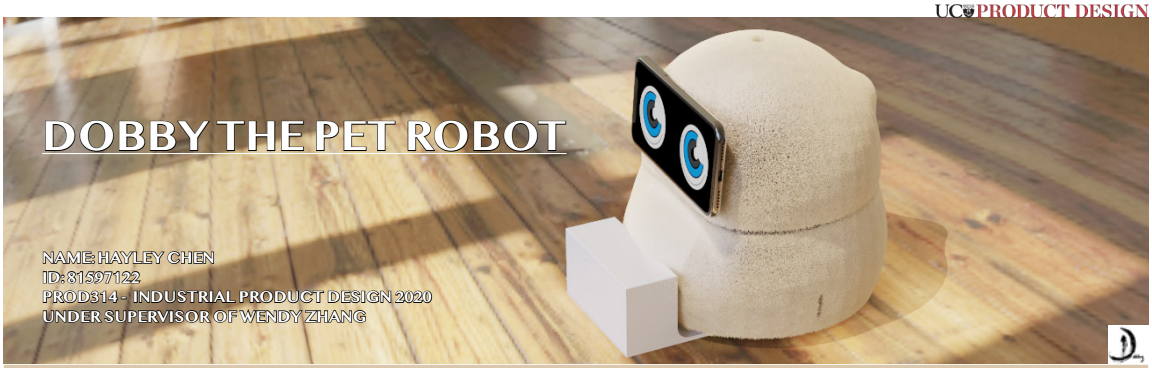
UC PRODUCT DESIGN

DOBBY THE PET ROBOT

NAME: HAYLEY CHEN
ID: 81597122
PROD314 - INDUSTRIAL PRODUCT DESIGN 2020
UNDER SUPERVISOR OF WENDY ZHANG



ABSTRACT

Loneliness created issues in physical health and mental health which affects people of all ages and backgrounds. Therefore, to determine the solution using the design process, the steps are followed, research, ideation, concept generation, development, prototypes, story board, final design, renders.

BRIEF

Design a product that can reduce the feeling of loneliness within a short period in the day and for user aged 18 - 25 years old.

RESEARCH

User psychology

Shape - circle:
- Unity, wholeness, friendly, intimacy & harmony.
- The circle has represents the concept of wholeness and harmony.
- Produce the feeling, such as gentle, friendly and kind help to cast positive emotional energy.

Caption 1: Different information of the circle format.

Warm colour:
- Feeling of warmth.
- Reflect the intimate and friendly content.
- Remind people of warm sunshine and have a certain psychological effect of heat.
- Characteristic such as excitement, enthusiasm and expansion.

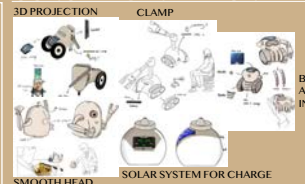
Caption 2: Sample of warm colors.

IDEATION

Caption 3: Ideation generation of different shapes.

SHAPE - Identify the body shape of an object, the part of the main body which all in one part or can have different part joint together. The screen of the that shows the emotion of the robot.

CONCEPT GENERATION



Caption 4: Concepts generated with different ideas and ways of usages.

Concepts have generated using the product design specification and lead to 5 concept ideas, which is the 3D projection, clamp, battery and intimacy, smooth head and the solar system for the charge.

APP INTERFACE

Welcome to the APP

Remainder page
- Plan the day
- Setup the time
- Remaining later

Messages page
- Voice typing
- Dobby read out the message for the user

Robot set up

ON/OFF switch for robot

Home page

Show the main activities and the quick access tools for the alarm, ball game. This page can be customizing the layout and add more tools by clicking the research bar.

Battery percentge of the robot.

Personal information page

Setting page for the personal information:
- Face ID
- Voice recognition (control the robot).
- Design system for the robot eyes.

Caption 6: The app interface for the setup and control the robot.

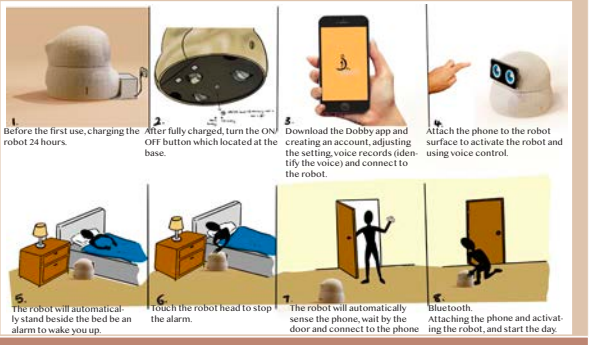
DEVELOPMENT

The shape of the robot has redefined into a smoother shape and different curves. The magnetic phone holder with wireless charging function has added to the design as useful for using the phone as the screen, the outer covering has been considering to use fur fabric or sequin to provide softness and creativity.

SHAPE IMPROVEMENT — FUNCTION — OUTER COVERING

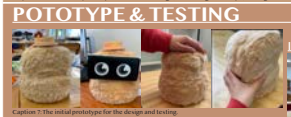
Caption 5: The development process of the design, and change on shape, adding function and the outer covering

STORY BOARD - USAGE



1. Before the first use, charging the robot 24 hours.
2. After fully charged, turn the ON/OFF button which located at the base.
3. Download the Dobby app and creating an account, adjusting the setting, voice records (identify the voice) and connect to the robot.
4. Attach the phone to the robot surface to activate the robot and using voice control.
5. The robot will automatically stand beside the bed be an alarm to wake you up.
6. Touch the robot head to stop the alarm.
7. The robot will automatically sense the phone, wait by the door and connect to the phone
8. Bluetooth. Attaching the phone and activating the robot, and start the day.

POTOTYPE & TESTING



Caption 7: The initial prototype for the design and testing

An initial prototype has made to testing the touch sense of softness and the size robot. As the following testing outcome can be improving to reach the final prototype, the size of the robot can scale down about 10-15mm, the touch sense in good condition. To improve the softness by adding a layer of soft foam under.

IMPROVED FINAL PROTOTYPE

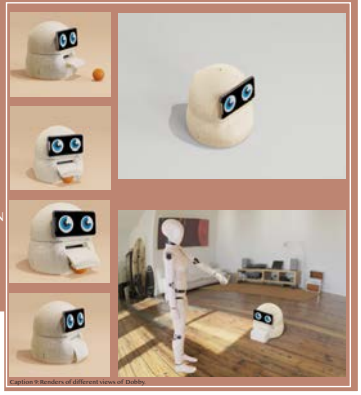
Caption 8: The improved final prototype.

The final prototype has improved on the softness touch sense with fur covering and a layer of 3mm thickness foam between the fur and the ABS plastic shape body.

FINAL DESIGN

ALL MEASUREMENT ARE IN mm

RENDERS



Caption 9: Renders of different views of Dobby.

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UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

QUICK-STANCE
SNOWBOARD BINDINGS

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Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

UC PRODUCT DESIGN

Discover

Brief
This project will is centred around creating a snowboard binding that will allow the user to customise their stance position quick and easily, it will give the rider the ability to discover what style of riding is best suited for them and for their riding conditions. This will be an inclusive design allowing anyone the ability to jump on this snowboard and start riding straight away.

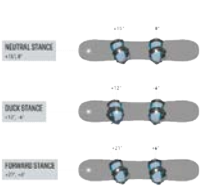
Discover
The discover stage in the design process is about realising the need or want for a change in a particular area or in a product. This project started as I found there is a desire in the snowboarding community for innovation in snowboard bindings. Looking into particular people in the community, I realised that certain people would benefit from a better type of binding, Snowboarding Instructors and Snowboard rental Shops.

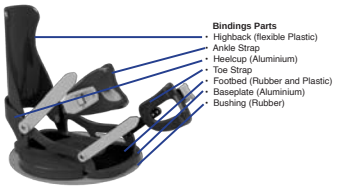


Define

Define is the second step in the design Process. This step was centred on defining the problem and defining a way of creating a solution. It included research into the problem and existing solutions, defining parts and characteristics such as the different angles of the bindings and the different components of snowboard bindings. Defining the Environment was also an important part as snow can cause corrosion for many materials.

Define





Bindings Parts
- Highback (flexible Plastic)
- Ankle Strap
- Heelcup (Aluminium)
- Toe Strap
- Footbed (Rubber and Plastic)
- Baseplate (Aluminium)
- Bushing (Rubber)

Discover
Define
Develop
Devilvery

Devilvery

Delivery
The Delivery stage is the last step in the design process. This step is about presenting the Design that has been created from the previous processes. Creating a Prototype which is scale 1:1 is a way to communicate design decisions and functions of the product fluently as the product and be held and seen as it would effectively be like. I used Fused Deposition Modelling (FDM) 3D printing to create a model, this Model has all of the components that the Final Design has.

Develop
The third stage in the design process is the Development stage. This stage centres on the development of the products design. Varying from the initial drawings and Ideation to the latest Computer Aided Design (CAD) Developments. Within the Development stage, there was conception of ideas and evaluation of concepts in which lead to creating a final design. This Final design takes inspiration from how a Drum Brake for motorbikes work. This Binding has the Ability to spin +/- 15° Degrees allowing for all Stance positions.

Develop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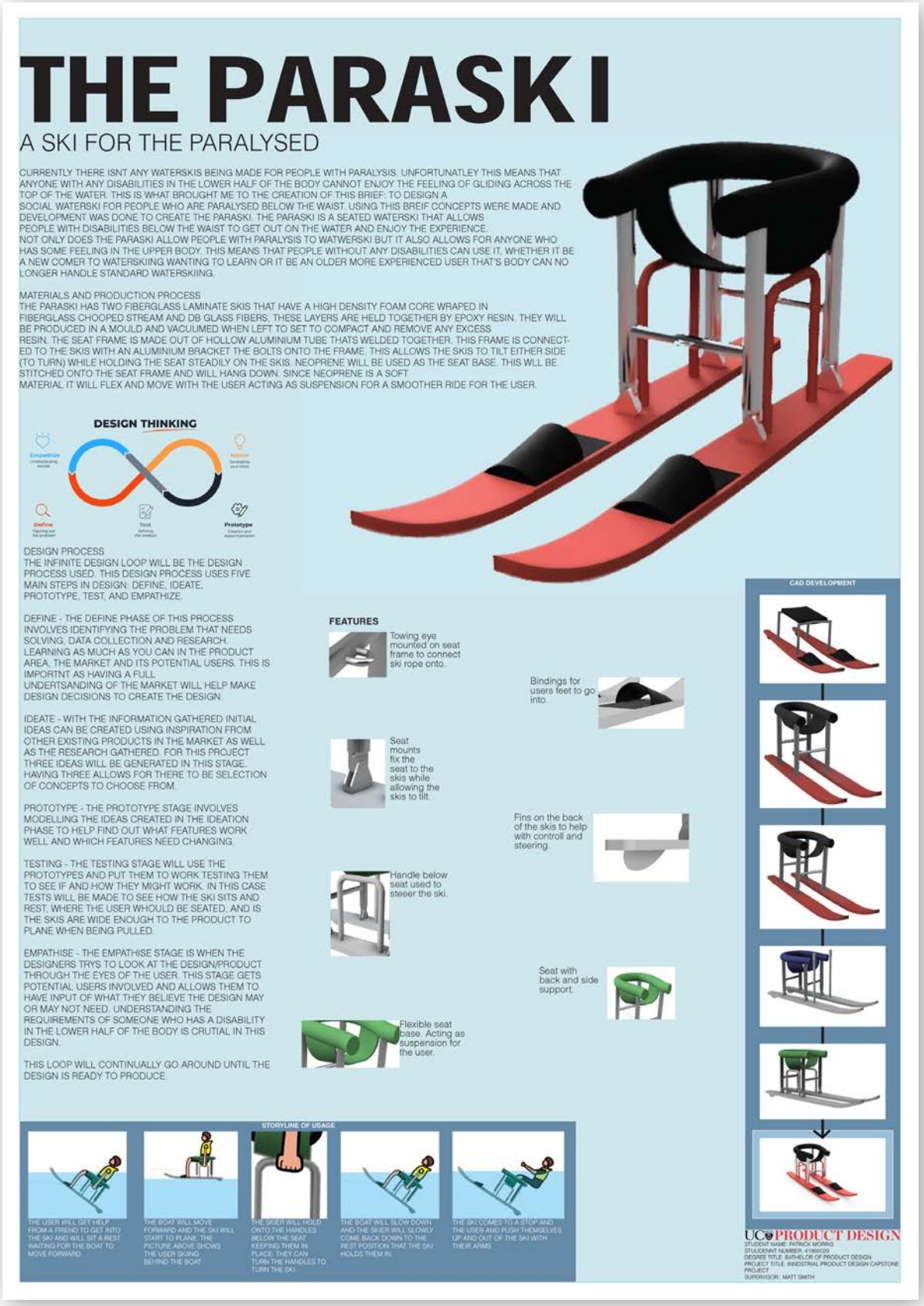


Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design

BIKEBAY

BEN ALLOWAY

CONJOINT BACHELOR OF PRODUCT DESIGN AND COMMERCE

TOM WOODS

UTKU YALCIN

26814255

Abstract

Bike thefts in Canterbury, New Zealand and the world are becoming more and more of a problem with bikes becoming more and more expensive therefore becoming a larger target for thieves. The aim of this project was to reduce the amount of bike thefts in Canterbury through design. I started the project researching into how many bikes are stolen, where the most are stolen among other things. I spoke to the Police and to bike lock Entrepreneurs about the problem to gain an insight around how I could achieve a solution. I was then able to define the problem and come up with a refined brief which guided me throughout the design process. I used the Double Diamond design process as a template for design and altered it depending on the design stage I was in. Completing ideation and evaluation gave my an initial idea to develop, then using CAD and physical prototyping I validated the idea to continue through the project. After extensive CAD development and testing, a full size prototype was built to show off the design and its workings in full scale. After completing this project I was able to reflect on how the final outcome compared to the initial brief of the project. I was happy to have been able to achieve the brief to an extent and have a successfully working product. There were a few things which could have changed however it was challenging because they only came apparent after completing the full scale prototype and testing it for myself. Overall I am happy with the project and where it progressed to over the 15 week semester.

Brief

In NZ around 3000 bicycles are stolen every year. It is a constant threat that cyclists must deal with and can make cycling a less enjoyable experience. It has been shown through an international survey that cyclists are three times more likely to have their bike stolen than car owners' cars or motorcycles.

Cycling is a great way to commute to work and is what more and more people are choosing to do as climate change becomes a bigger and bigger issue. Unfortunately, due to the number of bikes being stolen every year and a lot of people knowing of someone who has had a bike stolen, people are becoming reluctant to cycle to work if they need to park their bike in a public place.

To combat this, the brief of this project is to help reduce the number of bicycles being stolen in Canterbury and NZ through the use of design.

Concepts and Development

After completing the majority of my research, I began to sketch ideas that were popping into my head. This was a good way to just get everything down that I had been thinking about during the research stage and it was fun to do some blue sky sketching with no real boundaries.

I did have some preconceived ideas about what I was thinking for a solution which prevented me from being as creative as I would have liked.

Getting ideas down on paper before progressing to ideation techniques like scamper helped make scamper more effective and made me be more creative because I did not want to sketch things which were first sketched.

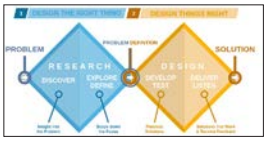
Prototyping

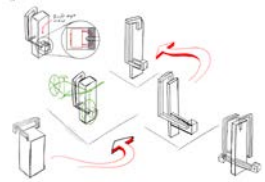
After creating an initial CAD model, I decided to move to some cardboard prototyping to make sure what I had designed would actually work with bikes. For this prototype I was making sure that I could reach the locking point with bikes in the stand. I was also seeing how close I could put two stands while still having adequate room to move the bike in and out of the stand.

CAD Development

After selecting a final concept to move forward with, I began to move the concept into 3D space and continue to develop the concept there. I started by looking at my bike and measuring distances to get ball park figures of dimensions. By doing this I removed the guesswork and could get straight to designing a stand which I could be pretty confident about it fitting most bikes.

After creating an initial prototype, I moved back to CAD and developed the idea further to aid manufacture. In the Development I was able to reduce the amount of parts and reduce some dimensions in the design which will reduce the material cost and the number of welds, decreasing the consumables cost and the manufacture time. The second prototype shown to the right was updated from the first by reducing the size of the vertical upright to save material.



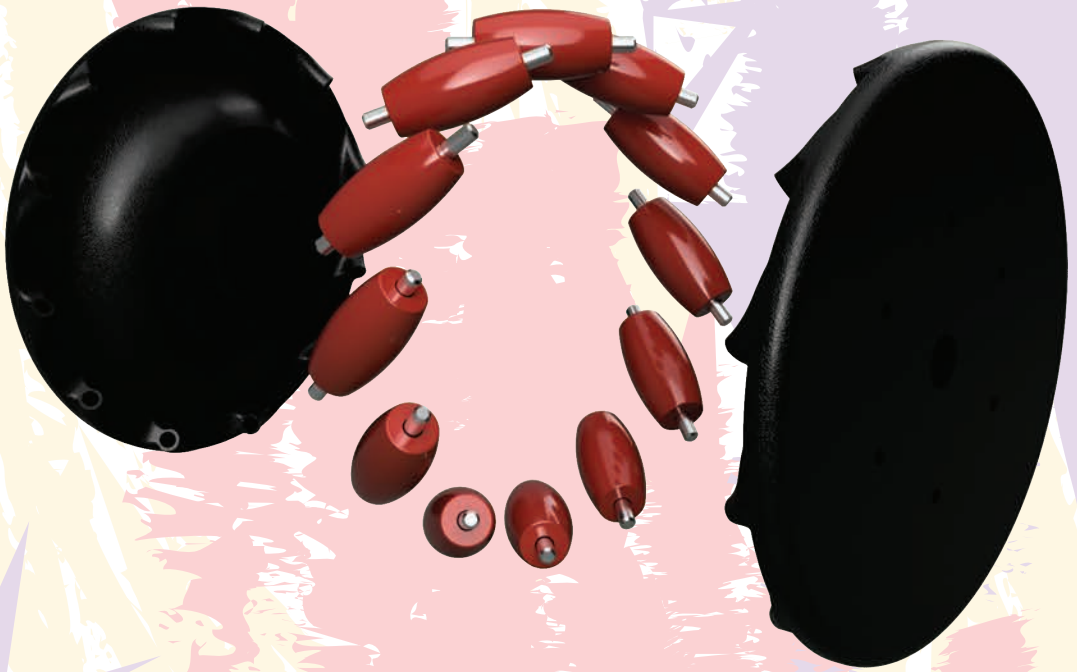


UC PRODUCT DESIGN

Omnidirectional Rugged Robot

South Pacific Sera requires an omnidirectional cart to move cargo around a workshop floor. I have been tasked to design a prototype omnidirectional wheel, capable of moving up to 150kg of cargo in a complex environment. The robot will be required to move in all directions and rotate. Its wheels are to be based on the Mecanum system.

Wheel description: The typical Mecanum design is a four-wheel configuration with 12 rollers attached to the whole circumference of its rim. These rollers typically each have an axis of rotation at 45° to the wheel plane and at 45° to the axle line. The entire wheel is 3D printed out of PLA plastic, with the complex design fitting perfectly with this type of manufacture. Mild steel is then used for the roller axle as this is a point of stress and it is cheaper and stronger to buy steel rods than print rods. Given all these points, the wheel has been optimized for both strength and cost.



Banon Hopman
53272193
PROD314-2052 - Industrial Product Design
bmh77@uclive.ac.nz
Will Duncan
Scott Spooner

Student projects: Product Design - Industrial Product Design

VYNCO

Outdoor EV Charger

PROD214 2020 Capstone Project

UC UNIVERSITY OF CANTERBURY

Introduction

Vynco Industries are a local company who supply a range of products to electrical industry. Their locally based design and development team is tasked with delivering product solutions specifically tailored to the New Zealand market requirements. Vynco Have realised an opportunity and need for an outdoor electric vehicle charging unit, with the ability to retrofit to existing buildings or structures such as exterior walls, garages, or low volume commercial buildings. The proposed charging system utilises existing hardware technology, but requires the design and manufacture of an enclosure to enablesthe charger to be established as their own, representing the company and upholding their reputation as a leader in the field. It also enables the product to be designed in a way to best suit the exact conditions and use case they are looking to serve, and the demands of the local market in key areas such as styling, installation and regulatory conformity, and environmental suitability. This project will investigate the requirements of the many parties involved in bringing the product to end users, including installers, regulators, and manufacturers, as well as the requirements of the consumer themselves to ensure the end result is the development of a solution which is fit for purpose, viable, and meets the needs of the market.

Brief

Vynco Industries are a locally owned electrical supply company, currently expanding their range of electric vehicle chargers with a specific focus on residential and light commercial applications. As part of this expansion an outdoor based electric vehicle charger is to be developed utilising existing technology and components. The development of this product and the subsequent final design must consider challenges of manufacture and installation, regulatory requirements, location, and environmental conditions. The final design must also consider ergonomics, aesthetics, and user features to ensure that it is a

Technical Research

Vynco provided technical documentation for the electrical system including technical manuals, specifications and CAD files for hardware. This provided valuable information for the types of componentry and mounting locations necessary for the enclosure to house.

User Research

A survey was conducted within the EV online community to gather insight on the demographics of users to be designed for. This gave thought provoking results which could be used to assist the drafting of product design specifications with which to design towards. The key points taken from user research were:

-The importance of weather resistance
-Cable hanging/management
-Style, Aesthetics, and the ability to hide or personalise the charger
-Longevity of plastics and construction
-Ease of use
-Minimising disruption of structures and surfaces during installation, while still looking tidy and presentable.

Product Design Specifications

-Target cost $100

-Largely Constructed from Sheet Metal

-Easily fixed to supporting structures with common tools

-Robust in design to withstand the elements

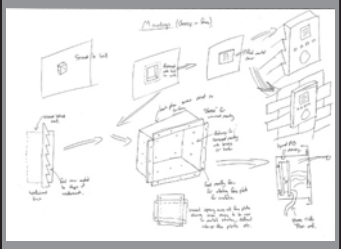
-Cater for bottom feed and rear feed Power entry

-Allow for customization of colour and style

-Designed with intent to comply with electrical regulations

Concept Generation

Concept Generation Was carried out through brainstorm and sketching of design solution alternatives to the key areas of the design. From this, the best ideas were taken forwards to the Development stage, and brought into their final form through CAD development.



Final Development and CAD

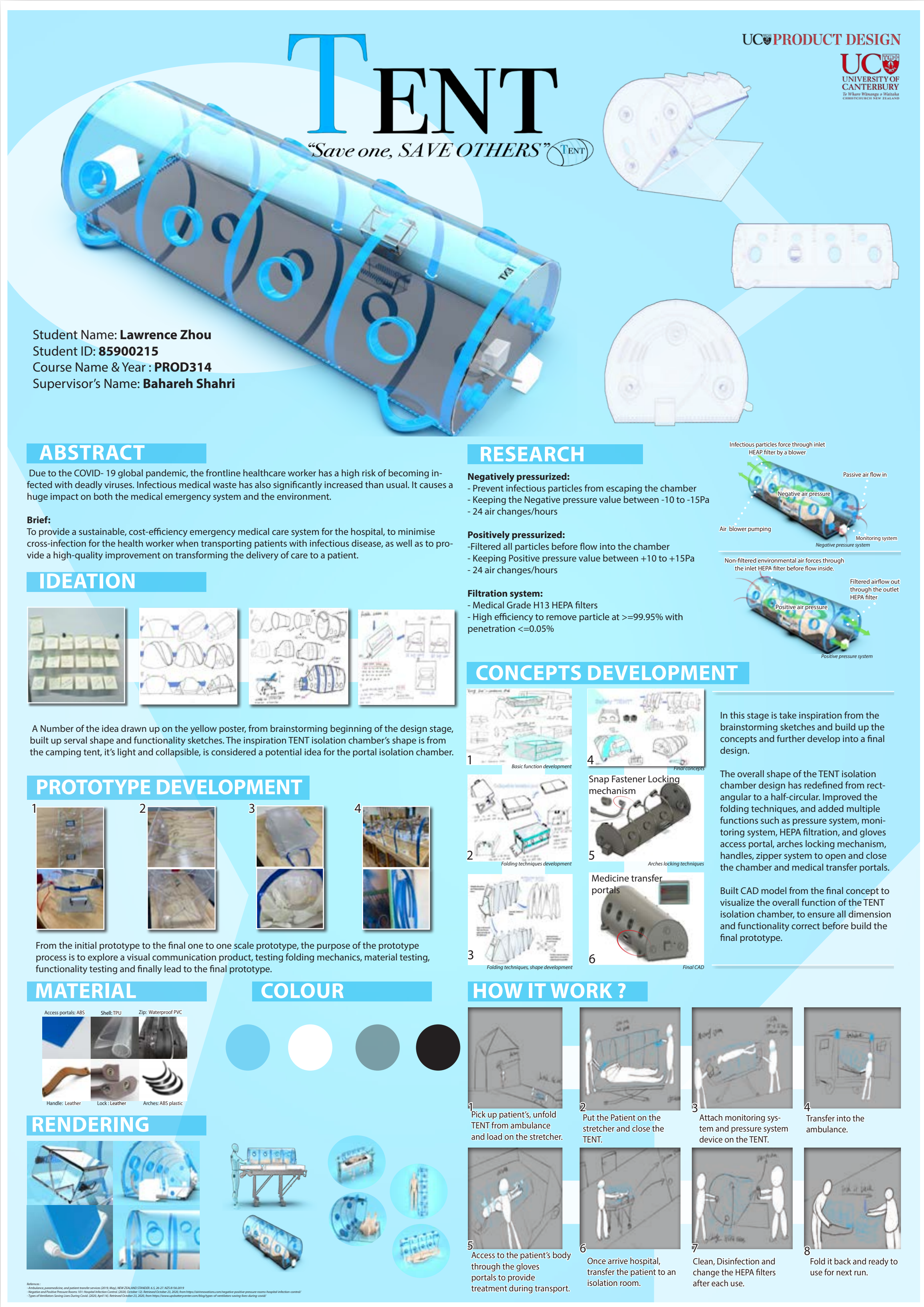
The concept ideas were developed through to the final model utilizing the Fusion360 Software package. This allowed the rapid ideation and creation of a final design, through the ability to quickly and easily test and modify design features. It also provided the ability to visualize and see the product in 3 dimensions as it took shape.

Final Design

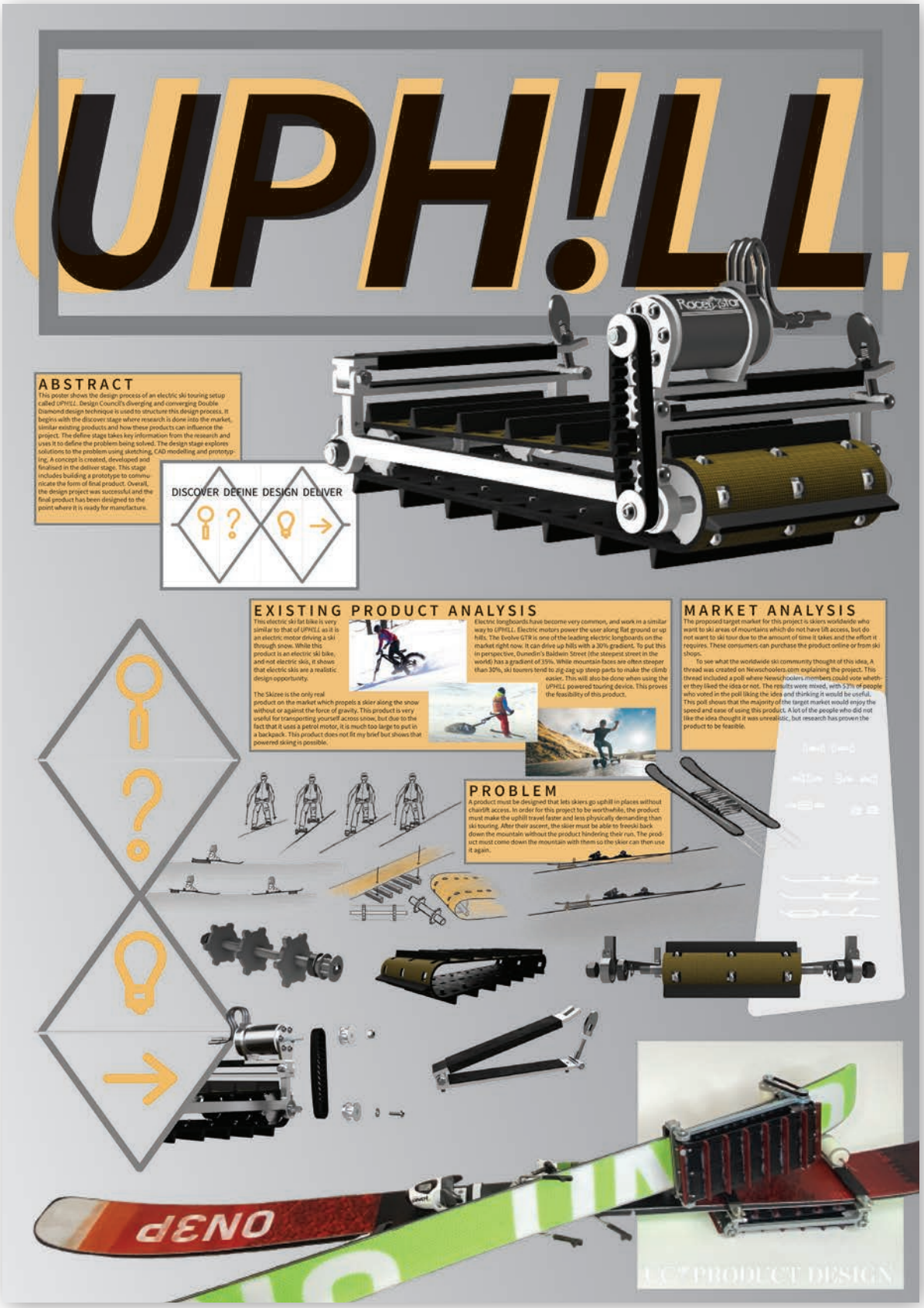
Name: Luke Prattley
Student Number: 84121645
Supervisor: Josh Campbell
Course: PROD314 Bachelor of Industrial Product Design

UC PRODUCT DESIGN

Student projects: Product Design - Industrial Product Design

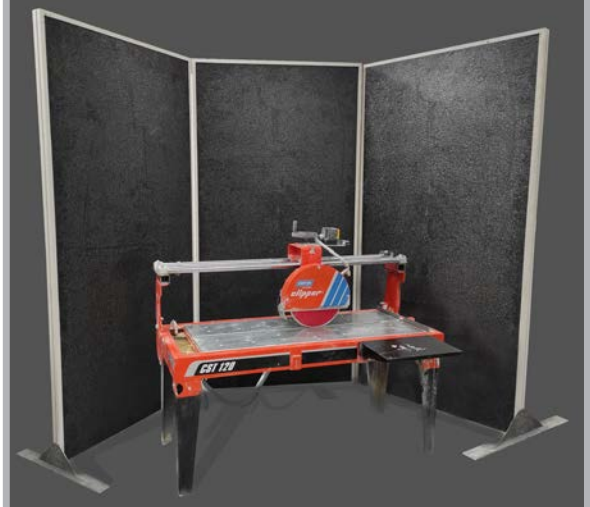


Student projects: Product Design - Industrial Product Design



Student projects: Product Design - Industrial Product Design

Student projects: Product Design - Industrial Product Design



Noise Barrier Wall

Ian Bresler
12451956
PROD314 - Third Year
Euan Coutts
Gracol Composites Limited

UC UNIVERSITY OF CANTERBURY · gracol COMPOSITES · Sealed Air · UC PRODUCT DESIGN

Abstract

This poster displays the creation and development of the Gracol portable noisebarrierwall.Throughkeyaspects of the design process. It outlines the areas of research, ideation, concept development, prototyping, and final design features.

Breif

We want the students to design a noise barrier wall using our composite products ie fibreglass and sound absorbing polyethylene foam for indoor and outdoor applications. These can also be known as acoustic screening.

Research

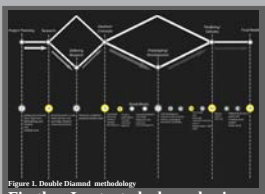


Figure 1. Double Diamond methodology

Figure 2. Competitor Moodboard

Firstly I started by chosing a methodology which was the double diamond and adapted it for my project timeline (As shown in Figure 1).

The main research conducted was to validate the PDS which involved getting inspiration from other noise barrier walls, and comparing competitors products with the PDS for the Noise Barrier Wall, to determine whether or not this wall was a viable product and if the materials pre-selected would do the job of a noise barrier wall. The finding were that the noise barrier wall to be designed for Gracol would be a viable product in its market of indoor and out doors, around loud machinary.

Ideate / Concept Development

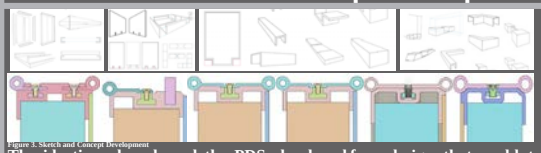


Figure 3. Sketch and Concept Development

The ideation phased used the PDS as a guide to create a rough outline for what the wall would look like. These sketches were quick and not very detailed, as this would be used as initial development.

Later down the line some more detailed concepts were designed and developed, Through multiple itterations. Using the ideas and initial concepts these profile designs were developed from designs that wouldnt work, into a selected concept profile, which was developed further into a profile that could be implimented into CAD for the final CAD design of the Noise Barrier Wall. The final profile for the wall frame was based around the T-Slot which allowed for a non-destructive hinge mount all the way along any of the frames, to attach almost anything that uses a T-Slot nut and bolt.

Prototyping Design

Figure 4. Original Prototype Feet

Figure 5. Prototype wall setup

Figure 6. Prototype hinge and feet

Figure 7. Back of Prototype

The prototype was created and developed using fibreglass pultrude at Gracol, and SealedAir's Whisper foam. The prototype was made by gluing certain profile together to create the T-Slot and then assemblying it exactly how the final product would be assembled. The final prototype wasnt just a scale model but it was a fully functional and useable Noise Barrier Wall. This included the use of the hinge system, sound proofing and T-Slots for both the feet and the hinges. Some basic structural tests were performed on the wall to make sure it was stable when pushed.

Final Design Aspects

Figure 9 Above. The hinge design allows the wall to rotate upto 180 degrees. so that the wall can be placed around any orientation of objected

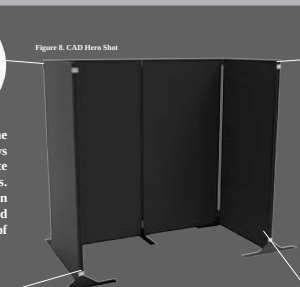


Figure 8. CAD Hero Shot

Figure 12 Above. Internal brackets in each of the front corners used to connect the mida joints securley, while also allowing the wall to be disassembled when required.

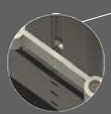


Figure 10 to the left. The T-Slot on the sides are used by both the hinges and the feet. The use of these for the feet gives the wall more tortional strength

Figure 11 to the right. StratoCell Whisper Foam developed by SealedAir, provides the sound absorption and reduction of around 20 - 30 db

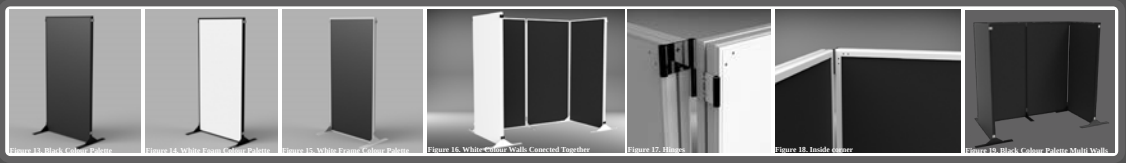


Figure 13. Black Colour Palette

Figure 14. White Foam Colour Palette

Figure 15. White Foam Colour Palette

Figure 16. White Colour Walls Conected Together

Figure 17. Hinges

Figure 18. Inside corner

Figure 19. Black Colour Palette Multi Walls

Student projects: Product Design - Industrial Product Design

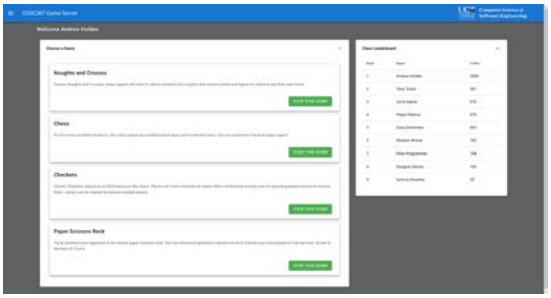
COSC367 Game Server

UC UNIVERSITY OF CANTERBURY Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND
Computer Science & Software Engineering

Andrew Holden
University of Canterbury
Supervised by Dr Kourosh Neshatian

What is it about?

Every year in the COSC367 Artificial Intelligence class at the University of Canterbury students learn how to create game-playing agents. The objective of this project is to create a server which students can use to test their skills against one another. The server is available to students via the internet.



How does it work?

First the course admin will create a game model, which consists of the following Python functions:

- get_initial_state(): str
- is_move_valid(before_state, after_state): bool
- is_game_over(state): str

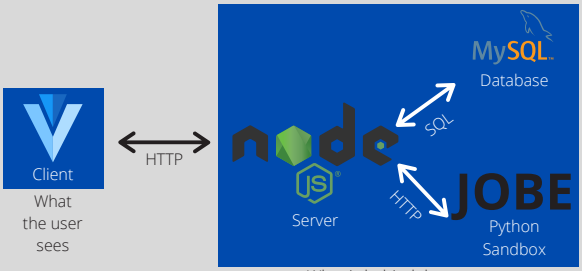
A description and any instructions on how the state works are also provided for the student. The game model is then published on the server for a class. Students belonging to this class can then create an agent for these games, which consists of the Python function:

- provide_move(state): str

These agents are then matched up and run in a sandbox environment to decide the winner. Students are then ranked by their wins on a leader board to encourage competitiveness.

Method

This game server was made using a distributed architecture in the form of a single page application. This consists of a web server buit using Express and NodeJs, a front end client built using VueJs and Vuetify, a MySQL database, and JOBE a sandbox environment to run the python code for the games.



The Architecture

Results

The game server was successfully developed for and deployed on an Ubuntu Linux virtual machine hosted by the university of canterbury. It is designed so that each component can be hosted separately and still communicate. However, due to security restrictions on access within and outside the university network the entire project was hosted on a single virtual machine. This also made the deployment of the project a far more straight forward process.

Scan here to have a look!!!

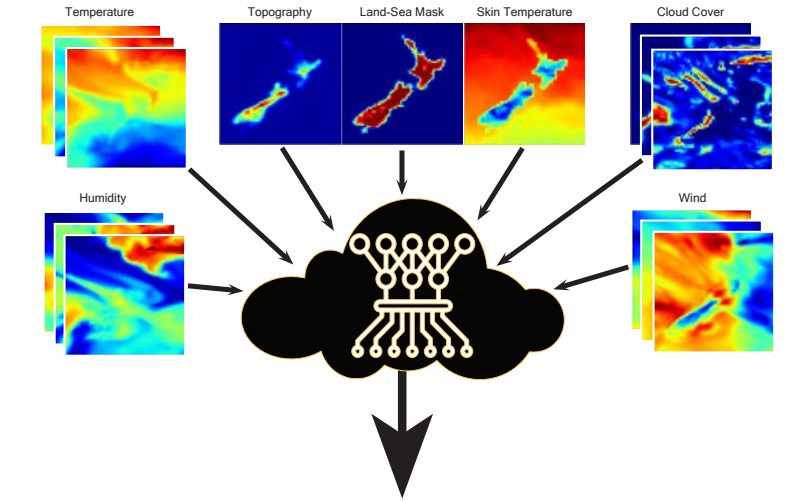
If you wish to contact the author of this project please do so via email at ash102@uclive.ac.nz or andrew.s.holden@gmail.com

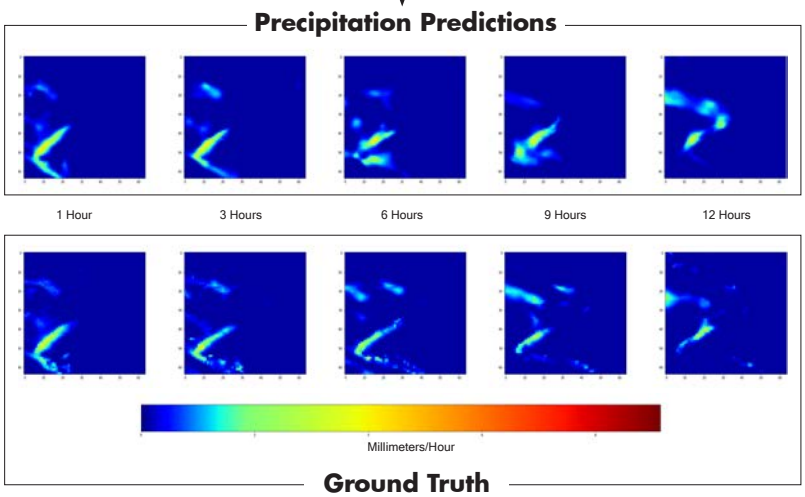
Student projects: Software Engineering

Weather Prediction with Deep Learning

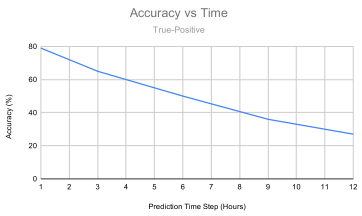
University of Canterbury — Computer Science & Software Engineering

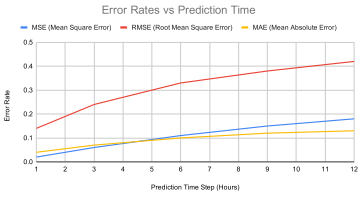
Solution





Evaluation





Context

Traditional methods of weather prediction are both computationally and time-intensive. Short-term weather forecasts are outdated as soon as they are produced due to the time taken to generate them. Research was conducted into using deep learning models to generate short-term accumulated precipitation forecasts in New Zealand. This dramatically decreases the time needed to generate forecasts.

Dataset

ERA5 is a historic weather reanalysis dataset recorded from 1970 to the present day. It contains surface and atmospheric variables over a range of heights and pressure levels. The data used to train the proposed weather model was sampled from 2000 to 2010.

Method

The proposed method leverages convolutional neural network architecture to identify weather patterns in the ERA5 dataset. The model learns to map features from the input dataset to the measured precipitation values. It can then be used to generate accumulated precipitation forecasts up to 12 hours into the future.

PyTorch

Student Adam Conway

Supervisor Kourosh Neshatian

Industry Mentor Leroy Bird

Sponsor Bodeker Scientific

Student projects: Software Engineering

Protecting Our Borders From Biosecurity Threats

Processing Container Scanning Outputs Using Deep-learning Techniques

Aaron Smith

Co-Students: Joel Ridden, Manoj Paladugu, Michael Shannon

UC Supervisors: Richard Green, James Atlas

Industry Advisors

AgResearch - Mark McNeill
Scion - Sam Davidson and Steve Pawson
Port of Tauranga - Mark Whitworth

BACKGROUND

New Zealand imports over 2 million twenty-foot equivalent units of containers per year. In one study almost 10% of containers had some form of external contamination[1].
This contamination can be a threat to New Zealand biosecurity. This could be from the introduction of an invasive species. The Port of Tauranga needs a fast and effective method of scanning incoming containers for these contaminants without interfering with port operations.

OBJECTIVES

- Produce a system capable of scanning containers as they enter the Port of Tauranga without slowing down port operations.
- Notify crane drivers when a container they are carrying contains a contaminant.
- Produce a map of likely contaminated regions on incoming containers to aid in the identification of contaminants.

System Flow Diagram

Figure 1

Figure 2

74% Containimation Confidence

APPROACH

Past research has shown promising results in using a surface anomaly approach to detect flaws on exteriors, such as cracks on motors[2]. For the problem of detecting contaminants, we implemented two networks based off of this approach. A Segmentation Network and a Decision Network.
The Segmentation Network produced outputs highlighting likely contaminants in a supplied region, like the one shown in figure 2. The Decision network processes the output and produces a confidence value that a region is contaminated. This confidence value is passed to the database stored and made available to be displayed to future users.

FUTURE WORK

The system we have developed is a proof of concept to show that the surface defect approach to detect contaminants on the exteriors of shipping containers is a valid and promising method. The next step is to implement this system in the port enviroment to gather real world data from incoming shipping.

PORT OF TAURANGA · agresearch · SCION · B3 Science Solutions for Better Border Biosecurity · UC University of Canterbury · Computer Science & Software Engineering

[1] Eckehard G. Brockerhoff 1, Lindsay S. Bulman 2, Andrew M. Liebhold 3, andJuan J. Monge. 2016. Role of sea containers in unintentional movement of invasivecontaminating pests (so called "hitchhikers"), and opportunities for mitigationmeasures.
[2] L. Xu, S. Lv, Y. Deng, and X. Li. 2020. A Weakly Supervised Surface DefectDetection Based on Convolutional Neural Network.IEEE Access8 (2020), 42285–42296.

Student projects: Software Engineering

ELIMINATING WILDING PINES BY SEMI-AUTOMATED SPRAYING FROM HELICOPTERS

AMBROSE LEDBROOK

Motivation

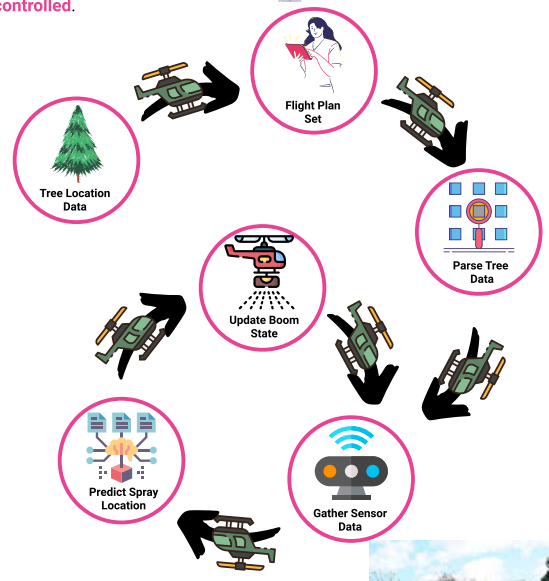
Wilding pines are invasive and aggressive introduced pests that threaten our country's environmental, cultural, and economic values. They thrive in the wild, competing with native species, and lowering soil fertility. The Department of Conservation (DOC) is concerned about further damage to NZ if wilding pines are left uncontrolled.

Objectives

- Determine the optimal way to execute the spray prediction model.
- Package spray prediction model.
- Develop communications with the spray boom and GPS controllers.
- Parse tree location data from raster (.tif) images.

Technology

GDAL
NumSharp
C#
intel NUC

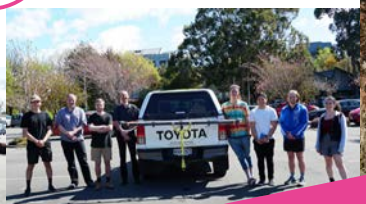


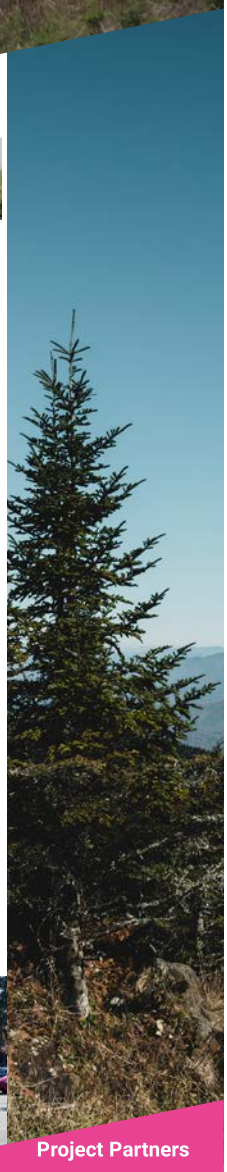
See the system in action!

Results

A fully operational proof of concept spray system running on a ute was developed and tested.

C# was determined to be the optimal execution environment for the spray prediction model.





Project Sponsors

James Griffiths
Brian Richardson

Project Supervisors

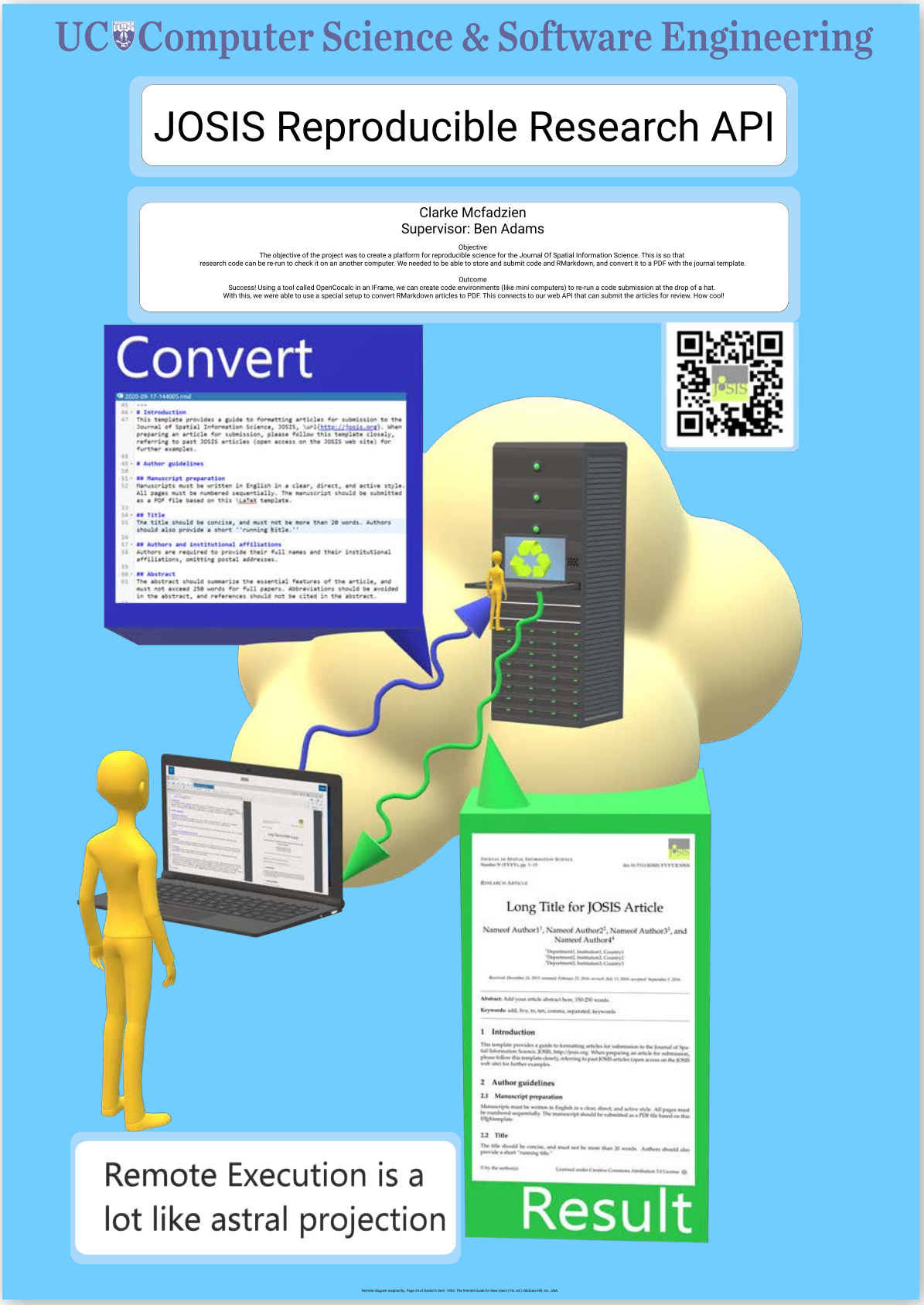
Andreas Willig
Mark Jermy

Project Partners

Exequiel Bahamonde Cárcamo
Rebecca Emanuel
Josh Hudson
Jack Taylor
Liam Hunn

Department of Conservation Te Papa Atawhai
UC University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand
Computer Science & Software Engineering
SCION FORESTS | PRODUCTS | INNOVATION

Student projects: Software Engineering



Student projects: Software Engineering

SQLMiner

A gamified tool for practicing SQL queries

The Problem

Gamification is a topic of inmcreaseing interest within the computer science and software engineering discipline. The incorperation of game elemenets has been shown by countless studies to increase students' engagement motivation and achivement.
However, could a solution benefit students if the game elements involved were designed for competitiveness?
SQLMiner intends to answer this question.

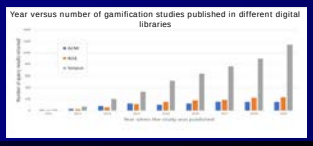
The Objective

Create a learning tool that uses game elements to foster competitiveness in students to increase overall performance in an introductory relational databases course.

Literature Review

We conducted a literature review was on secondary studies exploring gamification in computer science and software engineering education. We aimed to determine which game elements were most suitable for competitiveness.

From the researched studies, the suitable gamification elements leaderboards, points, ranks and timers.



Game Elements

Points

- Commitment towards goal setting
- Provide feedback
- Motivation to work harder

Leaderboard

- Instant feedback on performance
- Self recognition
- Enhance competitiveness against others

Timer

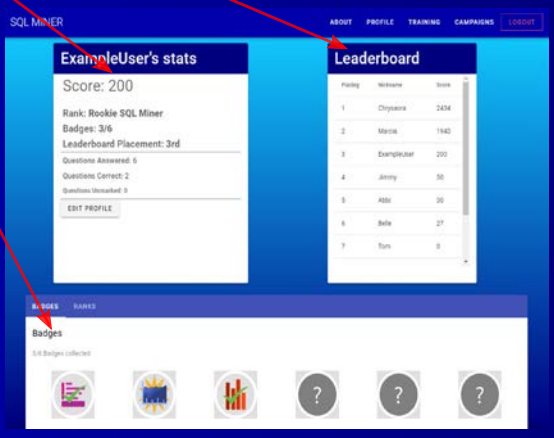
- Underutilized within gamificantion studies
- Increases the task difficulty

Badges

- Instant feedback on performance
- Self recognition
- Commitment towards goal setting

Ranks

- Give users a sense of progression
- Split progress into smaller reachable steps

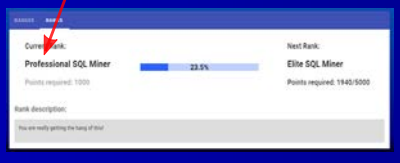


Training questions and campaigns

Students can answer queries within two different modes: training questions and challenge campaigns.

The training questions aim for students to complete a selected amount of queries in the shortest amount of time possible. The time the students have remaining is displayed to the students using a **timer**. Students are rewarded **points** based on the difficultly of queries, the number of queries they get correct and amount of time they give themselves to answer the queries.

Campaign questions are worth substantially more points then training questions. However, the campaign questions are more challenging and can only ever be answered a single time by the students. Campaigns are made available to the students for a limited amount of time and are only marked once the campaign is over.



Technology stack

spring boot · Vue · FastAPI

Empirical Study

An empirical study was completed with nine student volunteers to gain initial feedback on SQLMiner's usability and incorporation of game elements.

During the study, students were given verbal and written instructions to navigate around the interface and perform tasks such as completing a set of training questions or a campaign.

89% of participants said they strongly or somewhat believed that they'd use this system frequently.

78% of participants felt that the leaderboard made them more competitive.

78% of participants felt encouraged to answer queries as fast as they could to earn more points.

67% of students strongly or somwhat thought stress from the timer neagtively affected their ability to answer queries.

Student: Christopher Worrall

Supervisor: Miguel Morales

UC Computer Science & Software Engineering

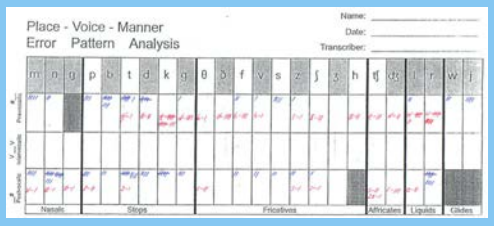
Speech Analysis App

Still processing results by hand?
Technology can help with that!

Have a go!

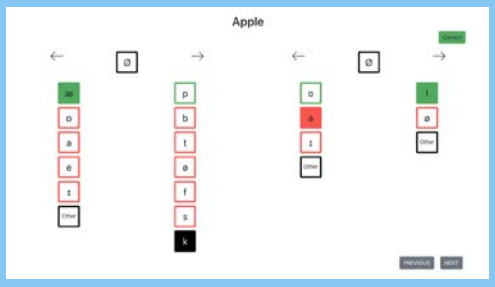
2.5 HOURS

is the time it typically takes a therapist to manually assess a child's speech patterns

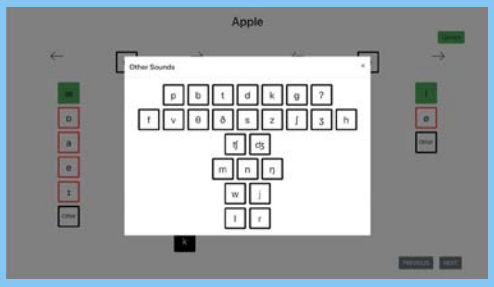


Results are transcribed by hand which takes a long time and can be error-prone

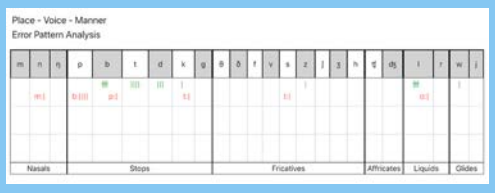
Results can instead be generated instantly by the app, allowing for a more efficient diagnosis



During assessment, the therapist enters the sounds the child makes



If a sound doesn't appear as a common error, all consonant are available under 'other'



The Speech Analysis App produces the results almost instantly using the sounds that were entered during assessment

By having the results available right away, the time taken to perform the assessment is reduced by **upwards of an hour.**
This allows the therapist more time to perform the actual treatment

MySQL python node.js Express

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Computer Science & Software Engineering

Claudia Field
Supervised by
Walter Guttmann
with industry partner
Toby Macrae
UC Speech and Hearing

Student projects: Software Engineering

Development and Analysis of "Braced Touch" Interactions

Objectives

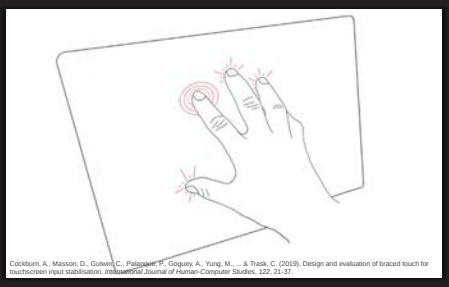
- To develop a more advanced gesture recognition engine that can reliably identify tap, drag, rotate, scroll and pinch gestures.
- Implement a user testing platform that can determine the reliability of the braced detection engine.

The engine was implemented into a **gesture testing platform**, which is aimed to analyse **how efficiently users can perform tasks** while performing a braced posture.

What is a braced posture?

A braced posture helps to enable fast, reliable and accurate target selection and interaction during high levels of vibration, such as what a pilot may experience during turbulence.

What it ends up looking like:



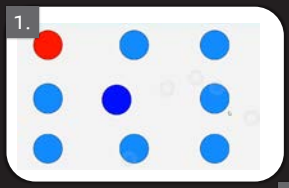
Cockburn, A., Masson, D., Gutwin, C., Palanque, P., Goguey, A., Yung, M., ... & Trask, C. (2019). Design and evaluation of braced touch for touchscreen input stabilisation. *International Journal of Human-Computer Studies, 122*, 21-37.

The Braced Detection Engine

1. Identify **touch points**
2. When **fourth finger** is placed, log location and start a timer
3. If **fifth finger** is placed close to fourth at less than 0.5 seconds, **braced posture recognized**

How the test works:

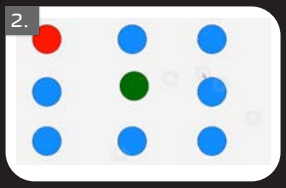
1.



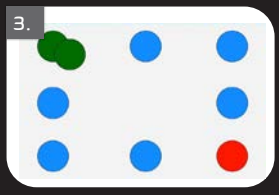
- The objective is to move the dark blue icon over the red target
- The target is randomized to help make the test unpredictable

- If a braced posture has been recognized, the dark blue icon turns green

2.



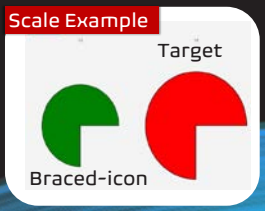
3.



- If the user successfully drags the green icon over the target using the braced position, that target will now turn green
- A new target will then show up and the test repeats itself until all targets are green

Rotation Example

Scale Example



Conclusion

- **Three testing platforms for drag, rotate and scale were created** with the braced detection engine being able to identify the three states individually
- **Future work** may evaluate the overall effectiveness and reliability of braced touch gestures in comparison to similar projects.

Acknowledgments

- Special thanks to Andrew Cockburn for helping me out throughout the project
- Many thanks to the University of Canterbury for providing a multitouch display for the project

Scan the QR code to read this poster online!

SCAN ME

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Computer Science & Software Engineering

Technologies

Java JavaFx

Dylan Carlyle – Student
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Andrew Cockburn - Supervisor
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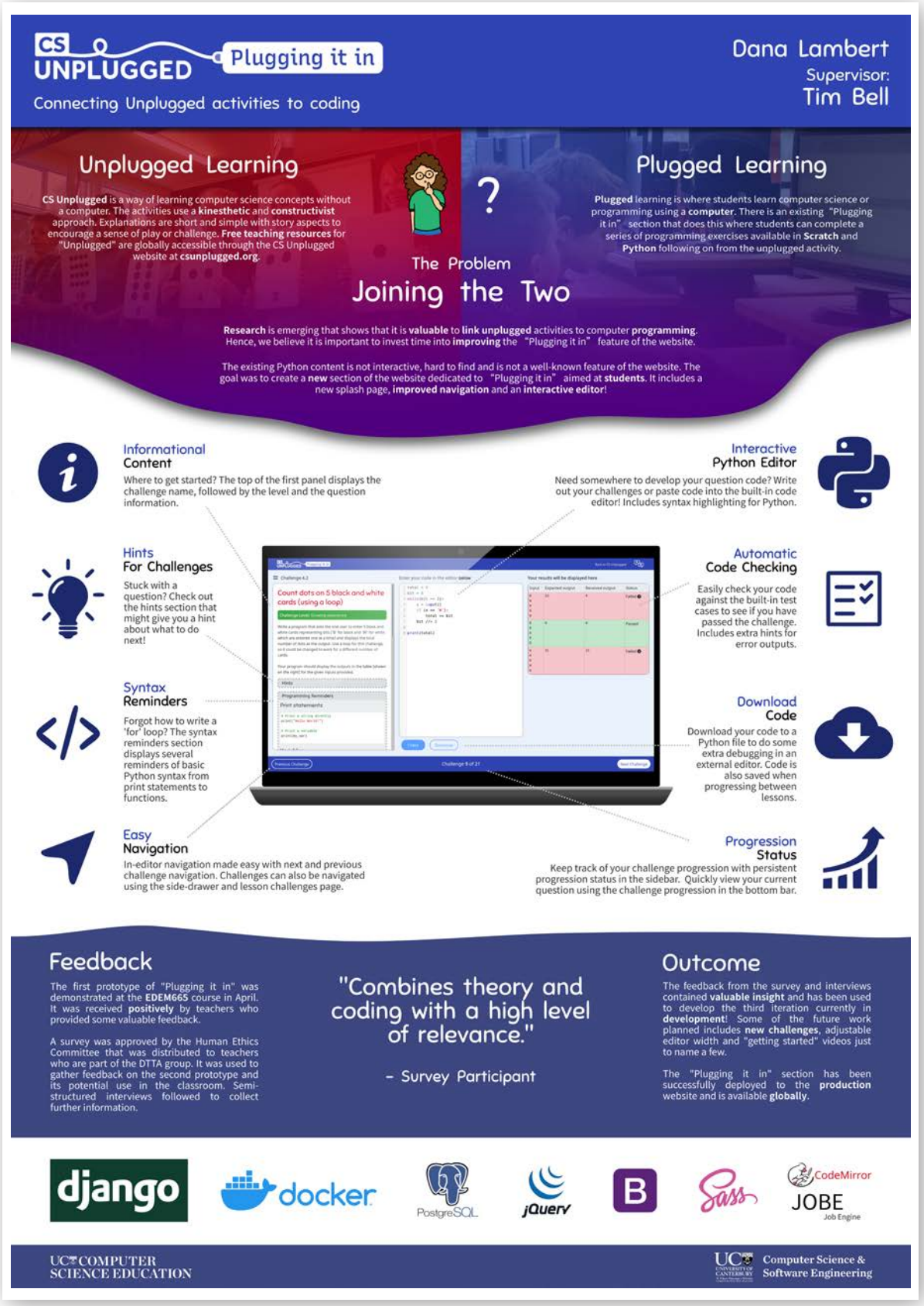
Student projects: Software Engineering



Student projects: Software Engineering

Eliminating wilding pines by automated spraying from helicopters

Exequiel Bahamonde Cárcamo

Why kill pine trees?

Wilding pines are invasive and aggressive **introduced** pests that threaten our country's environmental, cultural, and economic values. They **compete with native species**, lowering soil fertility, and **fueling bush fires**.

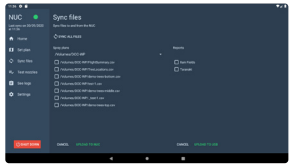
Objectives

Develop a **user interface** for the system to be used **before and after flying.**

Define and implement an API for the app to:

- **Sync** spray plans
- **Set spray plans**
- **Start and stop** automated spraying
- **Test the nozzles**
- **Show connectivity** to the NUC
- **Shut down** the system

Results



Sync spray plans from a USB

Set the spraying plan

Test the nozzles wirelessly

A spray **boom** with 5 nozzles was mounted to a vehicle, **coordinates** around a carpark were **entered** in a file to spray, and the system **successfully sprayed** in the **right locations**.

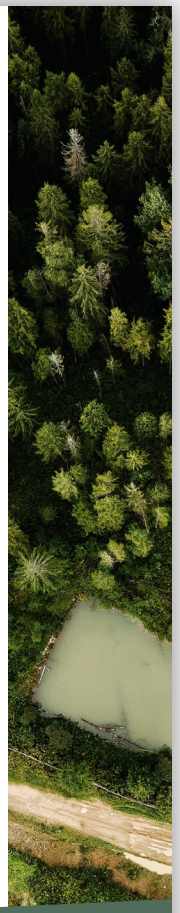
See the system in action!

Technologies

Android app written in Kotlin

App API server and command dispatcher to spray controller module w/ IPC via sockets

Most onboard processing is done on an Intel NUC computer



Supervisors

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Computer Science & Software Engineering

SCION Forests | Products | Innovation

Brian Richardson

Project Partners

Ambrose Ledbrook

Rebecca Emanuel

Josh Hudson

Jack Taylor

Liam Hunn

The Problem

Poor feedback practises occurring in the software industry.

Motivation

Poor practices can stall, and even reverse, the professional growth of employees.

Our Goals

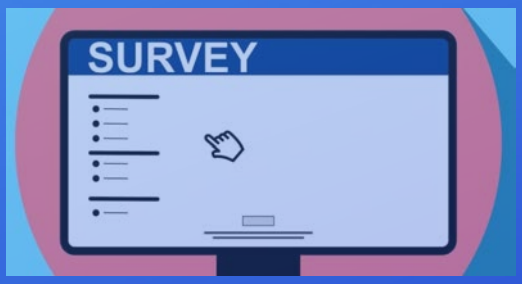
- Understand what effective feedback practise is in the software industry.
- Give recommendations for effective feedback practices.

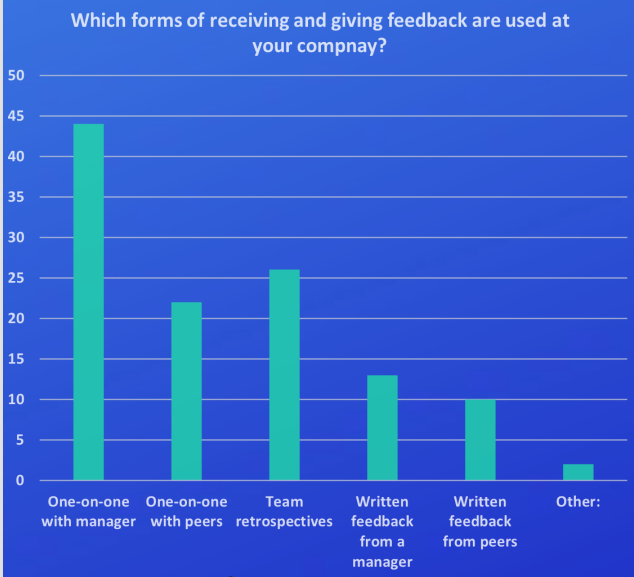
Effective Feedback Practise in Software Engineering

Fergus Meldrum

What we did

- Questionnaire-based online **survey**
- Open and closed questions.
- **Target audience**: Software Engineering professionals in New Zealand and overseas.
- So far **over 80 responses**.





Results so far

- Main feedback method: One-on-One with manager.
- 66% of respondents would like to choose who they receive feedback from.
- 70% would like to choose who they give feedback to.
- **Most common characteristics of effective feedback**: motivate the recipient to improve, help the recipient to achieve their own development goals.
- Most common characteristic of non-useful feedback: it felt like the feedback giver did not really care.
- Most common characteristic of detrimental feedback: it was too vague.

Supervisor:
Matthias Galster

UC University of Canterbury
Computer Science & Software Engineering

Student projects: Software Engineering

ADVANCED VISUALISATION OF THE ELECTRON LAUNCH VEHICLE

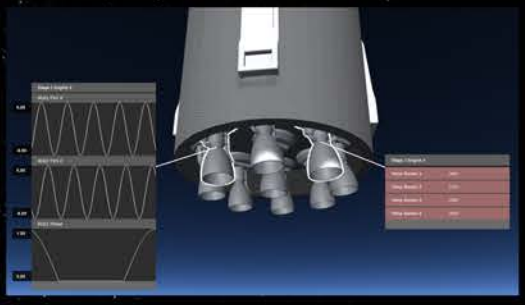
ROCKET LAB

MOTIVATION

Rocket Lab is an aerospace manufacturer and satellite launch company whose mission is to make tangible improvements to life on Earth by going to space. Every mission, billions of data points are generated by the Electron rocket and sent to operators and engineers on the ground. This amount of data is difficult to visualise in a way that is easily digestible and interactive using traditional data visualisation techniques. Rocket Lab required a visualisation solution that would intuitively communicate the state of the vehicle at any point during a mission.

IN-SITU DATA VISUALISATION

Every 3D object has the ability to be linked to its real-world counterpart's position, rotation and state. This information can be viewed intuitively by selecting components of interest and zooming in. Key flight events such as staging and payload deployment are also represented virtually when triggered.

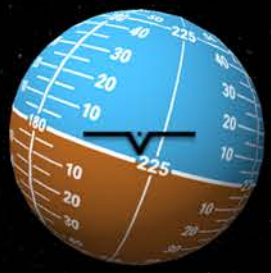


HIGHLY CONFIGURABLE

In order to remain flexible to mission-specific modifications of the vehicle's physical structure and sensor arrangement, the visualiser needed to be easily configurable. This was achieved through the use of hierarchical configuration files which allowed both new 3D models and telemetry streams to be added, manipulated and positioned relative to parent structures inside the visualiser.

FULL SCALE EARTH

To provide positional context for the vehicle during flight, the visualiser leverages geospatial streaming technology and satellite imagery to construct a 3D representation of the Earth. This was done so that there was a clear reference frame for the vehicle's movement. Additionally, an artificial horizon similar to those found in aircraft was implemented to provide context regarding the vehicle's attitude.



REAL-TIME DATA LATENCY RESULTS

During flight operations, the visualiser subscribes to hundreds of real-time telemetry data streams. Consequently, networking performance and scalability were important considerations for the project. The data point delivery latencies for various networking technologies such as gRPC, NATS and pure UDP were experimentally calculated for a number of data rates. It was found that while UDP had the best point-to-point data delivery latency, its reduced deployment flexibility resulted gRPC being selected for use in the visualiser.

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STUDENT
FLYNN DOHERTY

INDUSTRY MENTOR
CHRIS CHING

ACADEMIC SUPERVISOR
ANDREAS WILLIG

TECHNOLOGIES USED

C unity GO gRPC NATS

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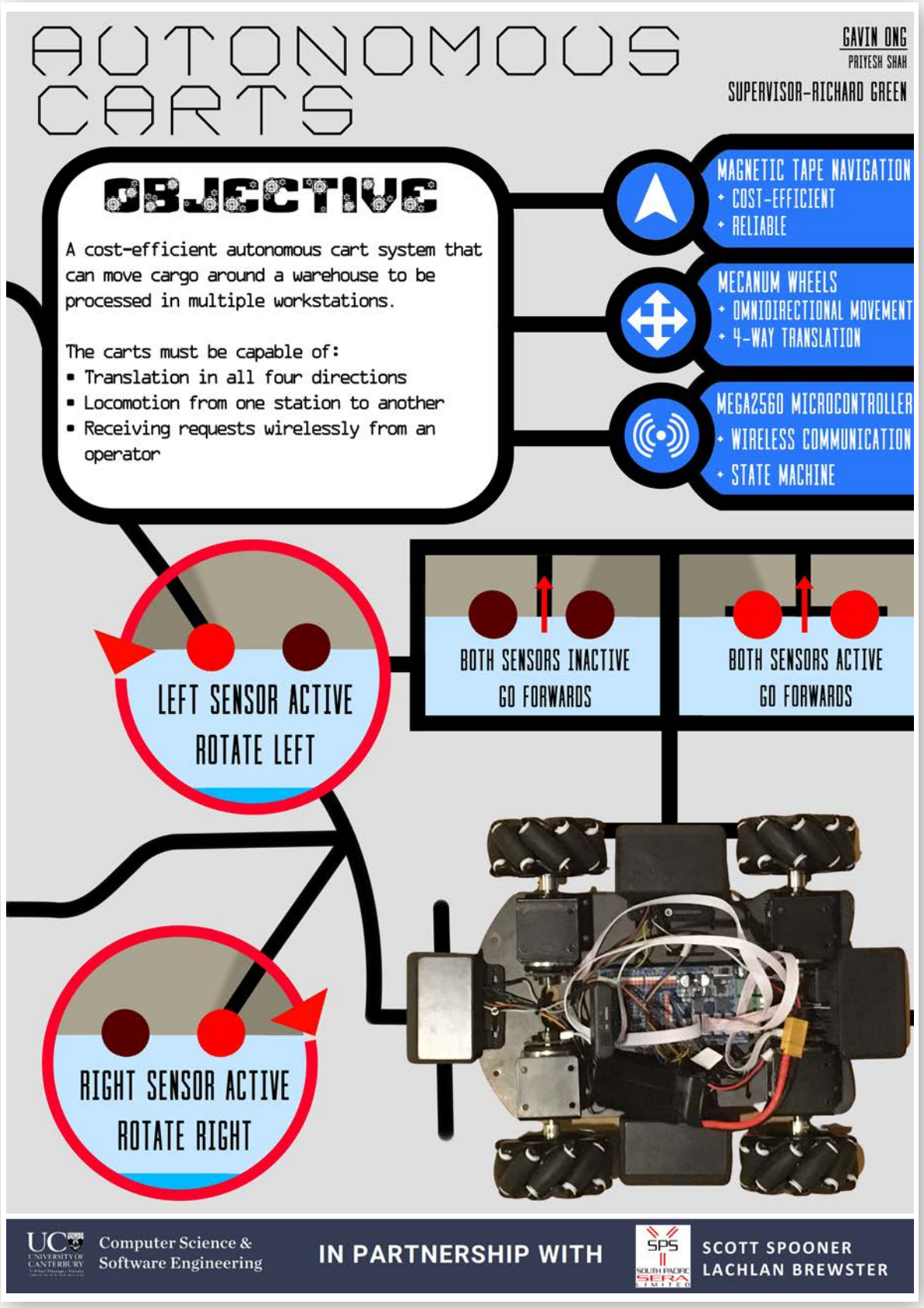
Student projects: Software Engineering



AUTOMATED SCREENING OF RETINAL IMAGES

HARRY FEASEY | SUPERVISOR: DR. ANDREW BAINBRIDGE-SMITH

Why Screen Retinal Images?

To detect diabetic retinopathy (DR), a common complication of type 1 and 2 diabetes. Because DR is initially asymptomatic, with no vision impairment until it progresses, screening is crucial to prevent severe vision loss.

ARE AFFECTED BY DIABETIC RETINOPATHY, OF THOSE WHO HAVE HAD DIABETES FOR 20 YEARS OR MORE [1].

REDUCTION IN RISK OF BLINDNESS AND SEVERE VISION LOSS

for Diabetic Retinopathy patients through early detection and treatment [2].

Stage 1 - Auto-Grade Images

To screen for diabetic retinopathy, images must be of sufficient quality. Currently, graders from across the country have to manually determine image quality as well as screening for DR.

Quality was tested using traditional computer vision techniques, such as open & close morphology and Hough circle detection.

This process was then automated according to Ministry of Health guidelines, and the script put through sensitivity analysis to determine robustness.

Optic disc detection used to grade quality of retinal image.

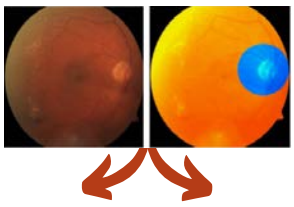


Image failed: insufficient FOV

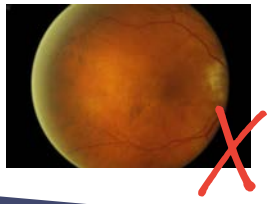
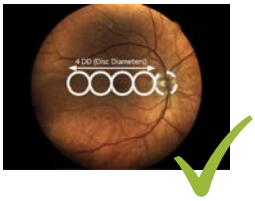


Image passed: sufficient FOV



What's Next?

Saving graders time is one thing, but what if we could automatically do the screening also?
The next step is to implement a robust neural network for detecting diabetic retinopathy. Other projects in this area have reached some success, but have been limited by the size of their dataset.

273,000

PATIENT IMAGES IN THE ANONYMOUS DATASET kindly provided by the CDHB.

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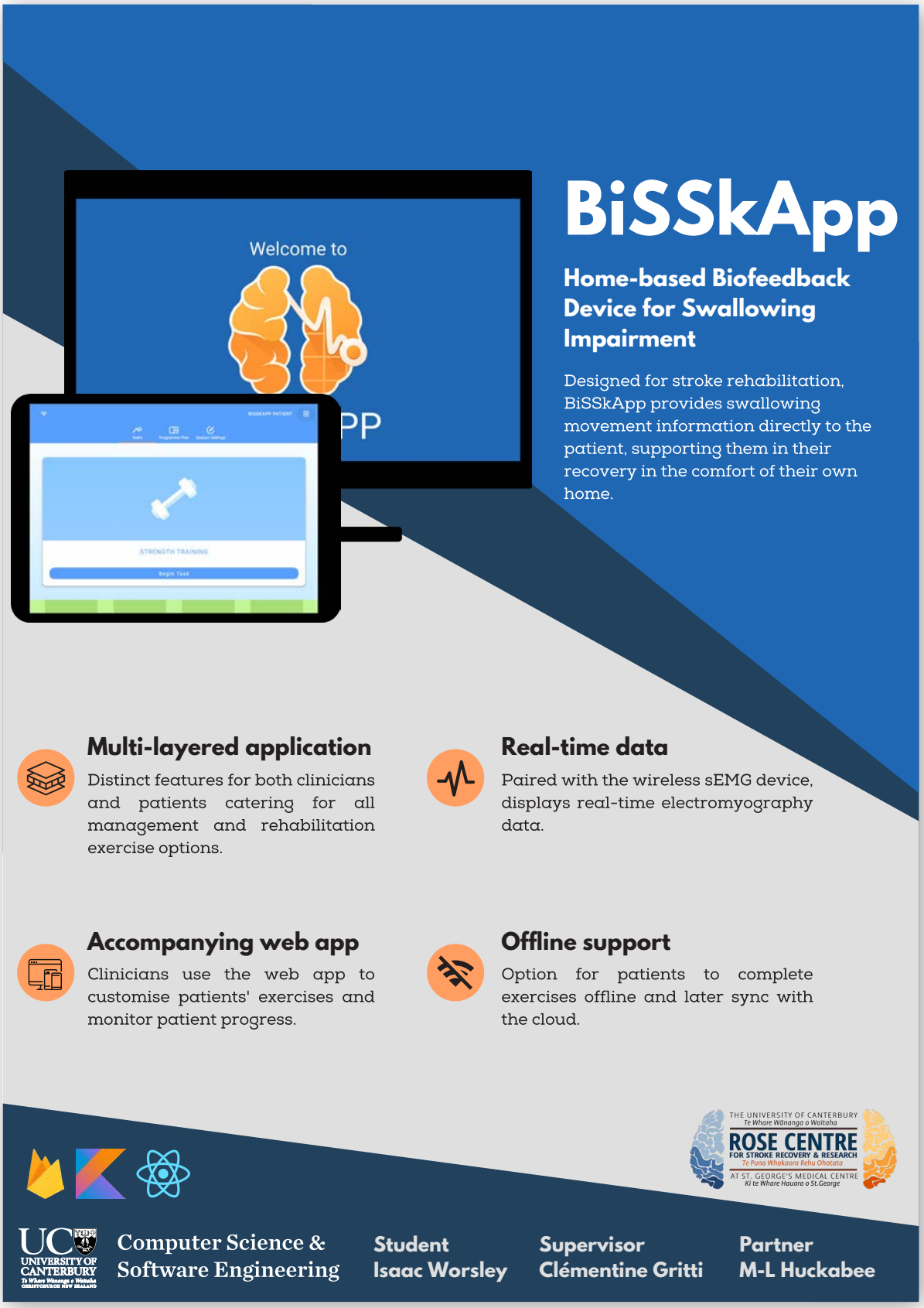
Computer Science & Software Engineering

1.S. Roychowdhury, D. D. Koozekanani, and K. K. Parhi. 2014. DREAM: DiabeticRetinopathy Analysis Using Machine Learning.IEEE Journal of Biomedical andHealth Informatics18, 5 (2014),
2.Kertes PJ, Johnson TM, eds. (2007). Evidence Based Eye Care. Philadelphia, PA: Lippincott Williams & Wilkins.

Student projects: Software Engineering

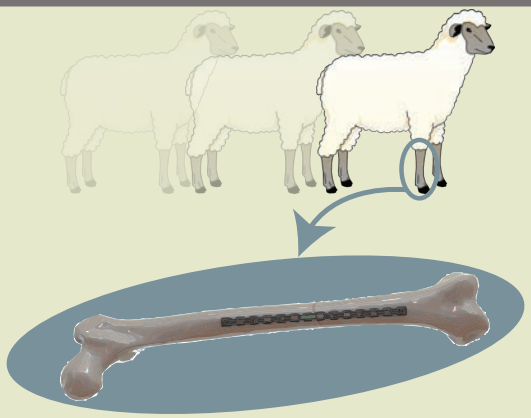


PROTOCOL AND SENSOR SOFTWARE DEVELOPMENT FOR FRACTURE HEALING

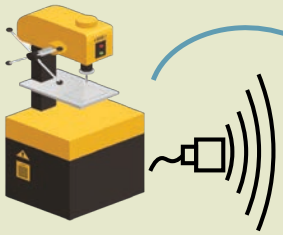
PROBLEM

Assessing the progress of a healing fracture is a difficult process. The use of microelectronic strain sensors in sheep leg fractures hopes to address this difficulty.

Strain data is gathered as sheep complete simple activities such as walking to a point. The software developed needs to **classify these activities from strain data**. The final goal is use this data to track healing progress.



SOLUTION



STRAIN DATA

We simulated sheep bone activity with a drill press protocol.

MODEL

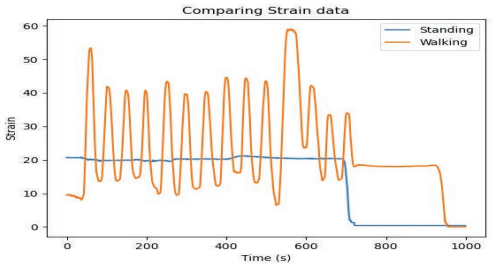
We developed a **Time Series Forest Machine Learning Model** which classifies activities, such as walking and standing.

CLASSIFICATION

The model achieved a cross fold validated **accuracy of 0.8095**.

IMPLICATIONS

Our model **enables comparison over time** of similar activities to assess healing progress. This is a step towards having a software system to track the progress of a healing fracture.



UC UNIVERSITY OF CANTERBURY Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND

Computer Science & Software Engineering

Jack Orchard

Supervisor: James Atlas

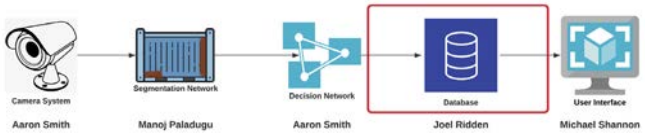
With thanks to:
Spinal Sensor Group
Deborah Munro
Sam Flint

Student projects: Software Engineering

PROTECTING OUR BORDERS FROM BIOSECURITY THREATS DATABASE AND COMMUNICATIONS

Joel Ridden
Aaron Smith, Manoj Paladugu, Michael Shannon
UC Supervisors: Richard Green, James Atlas
Industry Advisors: Port of Tauranga - Mark Whitworth, Agresearch - Mark Mcneill, Scion - Steve Pawson

Computer Science & Software Engineering



INTRODUCTION / AIM

- To create a database system to manage the millions of incoming container images and data efficiently.
- To store information of the biosecurity risks associated with containers and any other information that is helpful to help inspection.
- To manage communications between the decision network and the user interface at the Port of Tauranga.

TECHNOLOGY STACK

Tesseract OCR, spring, PostgreSQL, POSTMAN

RESULTS

From the years worth of work on this project a fully working efficient database and communications system was created and tested to be able to manage the possible millions of container data entries from the Port of Tauranga.

DEVELOPMENT

API stands for Application Programming Interface and is a software intermediary that allows two applications to talk to each other. This was the main piece for software communications developed to transfer information between the decision network to the database and the database to the user interface.

The database manages the storage and persistence of the incoming container data, this included the images, time of entry and the container identification number and any biosecurity risk information that was detected on the container and where.

Clustering is an operation that helps ensure efficient retrieval of information when there is potential millions of data stored. It arranges the database table by grouping all the containers by their container id number to allow for a faster search of all six sides. This process happens every 24 hours at 3am. Also at the same time any container images that are older than 24 days can be safely removed as they are no longer needing inspection/evaluation. However the other information is still kept by the system for history. The reason for this is to save storage since storing millions of high resolution container images will result in petabytes worth of image data.

A simple container id number reader was implemented using Tesseract to identify on a container its identification number which is useful information to know when inspecting a container for a potential bio risk.

CONCLUSION

This system is ready for deployment at the Port of Tauranga.
For the communications aspect of the system a fast network speed is required for the transfer of the large image files. Because of this the solution at the Port would be run this system over their line of fast fibre which currently is being run to two of their nine gantry cranes.
For the container id scanner a better model is needed. Options to improve this part of the project would be to either using an already existing industry built solution or using a better designed model with a deep learning approach.

REFERENCES

[1] F. Cazals, D. Mazauric, R. Tetley, and R. Watrigant. 2019. Comparing Two Clusterings Using Matchings between Clusters of Clusters. J. Exp. Algorithmics 24, 1, Article 1.17 (Oct. 2019), 41 pages. https://doi.org/10.1145/3345951

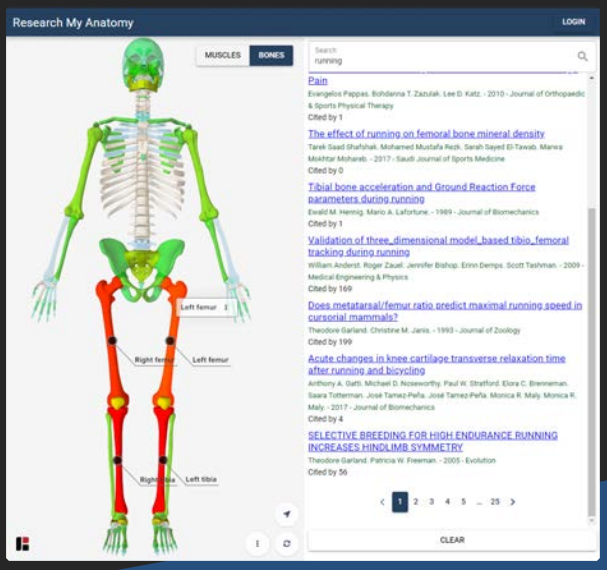
[2] Timothy Andrews and Craig Harris. 1987. Combining Language and Database Advances in an Object-Oriented Development Environment. SIGPLAN Not. 22, 12 (Dec. 1987), 430–440. https://doi.org/10.1145/38807.38847

Exploratory Search Engine for Anatomical Research

Jason Little | Supervisor: Ben Adams

The Problem

Research is an integral part of the medical field, for both medical professionals and medical students. However, the tools available to discover relevant research are limited. The current options are library search engines and online search tools, such as Google Scholar. These tools do not take advantage of the domain knowledge to provide and improve search features for a given field.
The aim of this research is to develop a functional search engine tool which uses information from the medical domain to improve the performance of exploratory research tasks for both medical professionals and medical students.



The Solution

The solution uses interactive 3D human models, powered by Biodigital, to display the relationships between query and anatomy. The medical researcher can interact with these relationships to explore the related research. A heatmap is used to indicate the relevance of the different anatomy objects to the query. Clicking through these different objects will display the relevant research papers. To join the anatomy components of the models to the research papers an index was constructed using Elasticsearch. The data builds off the Academic Observatory project out of Curtin University.

ACADEMIC OBSERVATORY

For more information contact:
jpl62@uclive.ac.nz | benjamin.adams@canterbury.ac.nz

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Computer Science & Software Engineering

Student projects: Software Engineering

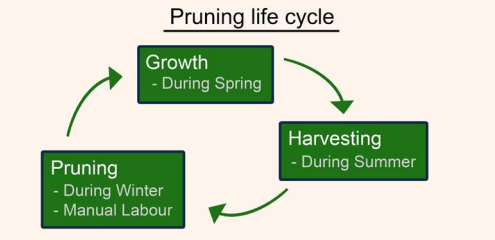
Synthetically 3D Generated Vine Labeling and Manipulation.

Kevin Langbroek

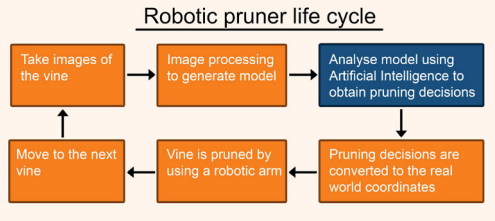
Proposed software solution developed for MaaraTech as a final software engineering project at University of Canterbury, supervised by Richard Green.

Background

Vineyard grapevines are pruned to obtain a desired quality of grapes through experience and physical labour. Vines are pruned by human workers when appropriate weather conditions are met. During the pruning season, days containing rain will slow down the speed of which the vines are pruned.



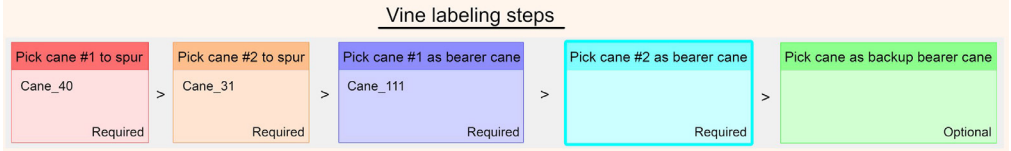
Therefore, robotic technology is being developed to prune vines without human interference while attaining consistent results. An Artificial Intelligence (AI) is created to compute the most optimal pruning decision when analysing the grapevines.

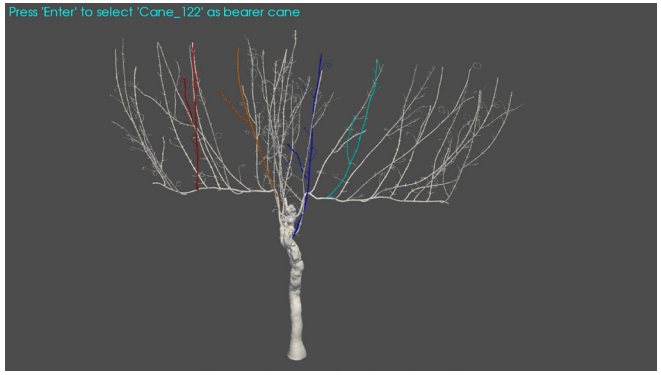


The blue step shown in the Robotic Pruner Life Cycle diagram is the scope to which the solution discussed in the poster relates to. To train the AI, a dataset of pruning decisions is required for it to learn and compute solutions. The proposed software solution will allow experienced pruners to label numerous synthetically three-dimensional (3D) generated grapevines

Technologies

The data sets to train the AI are based on the decisions for labeling 3D generated vines. The 3D vine models were generated using SpeedTree, an application consisting of vegetation programming and modeling software. Generated vines were converted to a Python NumPy array. The proposed software is developed using Python and the PyVista library for 3D plotting.





Methodology

The software guides the user through five steps after importing a folder or singular vine model. Four of the steps are required and are the most importtant information for the data set to teach the AI. Experienced pruners are the primary users of the software. As shown in the Labeling steps diagram the user is guided to label the branches in the specific order from left to right. The user is shown a 3D interactive representation of the generated vine model of which its branches can be selected.

Conclusion

The software allows the user to label up to five different branches of the synthetically generated vine model. Each modeled vine will have its corresponding labeling information exported to a JSON formatted file. Having multiple experienced pruners use the software to label an arbitrary number of vines will allow us to collect a large variety of decisions for a data set.

UC University of Canterbury
Computer Science & Software Engineering
MaaraTech

Student projects: Software Engineering

KOMODO MONITR

UC UNIVERSITY OF CANTERBURY

Computer Science & Software Engineering

Student: Lorenzo Fasano
Supervisor: Miguel Morales

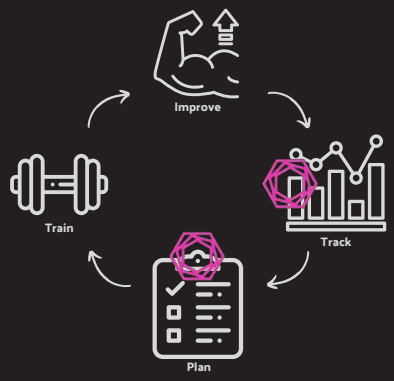
S&C Program Builder by Komodo Monitr

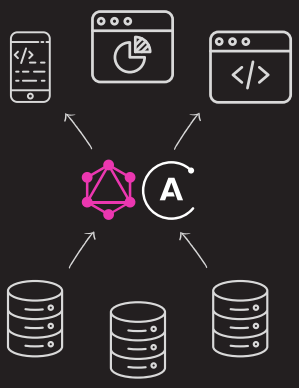
This project focuses on the delivery of a Strength & Conditioning (S&C) Program Builder application to integrate with Komodo Monitr's existing product. During the development of this service, the performance of GraphQL was tested as part of the Komodo Monitr technology stack.

What is an S&C Program Builder?

Strength & Conditioning coaches are responsible for the development of athletes' physical training. They create detailed training plans for their athletes to improve their condition over the season in a controlled way.

The service created as part of this project allows coaches to manage training plans and to track their athletes' improvements within the Komodo Monitr application.





Industry standards

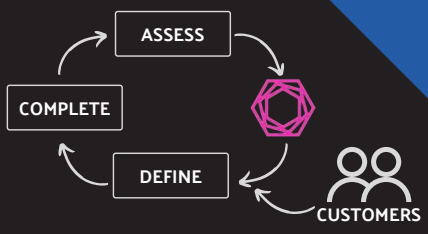
The development of the S&C Program Builder was completed following the company interpretation of Kanban.

This was key to ensure that processes such as task creation and quality assurance were maintained to the same industry standards that Komodo Monitr applies to the rest of the product.

GraphQL in between

Sitting on top of the API, GraphQL offers a unique interface to expose the back-end models to the multiple front-ends for a product.

It then becomes the front-end responsibility to query only the parts of models they are interested in. This pattern helps developers create comprehensive back-end models that can be flexibly queried by the front-ends.



Student projects: Software Engineering

SUPPORTING PROVER9 IN ISABELLE/HOL

LUKE PARKINSON
SUPERVISOR: WALTER GUTTMANN

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Computer Science & Software Engineering

Prover9

CONTEXT

Isabelle/HOL is an interactive theorem prover. Isabelle/HOL helps users formally verify the correctness of software, circuits, and mathematical proofs.

Isabelle/HOL uses a tool called Sledgehammer to invoke automated theorem provers (ATPs) to find proofs for various goals.

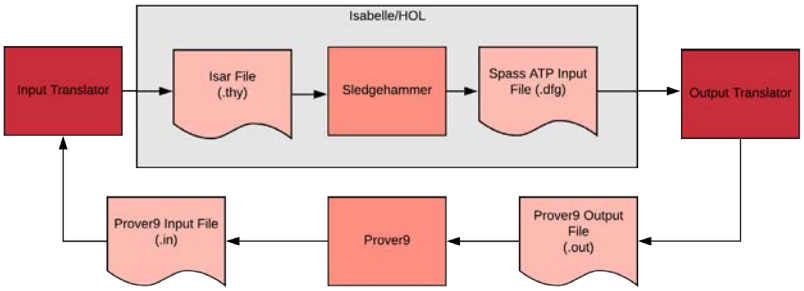
Prover9 is an ATP that can prove some mathematical lemmas faster than other automated theorem provers.

OBJECTIVE

The objective is to support use of Prover9 to find proofs in Isabelle/HOL, and allow those proofs to be verified by Isabelle/HOL. The end user should expect three things:

1. The user can select a goal to prove in Isabelle/HOL
2. The solution will take information from Isabelle/HOL and use Prover9 to generate a proof
3. The proof found in Prover9 will become input for Isabelle/HOL which can then verify the proof.

SOLUTION



We propose a solution of leveraging the file that Sledgehammer sends to another ATP, Spass, and translate this similar syntax into the syntax required by Prover9. From there, Prover9 can generate a proof. Our solution can then translate the syntax of Prover9's output back into Isar, the language required by Isabelle/HOL. This solution would work as a standalone tool separate from Isabelle/HOL, consisting of the input and output translators shown.

OUTCOME

The output translator stage of the solution is completed. Testing shows positive results with various Prover9 output files, allowing proofs found in Prover9 to be used in Isabelle/HOL. Further work is required to allow a user to choose a goal in Isabelle/HOL and have it translated into the language usable by Prover9. Currently, the output translator is designed to work with prefix notation files, so the proposed input translator will have to convert infix notation to prefix notation.

Document Importing Service

Data Storage

To ensure customers can use the importing service with any form template, we made the design decision to implement a template-based solution. The customer only needs to select the Region Of Interest for each field the first time they use a new form. To ensure sensitive data is never stored, only the top-left and bottom-right region corners are saved.

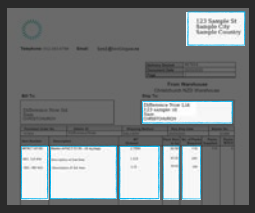
(X1,Y1)

123 Sample St
Sample City
Sample Country

(X2,Y2)

Image Segmentation

The first step of the pre-processing phase is image segmentation, splitting the image into regions defined in the preloaded template.



123 Sample St
Sample City
Sample Country

Open Morphology

The second step is applying Open Morphology. Open Morphology is a combination of Dilation and Erosion to remove noise from the images.

Geometric Scaling

A proof of concept investigation found that geometric scaling with a factor of three provided a 4.91% increas in recognition accuracy.

1.Template Process 2.Image Preprocessing 3.Character Recognition

Tech Stack

Character Recognition

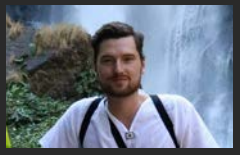
After pre-processing each region is recognised using the Tesseract OCR engine. The raw output is read into a model class where it is converted to JSON data, ready to be sent to the Consignly system provided by Global Office.

Python Model Class

+ clientCode
+ referenceNumber
+ dateEntered
+ destinationAddress
+ products = []

JSON

consignly



Luke Walsh

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Fabian Gilson

Global Office
Technology at work

Global Office

Student projects: Software Engineering

oVRcome.

Chatbot

UC University of Canterbury
Te Whare Wānanga o Waitaha Christchurch New Zealand

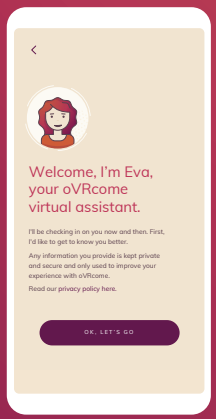
Computer Science & Software Engineering

Student: Matt Mischewski
Supervisor: Fabian Gilson
Product Owner: Adam Hutchinson

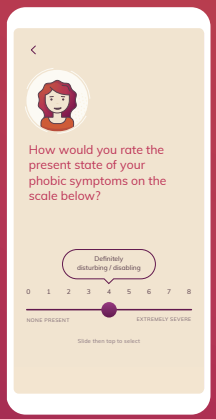
The oVRcome project is an application which focuses on helping people to overcome various fears and phobias they may have, through the use of virtual reality.

This virtual reality allows users to experience and adapt to situations that they might feel uncomfortable in, without having to actually be exposed to the situation in real life.

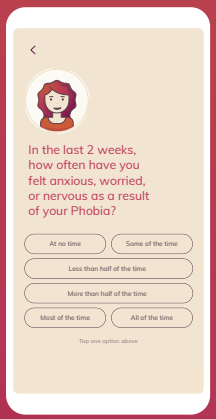
OVRCOME VIRTUAL ASSISTANT CHATBOT



One function of the oVRcome application is the digital assistant chatbot. This chatbot talks to the users of the application and helps them through any problems or difficulties they may come across.



The chatbot can ask questions and gather data so that the different oVRcome programs can be tailored towards the user and improve their experiences.



Users are presented with different options they can answer to the chatbots questions. Different chat flows occur based on the answers given by users.

Autonomous Vineyard Navigation

MAX ANDREW
Student

RICHARD GREEN
Supervisor

MAARATECH
Industry Partner

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND
Computer Science & Software Engineering

Objective

A COST-EFFECTIVE AUTONOMOUS SCANNING PLATFORM

Crop Scanning Platform

+

Single Camera

=

Obstacle Avoidance
+
Row Following

Obstacle Avoidance

CORRIDOR NAVIGATION METHOD FOR OBSTACLE AVOIDANCE

Adjustable Regions

- The corridor navigation method uses a set of four navigation regions.
- The area of each region can be adjusted for different navigation environments.
- The data in each region is assessed to determine the next navigation command.

Corridor Navigation

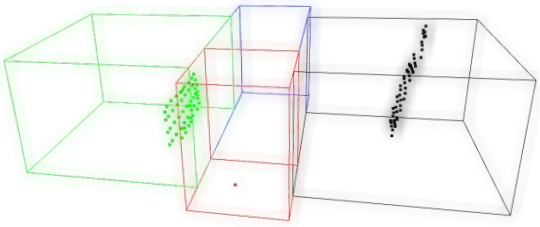
- The vehicle will navigate within the plant row corridor using commands.
- The possible commands are left, right, forward, and row following.
- Once the vehicle is comfortably navigating within the vineyard row, the row following state will be activated. This is performed for more precise navigation.

Stop
The vehicle will stop to avoid a collision with an obstacle.

Center
The vehicle will turn left or right to avoid the obstacle.

Left
This region will hold points for the left crop row.

Right
This region will hold points for the right crop row.



Row Following

CONSTANT DISTANCE FROM CROP ROW USING PLANE ESTIMATION

Plane Estimation

- The row following method uses point cloud plane estimation to represent the plant row wall.
- This allows the vehicle to estimate its distance from the plant row without having a sensor looking directly at it.

Distance Corrections

- The equation of the plane determined in the plane estimation step is used to estimate the vehicle's distance from the crop row.
- This extrapolation of the point cloud data allows the vehicle to make navigational adjustments to ensure it is the target distance from the wall.

Angle Corrections

- The plane estimation equation is used to calculate the vehicles angle relative to the plant row.
- Corrective adjustments are made to ensure the vehicle is in line with the crop row.

python OPEN3D intel REALSENSE

Student projects: Software Engineering

Protecting Our Borders From Biosecurity Threats
Container Scanning Using Deep Learning

UC Supervisors : Richard Green and James Atlas
Team : **Manoj Paladugu**, Aaron Smith
Michael Shannon and Joel Ridden
Industry Advisors
AgResearch : Mark McNeill,
Port of Tauranga : Mark Whitworth
Scion : Steve Pawson and Sam Davidson

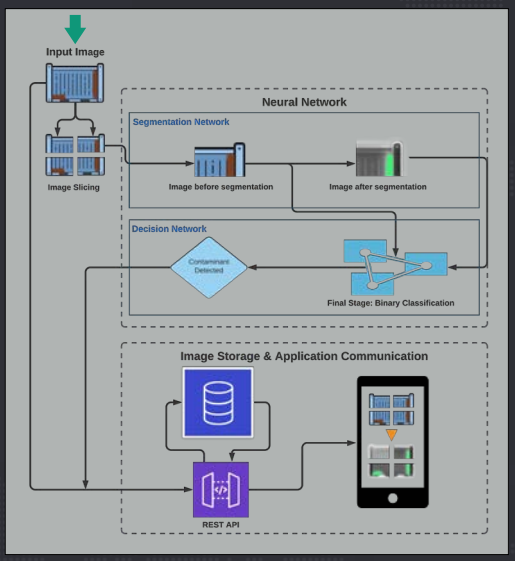
The Problem

New Zealand imports over 2 million twenty-foot container equivilents per year. Best efforts are made to ensure that biosecurity risks are mitigated offshore. However, there is an ever-present risk that hitchhiker pests or soil that contains weeds, seeds or pathogens could be present on containers and undetected when they are processed through our sea-ports. To this day the existing methods are still exceedingly reliant on visual inspections conducted at the ports.

The Solution

The final product uses a segmentation-based deep learning approach to detect surface anomalies on the exterior sides of a container. We propose a two-stage network. The first stage performs a pixel-wise localisation of the contaminant on a container image. This is the segmentation network. It also ensures that small but essential details are picked up by using each image pixel as an individual training sample. The output from this network is then fed into the second stage i.e. decision network.

The Architecture



Implementation

Before a full-size container image is directed to the segmentation network, image slicing is first performed to break an image into many small images. Every image is then supplied to the network as an input. The network then outputs its best approximation of the contaminated surface area. This output is then supplied into the decision network where it performs a more rigorous classification to determine the real output, i.e. contaminated or not contaminated.

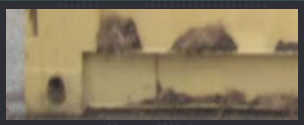
Challenges & Learning Outcomes

- Data scarcity is a critical problem which was experienced during the length of this project. Therefore, some preprocessing steps were implemented to maximise the data available.
- The anomaly detection network has shown promising results when analysing images with various types of contaminants.

Tech Stack

python PyTorch OpenCV

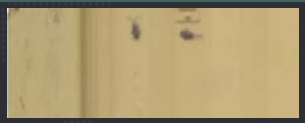
The Results



Original Image • Bottom left corner frame
• Contaminated with soil

Image Mask • Bottom left corner frame
• Unseen from neural network
• Used to evaluate network output

Network Output • Surface-anomaly prediction
• Output compared with image mask (left) for evaluation
• Some noise on the left from the surrounding environment.



Original Image • Top left corner frame
• Contaminated with bugs

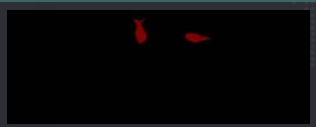


Image Mask • Top left corner frame
• Unseen from neural network
• Used to evaluate network output

Network Output • Surface-anomaly prediction
• Output compared with image mask (left) for evaluation
• Some noise from a surface ridge

References

[1] Andrew M. Liebhold Juan J. Monge Eckehard G. Brockerhoff, Lindsay S. Bulman.2017. Role of sea containers in unintentional movement of invasive contaminatingpests (so called "hitchhikers"), and opportunities for mitigation measures.
[2] Jure Skvarc Domen Tabernik, Samo Sela and Danijel Skocaj. 2019. Segmentation-Based Deep-Learning Approach for Surface-Defect Detection.

B3 Science Solutions for Better Border Biosecurity AOTEAROA NEW ZEALAND
PORT OF TAURANGA
agresearch
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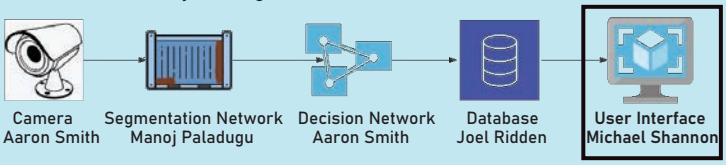
Computer Science & Software Engineering

Protecting Our Borders From Biosecurity Threats

User Interface

Joel Ridden, Manoj Paladugu, **Michael Shannon** and Aaron Smith

UC Supervisors: James Atlas and Richard Green
Industry Advisors: AgResearch - Mark McNeill, Port of Tauranga - Mark Whitworth, Scion - Sam Davidson and Steve Pawson(prev).

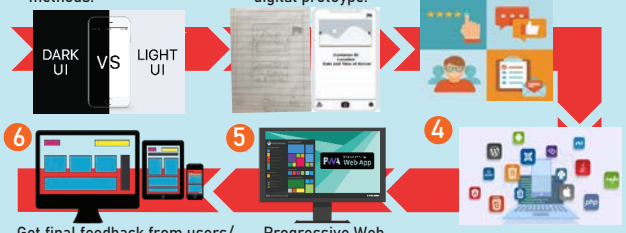


Objective

Design a user interface (UI) for the of the Port of Tauranga operating enviroment. This not only includes delivering a UI that can provide the correct implementation and features for the key users but also factoring in how the physical environment can affect the usability.

Methods

1. Research existing solutions and user interface design methods.
2. Create initital paper sketch and low fidelity digital protoype.
3. Gather user feedback and update UI design accordingly.
4. Choose a Tech Stack for Full-Cycle Web Application Development.
5. Progressive Web App(PWA) is developed for use on Desktop.
6. Get final feedback from users/ stakeholders and set up project for future development.



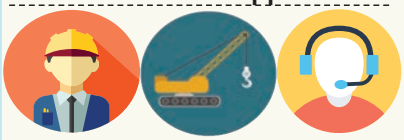
Introduction

The Port of Tauranga has set out to reduce the risk of contaminants entering New Zealand via sea containers and are a key participant in the biosecurity excellence in port communities initiative.

With funding from AgResearch and Scion this project set out to discover ways of spotting contaminated containers entering the port of Tauranga using a prototype deep learning camera system.

It is important that the interface takes into account the user's environment. This is not only referring to where the user is interfacing with the platform, but also when. Enviromental challenges includes glare from the sun or bright lights, use at night, wind and dust.

Who will use the app?



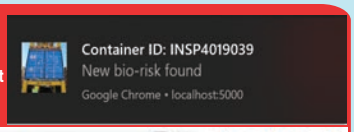
Exception Area Workers | Straddle Crane Drivers | Port Operations

There is a need for both a mobile and a desktop app.

Results

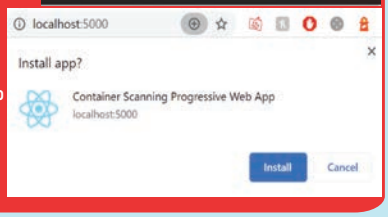
Solution

A Progressive Web App[1] built using React was developed



Main Features:

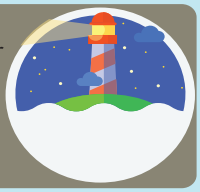
- Push Notifications
- Installability for Desktop and Mobile
- Caching and Offline use



Chrome Lighthouse Audit

Lighthouse[2] is an open-source, automated tool for improving the quality of Progressive Web Apps.

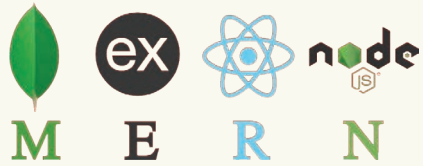
- Metrics
- Performance Scores
- PWA Optimization



Future Work

App development was focused on a Desktop application for this project so Mobile compatibility and better performance optimization has the potiental for further development. This includes for an increase in users and usage.

The MERN Tech Stack[3]



- MongoDB is a NoSQL (non-relational) document-oriented database.
- Express is a web application framework for Node.js. Instead of writing full web server code by hand on Node.js directly, Express can simplify the task of writing server code.
- ReactJS is an open source JavaScript library used to build user interfaces, typically for single page applications. React also allows for the ability to develop a PWA for both desktop and mobile functionality.
- Node.js works without an enclosing HTML page, instead using its own module system based on CommonJS, to put together multiple JavaScript files.

References

[1] Tandel, Sayali & Jamadar, Abhishek. (2018). Impact of Progressive Web Apps on Web App Development. 10.15680/IJIRSET.2018.0709021.
[2] https://developers.google.com/web/tools/lighthouse
[3] Wilson, Eddy. MERN Quick Start Guide : Build Web Applications with MongoDB, Express. js, React, and Node, Packt Publishing, Limited, 2018.

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PORT OF TAURANGA

October 2020

Student projects: Software Engineering

Interactive Tool for Relational Programs on Weighted Graphs

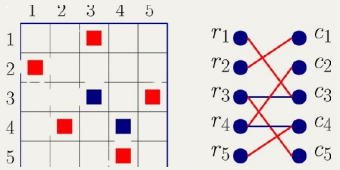
Developer / Author - Ollie Sharplin

UC Computer Science & Software Engineering

Project Supervisor - Walter Guttmann

Introduction

Graph theory is the study of mathematical structures used to model relations between objects. A graph is made up of nodes or points which are connected by edges. These graphs are used in a wide range of applications to represent complex problems or equations, which by performing certain operations and algorithms on them, give a resultant graph which can be used to find a solution.



A relational programming language is a language which allows a programmer to specify operations which can be performed on relational objects. Relating this to graph theory, a relational programming language should allow users with little to no experience in programming, perform operations on graphs. This project aims at creating a system which abstracts the underlying computations from its users and provides them with a simple programming language to allow them to perform graph theory calculations.

Research was done into existing solutions which may relate to this aim. However, although there were some systems out there, none allowed for graphs to incorporate weights on its edges. This limited the range of use cases for such a system. This project incorporates edge weights opening up a new range of operations which can be performed.

Conclusion

In conclusion, this project provides a tool for developing and executing relational programs on weighted graphs. It is unique in the current market and has a wide range of use case opportunities. In its current state, it provides a basis for future development to enhance its feature set and execution capabilities, to result in a system which can be used widely in the graph theory world.

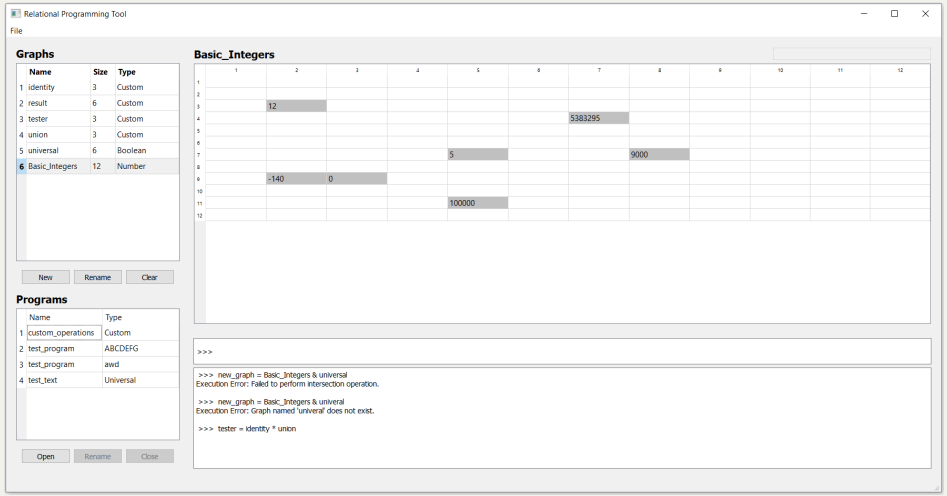
Product Features

Users can implement their own graphs with custom edge weight types into the system. This is done by giving them a simple algorithmic template, which they can then modify. The system will import and execute these at runtime. This allows users to come up with their own use cases for the system to meet their needs.

To allow for complex graph theory algorithms to be executed more efficiently, the system provides its users with a built-in programming language. Users can define functions, if-statements and while loops to form algorithms which can be used repeatedly using graphs as parameters and return values. These can be imported into the system and executed from the shell environment, saving the result in the library of graphs. Single operations can also be executed manually via the shell to improve efficiency.

The system includes its own set of built-in functions for calculating the state of graphs. These also return resultant graphs which can be reused or evaluated in an if-statement or while loop.

```
func Reachable(R, S):
    Q = S                       # Q = nodes reached so far
    while -empty(-Q & R^ * Q):  # any new nodes in next step?
        Q = Q | R^ * Q          # add nodes reached in next step
    endwhile
    return Q
endfunc
```



Autonomous Cart Operating System

Priyesh Shah

Supervisor: Richard Green | Student Partner: Gavin Ong | Industry Partners: Scott Spooner & Lachlan Brewster

Context

South Pacific Sera currently uses manpower to move heavy cargo around a warehouse to be processed. This process is very inefficient and resource-heavy. Thus, SPS required a safe and efficient process with the goal to reduce staff costs and increase productivity.

Our Solution

We decided to implement an autonomous system using automated carts to replace manual labour. We achieved this by implementing two main parts of this autonomous system, a cart requesting device and the central operating system.

Objectives

- Receive requests from the operators and sensors
- Schedule and control cart movements between stations
- Optimise cart movement flow (traffic handling)
- Display all system information on a monitoring interface
- Reduce costs and increase productivity

Achievements

1. Cart requesting device was built using a LOLIN D1 Mini microcontroller board with ESP8266 wifi module. This device is used to request or dispatch carts to and from a station.

2. The Cart Operating System (COS) is able to receive requests from the cart requesting device and schedule and control cart movements between stations in a safe and efficient manner.

3. The COS is built using Python and is deployed on a Raspberry Pi board which communicates with the carts and the requesting device wirelessly via Wi-Fi.

4. The entire workflow with important system information can be displayed on a monitoring screen.

5. Reduced labour costs and increased work productivity.

SPS SOUTH PACIFIC SERA LIMITED

UC UNIVERSITY OF CANTERBURY Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND

Computer Science & Software Engineering

Augmented reality application for treating anxiety phobia.

Ryan Chen
Fabian Gilson

problem

- The lifetime prevalence rate for specific phobia in New Zealand and United States are **10.9%** and **12.5%** respectively.
- These disorders can seriously disrupt the daily lives of those who are affected, and cause harm to physical and mental health.

- **The most effective form of therapy (exposure therapy) is expensive and intimidating.**

solution

A mobile application to let you confront your fears in augmented reality

- **Augmented reality exposure therapy is an innovative and cost-effective alternative to traditional methods.**
- **Studies show that virtual and augmented reality exposure therapy is equally as efficacious as *in vivo* exposure therapy.**
- **Augmented reality is easy to approach.**

technology

unity
Cross-platform game engine

Google's ARCore Augmented reality API

Apple's ARKit Augmented reality API

Augmented reality can be an intermediate step to aid in treating phobia.

Improve mental and physical well-being!

UC University of Canterbury
Computer Science & Software Engineering

IN PARTNERSHIP WITH mogeo

Student projects: Software Engineering

Augmented Reality Dictionary

Abstract

The Dictionary Augmented-Reality app is a project to explore the practical application of optical character recognition(OCR) together with augmented reality(AR) technologies into a Kotlin based mobile application. The application is designed to enrich and simplify the user experience of extracting text and searching up the definitions of words that a user does not understand. The application must meet the following requirements: be able to extract text from a live camera feed, track the detected text with bounding boxes, can obtain a dictionary definition of a selected word, and display the text definition on a text object in augmented reality.

Objectives

The objectives of the project are as follows:

- Extract text from a live camera feed
- Track detected text with bounding boxes
- Retrieves the dictionary text definition of a word selected by the user
- Display the dictionary definition of the selected word as a text object in augmented reality

Application software pipeline

The application pipeline primarily consists of three main processes which consists of the following: extracting text from an image extracted from a live video feed, requesting and receiving the dictionary defition for a specified word, displaying it on text in augmented reality. The application makes use of ML Kit Vision in order to extract text from images. Once the data has been processed and user input is detected, datamuse will be called to obtain a dictionary definition of the selected word. When the word definition has been successfully retrieved, sceneform will be used to generate a text object displaying the text object. ARCore will then be used to render this object in augmented reality.

datamuse

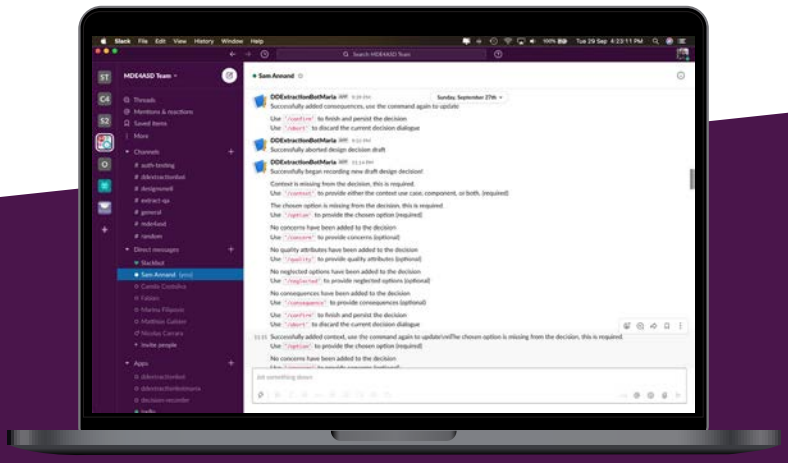
Results

The application in its current state can extract text from a live camera feed and create interactable bounding boxes for each piece of text. After this has been done the application can request and receive a dictionary definition of the selected word. As the sceneform and ARCore component has not yet been fully implemented, there is a chance that this section of the project will not be able to be demonstrated in the showcase and this will be potential future work for the project. The application currently focuses on functionality so future work on the project may include improving the UI design or looking into more functionalities that could be implemented such as ways to obtain definitions for other languages to assist people with languages they are unfamiliar with.

UC University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand
Computer Science & Software Engineering
Ri Sheng Huang
Supervisor
Andrew Cockburn
Lab
Edward Armstrong
Jake Crouchley

Easy Design Decisions

Sam Annand



Problem:

Agile software development teams **sparsely document** their design decisions as it is **cumbersome**.

Solution / Objective:

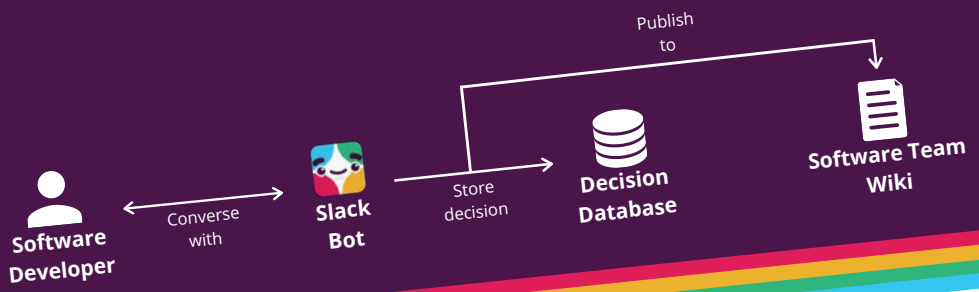
Integrate the documentation process into a tool already commonplace in software engineering teams using a **Slack Bot**.

Results:

- **Removed** first generation installation **barriers**
- Converted to **SAAS model** using AWS
- Implemented **searchable decisions**
- Implemented **multi-user** functionality
- Created MVP for **chat based** interactions
- Heuristic **usability evaluation** performed
- **Paper written** for ICSA 2021

Learnings:

- Dialogue based interactions **reduce rigidity**
- **Deep learning** could enhance NLP capability of solution
- A proper **user study** should be completed in the future



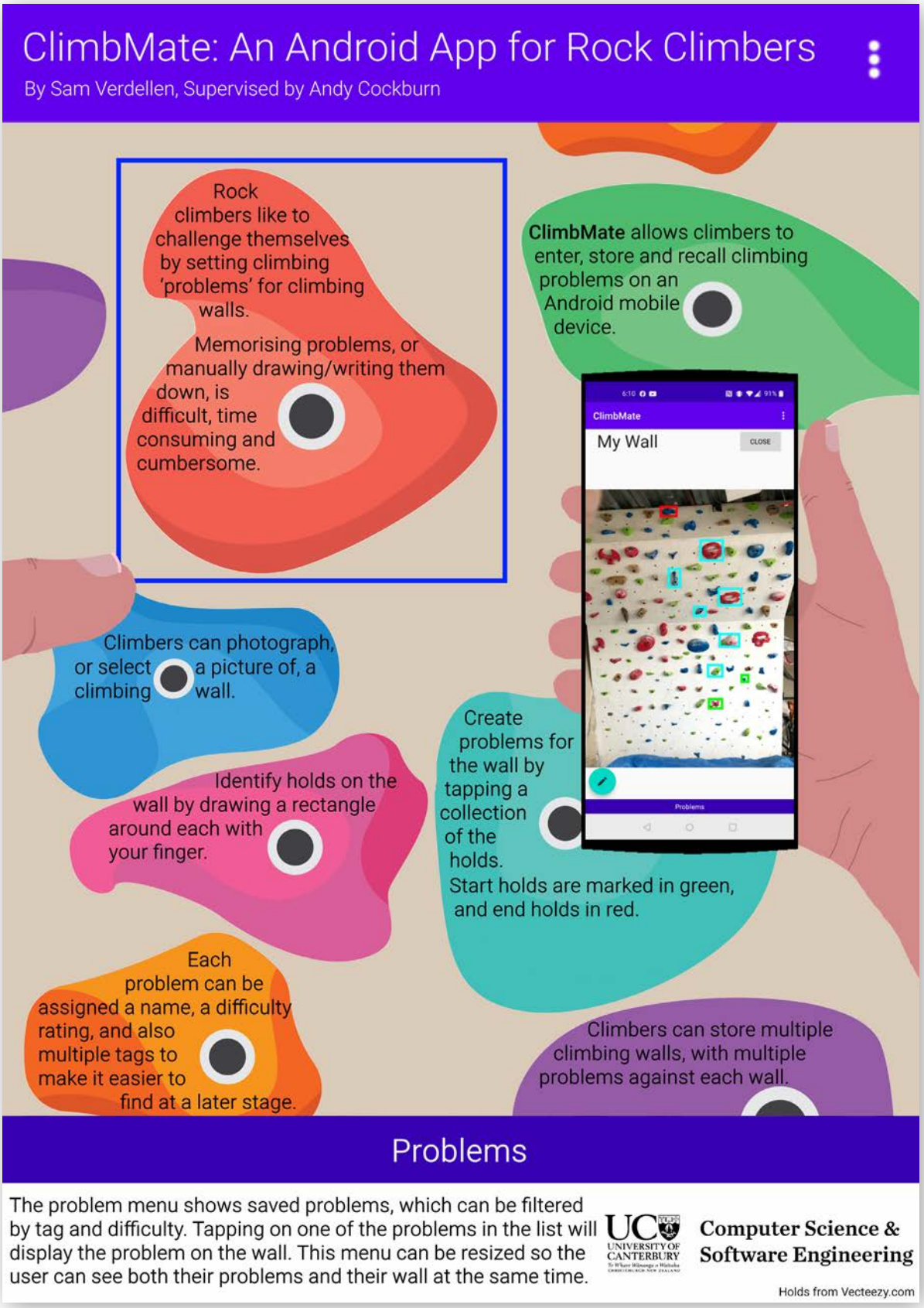
slack

UC University of Canterbury Computer Science & Software Engineering

Supervisor:
Dr. Fabian Gilson

SCAN ME!

Student projects: Software Engineering



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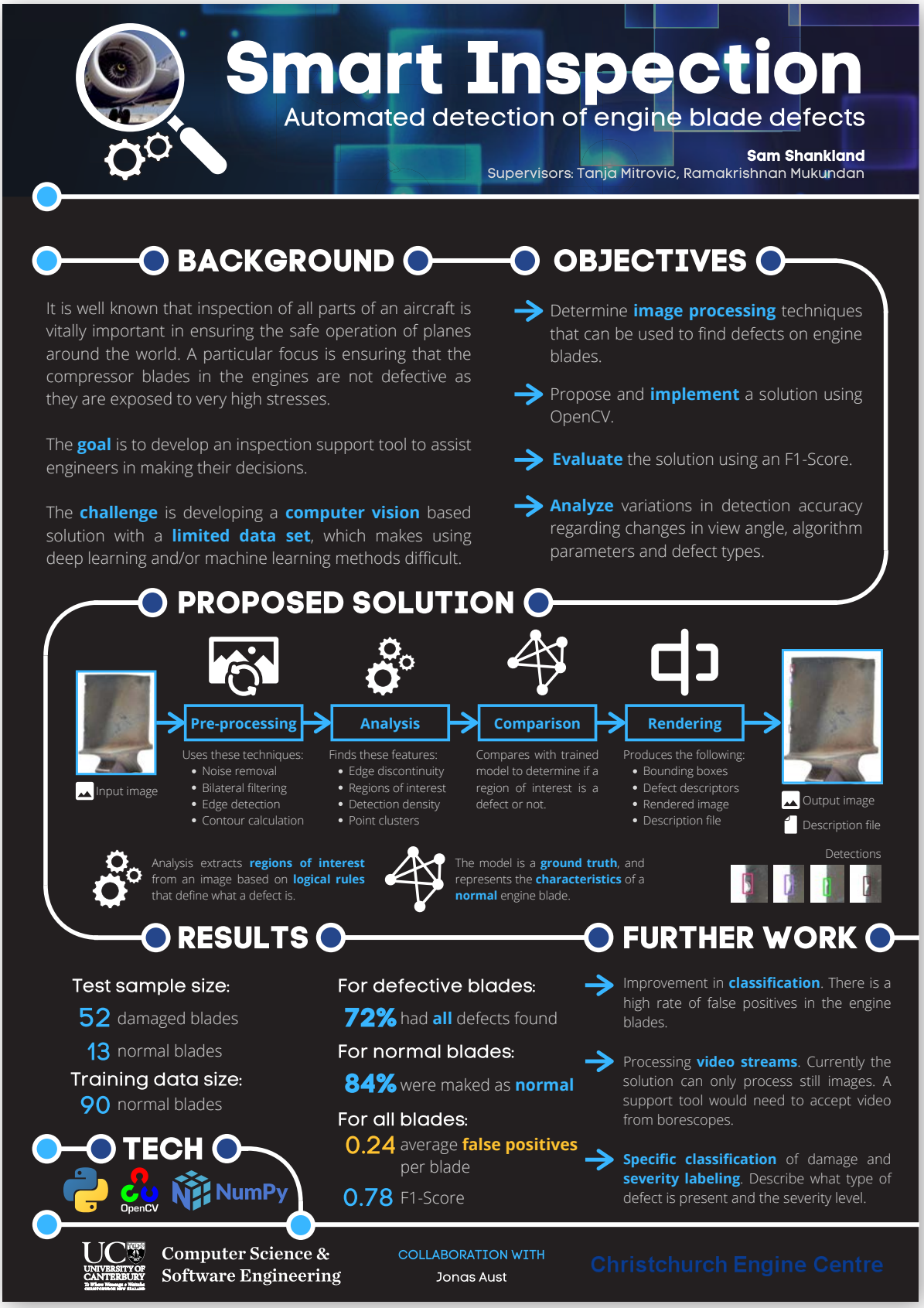
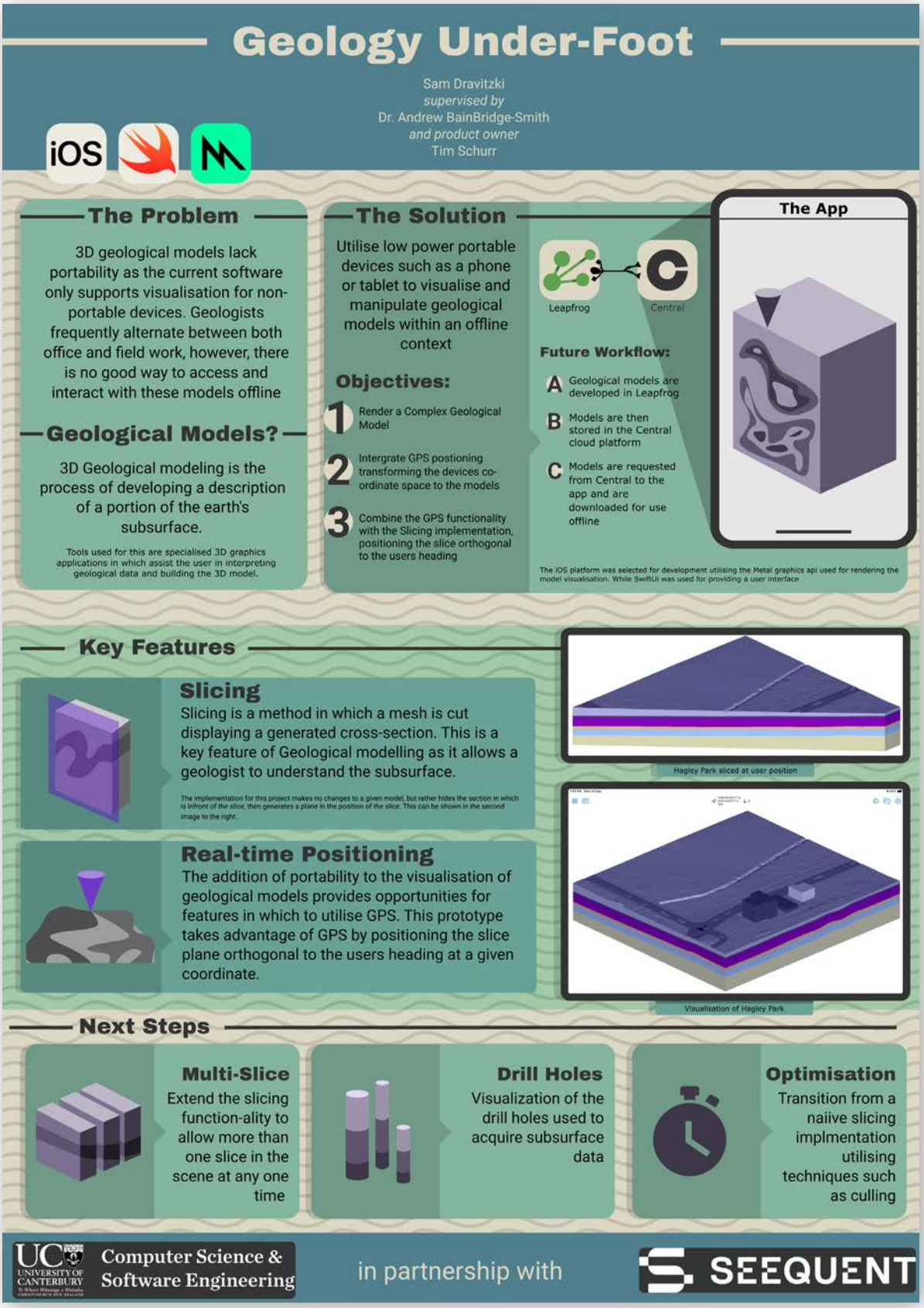


Student projects: Software Engineering



Student projects: Software Engineering

Micro-services for Human Computer Interaction

OVERALL PROJECT
OVERVIEW

PROJECT OBJECTIVE

The aim of this project was to compare and evaluate two front-end microservice infrastructures: SINGLE-SPA and WEB-COMPONENTS and recommend one of them to the Industry Sponsor.

PROJECT REQUIREMENTS

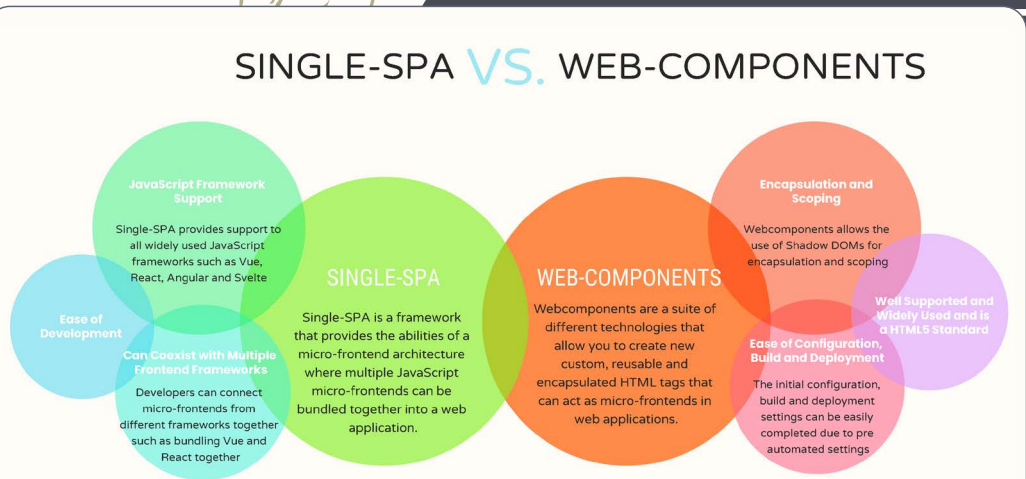
- Design and Develop three proof of concepts for each infrastructure to display required functionality such as CRUD (Create, Read, Update and Delete) operations, Search and Filter, Admin roles and Security.
- Research and Create a comparison framework that can be used to compare and evaluate these two approaches.
- Evaluate both approaches using the comparison framework, using these concepts and personal experiences to recommend an approach.

FINAL
VERDICT

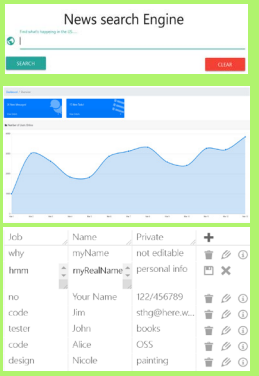
After evaluating both microservice infrastructures against functional, quality and commercial requirements of the Industry, I recommend WEB-COMPONENTS as the most suitable option to create micro-services.

By Sachin Sakthivel
Supervised by Matthias Galster (University of Canterbury)
Industry Partner: Mark Cargin (Intellihub)

SINGLE-SPA VS. WEB-COMPONENTS

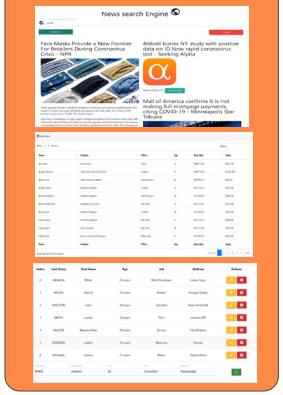


SINGLE-SPA CONCEPTS



WEIGHING IN ON RESULTS

WEB-COMPONENTS CONCEPTS



INTELLIHUB
UC UNIVERSITY OF CANTERBURY
Computer Science & Software Engineering

Goal Recommendations Using Collaborative Filtering

By Torben Klausen
In collaboration with Matthew Minish
Supervised by Moffat Matthews

PROBLEM

In 2020, New Zealand was exposed to the pandemic of covid-19 which caused mass self-isolation to be put into effect. This caused a decline in general mental health as people were separated from people they cared about, their structure and their routines. There is also a general decline in mental health across the world. To assist people with maintaining a routine, a smart system was researched and developed that would help people maintai

SOLUTION

A goal recommendation system was developed that suggests goals to the users of a goal-setting application. By using collaborative filtering and q-learning together, this system can work in a complex state space. The system:

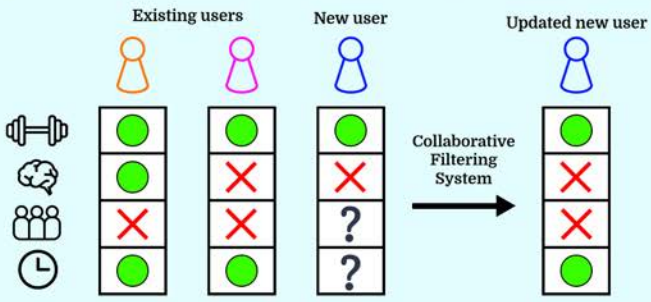
- Suggests template goals and personalized goals to users based on their past goals.

- Tracks user activity and tendencies to optimize the goals recommended to them.

HOW IT WORKS

Collaborative Filtering

The collaborative filtering system fills in the gaps for new users. It does this by comparing the new users with similar existing users and making guesses about what the new user will prefer based on that. In the example below, a user's preferences on social goals and long goals are estimated.



Q-learning

Q-learning works by finding out what users like through trial and error. Using q-learning, the system suggests different goals to users. After this, a reward is given to the system based on how well the user performs after recieving the suggestion. This changes what the system recommends in the future. User activity and goal completion rate are two reward metrics measured.

X	Action 1	Action 2	...
State 1	0	1.4	...
...	...	...	...
State 86	0	0	
State 87	1.5	0.3	
State 88	0	1.1	
...	...	...	...

X	Action 1	Action 2	...
State 1	0	1.4	...
...	...	...	...
State 86	0	0	
State 87	2.4	0.3	
State 88	0	1.1	
...	...	...	...

Respondants to a survey stated that their mood and motivation was negatively affected by the lock-down, and that a goal recommendation system would help them stick to achieving goals.

65% of respondants agreed that their motivation levels were lower over lock-down.

The number of respondants that agreed template goals would be helpful was 73%

69% of respondants agreed that personalized suggested goals would be helpful.

FUTURE WORK

This project has lots of room for further innovation. Some improvements could include:

- Upgrading the q-learning system to a deep q-learning system

- Accessing large user spaces on other existing goal-setting applications

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Computer Science & Software Engineering

Contact me at tkl34@uclive.ac.nz
for more information

Student projects: Software Engineering

CHARIOT

Cloud-Assisted Access Control for the Internet of Things

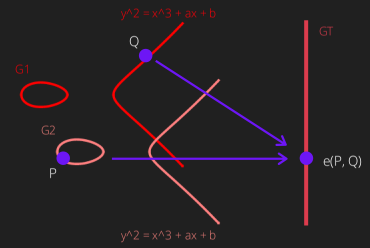
Viktor Bubanja Clémentine Gritti

University of Canterbury
Computer Science & Software Engineering

Objective

- Increase the security within an Internet of Things (IoT) environment
- Build a prototype of CHARIOT [1], an authentication protocol
- Perform benchmarks to validate the protocol

Elliptic Curve Cryptography



Elliptic curve pairings:

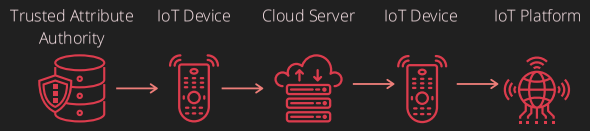
- Expand what traditional cryptographic protocols are capable of

Groth-Sahai proofs:

- Allow one party to prove to another party that they know a value x, without conveying any information about x and without any interaction
- Within CHARIOT, allow expensive operations to be offloaded to an untrusted cloud server without compromising security

Solution

- Authenticate IoT devices based on their attributes
- Keep attributes hidden with digital signatures
- Offload computationally intensive signature generation to a powerful cloud server



Setup Initialise protocol
KeyGen Initialise keys

Request Hash attributes and send to cloud server

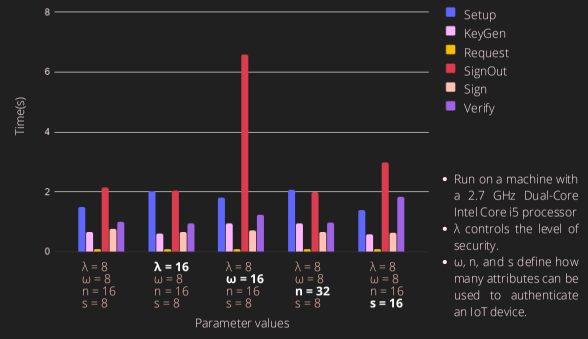
SignOut Generate signature for IoT device

Sign Finalise signature

Verify Authenticate the IoT device

Evaluation

Time Benchmarking to Determine Scalability



- Run on a machine with a 2.7 GHz Dual-Core Intel Core i5 processor
- λ controls the level of security.
- ω, n, and s define how many attributes can be used to authenticate an IoT device.

Results

Setup	Increases linearly with n and λ
Keygen	Increases linearly with n and ω
Request	Increases linearly with s
SignOut	Increases exponentially with ω
Sign	Increases linearly with λ
Verify	Increases exponentially with s

Conclusion

- Successful implementation of CHARIOT
  - IoT devices can be authenticated based on their attributes
- Time benchmarking determined that CHARIOT is:
  - Suitable to be run on IoT devices
  - Not scalable for large systems
    - Can mitigate by scaling up the computational power of machines that run the slow algorithms

References

[1] Clémentine Gritti, Melek Önen, and Refik Molva. 2018. CHARIOT: Cloud-Assisted Access Control for the Internet of Things. 2018 16th Annual Conference on Privacy, Security and Trust (PST), 1–6.

AGILITY IN SMALL NZ SOFTWARE ENTITIES

VINCENT JAMIESON

DR MIGUEL MORALES
Project Supervisor

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Computer Science & Software Engineering

GOALS

- *Get a snapshot of current practices in small NZ software entities*
- *See how closely agile practices are followed by these small entities*
- *Discover links between challenges faced and the practices in use*

METHOD

Systematic Mapping Study

The first stage of research involved a Systematic Mapping Study (SMS), where existing literature was reviewed to produce a map of topics. From the SMS, we obtained key topics relating to software development in small agile entities. These were 'Requirements Gathering', 'Stakeholder Engagement', 'Incremental Development', 'Developer Groupings', 'Agile Roles & Rituals', 'Challenges', and 'Perception of Agile'.

Surveying our Industry

After performing the SMS, a survey was conducted to determine current practices in NZ using those topics. Developers in small software entities were asked about these aspects of development without directly naming them to mitigate bias. Then they were asked to identify their development approach and how satisfied they were with it, while also listing the challenges they encounter when developing.

CONTEXT

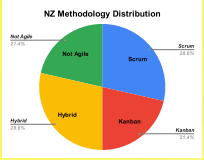
The NZ IT Scene

The New Zealand Information Technology industry is experiencing some of the highest growth of any industry in the nation, with software development playing a large role. The key drivers for this are small software companies with fewer than 20 developers, for they make up 73% of the this industry. However, little research into the practices in use by these companies exists, despite this industry trend.

What is Agile?

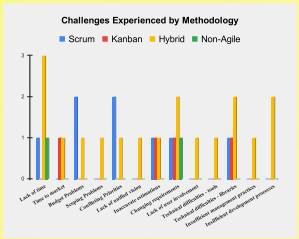
In this context, the term 'agile' refers to an approach to project management and development characterised by a focus on client collaboration, people, functionality, and adapting to change. Agile development differs from the more rigid traditional model of project management, which has strict phases, by favouring frequent and small deliveries. There are many agile ways of working, and this study focused on Scrum and Kanban.

RESULTS



From the survey results, small software entities mostly adopted some sort of agile methodology, with 87.6% of respondents indicating this. Scrum and Kanban were the dominant methodologies, with the rest of the agile respondents using a hybrid approach.

Additionally, we see that common challenges are experienced by small software entities. From these results, hybrid approaches appear to present the most issues. However, more research should be done to better conclude this.



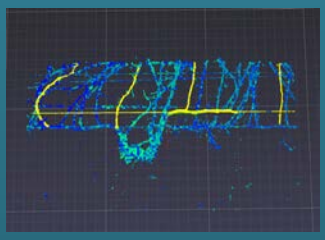
Student projects: Software Engineering

3D ANNOTATION ON HIGH-RESOLUTION ORCHARD POINT CLOUD SCANS

VIKAS SHENOY SUPERVISED BY RICHARD GREEN AND OLIVER BATCHELOR

BACKGROUND

- MaaraTech Human Assist is a collaborative research project which aims to create tools to assist workers in orchards and fully automate certain activities
- It is currently hard for the structure of plants to be analysed with artificial intelligence methods due to the lack of annotated data available
- MaaraTech has access to point cloud scans taken from orchards, although these often contain noise and gaps in the scan



OBJECTIVES

- Develop an algorithmic method for finding all the points in an feature (such as a cane or a wire) from only its endpoints
- Ensure the algorithm can run in close to real-time and overcome noise and gaps in the scans
- Create a user interface for loading and annotating point clouds using this algorithm

SOLUTION

DOWNSAMPLE

Downsample the point cloud to reduce the number of points and speed up processing

BUILD GRAPH

Build a graph based on the point cloud, where edges are formed between nodes within a certain radius of each other

FIND PATH

Find the shortest path between the endpoints the user selects on a feature to annotate using Dijkstra's algorithm

SELECT POINTS

Select all the points within a certain radius of the path points to generate the annotation

GRAPH BUILD

- Synthetic points with a high edge cost are added to the graph to help overcome gaps in the scan. Without these points, the algorithm could regularly fail to find a path between endpoints of a feature
- The amount of downsampling can be increased to decrease graph build time
- The radius for forming edges between graph nodes can be increased to help overcome gaps. This brings a corresponding tradeoff, with increased graph build time

TECH

OPEN3D

PPTK

RESULTS

- The GUI created with PyQT5 and PPTK point cloud viewer allows the user to load and annotate point clouds
- The graph build process takes roughly 5 seconds with parameters which enable the annotation of features even in noisy point cloud scans with 1.8 million points
- Future work could involve the extraction of the point cloud's skeleton or the ability for the user to link annotations together

ACKNOWLEDGEMENTS

Thanks to industry partner MaaraTech, and Oliver Batchelor in particular for providing advice and help with the project solution.

MaaraTech

UC University of Canterbury Computer Science & Software Engineering

A SENSEMAKING ATLAS OF SCHOLARLY KNOWLEDGE PRODUCTION

William Wallace *Supervisor: Ben Adams*

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Background

Exploratory search is the process of foraging for information when you are initially unsure of a definitive search goal. As you are actively searching and absorbing more information you are able to refine your search, formulate search queries and identify relevant items. This project builds upon an existing codebase in collaboration with the **Curtin Open Knowledge Initiative (COKI)** group at Curtin University in Australia. COKI is developing a project called the **Academic Observatory** which includes a data set containing more than **100 million records** relating to academic work. Ben Adams has built an index for the data set and a web client that is able to query against that index.

ACADEMIC OBSERVATORY

More than
100 million records
relating to academic work

Objectives

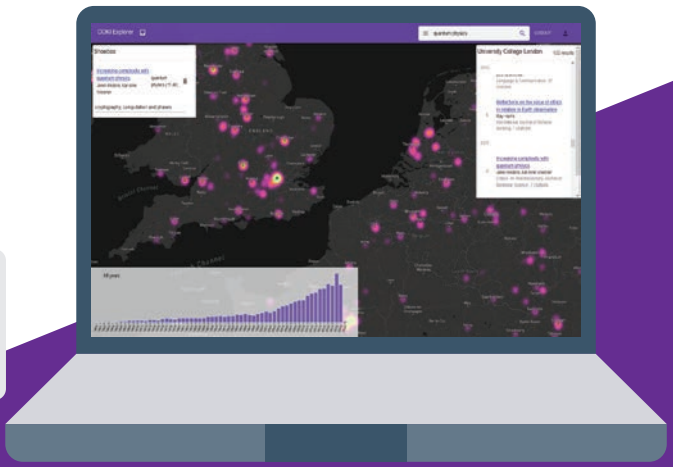
Hundreds of millions of research publications and scientific literature are available online, however the tools in existence to find and discover relevant knowledge for someone doing research are quite limited. Building upon the web client Ben Adams started, the system hopes to show **knowledge production** in the context of the **research institutions** and **regions** that it originates from. We aimed to introduce new features to aid **exploratory search** and **sensemaking** while increasing **user engagement**.

Solution

To encourage exploratory search and user engagement new and unique features were implemented. These features include: **user accounts and profiles**, user search history and also pulling together relevant articles on the fly and storing them into a '**shoebox**'. The shoebox allows users add and remove research publications of interest, write notes under each of them and save the shoebox to continue their exploratory search some other time.

User profiles

Shoebox
store articles as you research!



Future plans

- Allow users to share their shoebox with others
- Enable collaboration on developing annotated reading list for research groups and funding insitutions
- Integrate the web client into COKI's automated data pipeline and make it a live website
- Futher evaluation of the user experience

Built with Firebase

UNIVERSITY OF CANTERBURY **Computer Science & Software Engineering**

Curtin University

Submit a project for 2021

or summer project for 2020

If you have a project idea - half a page is sufficient at this stage (the brief can be refined later) - please email the following information to engindustry@canterbury.ac.nz:

- Title of the project.
- Contact name and contact details for the project.
- Summary of your expected project outcomes, for example, what you want to achieve or the problem you would like to solve.
- Constraints and/or expectations that need to be taken in to account for the project.
- Type of sponsorship option (platinum/gold).
- Indicative number of students your business/organisation would like to sponsor for the project.
- Support (time, resource & equipment) your business/organisation will provide (in addition to sponsorship).
- Any other information you consider relevant.

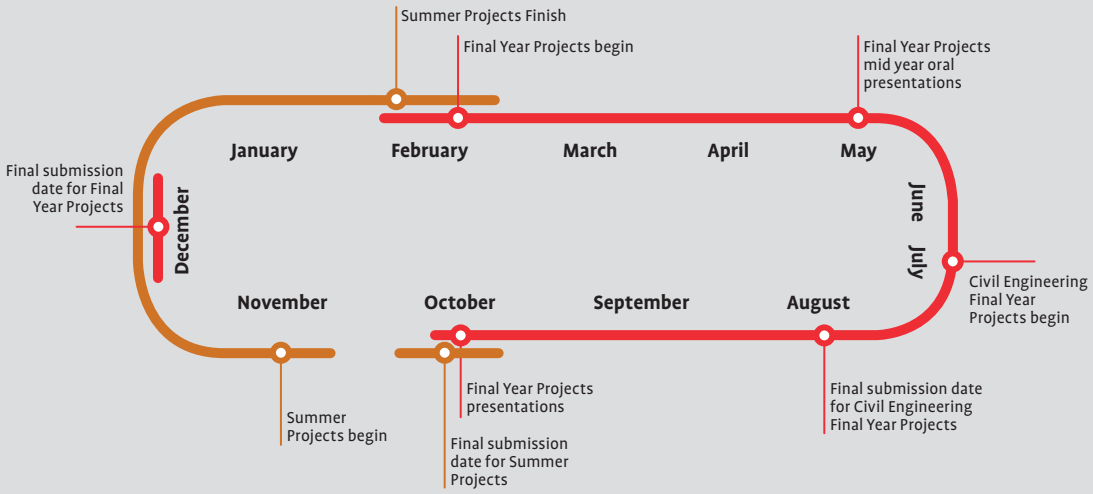
Or complete the online form: **www.canterbury.ac.nz/engineering/industry/project-sponsorship**

PROJECT TIMELINE:

Final Year Project final submission date for an idea or project is: Monday, 21 December 2020, for projects to be started in February 2021.

Thursday, 13 August 2020, for Civil Engineering projects to be started in July 2021.

Summer Project final submission date for an idea or project is: Friday, 2 October 2020, for projects to be started in November 2020.



As student numbers are limited, and vary from year to year, we recommend starting this process early to avoid missing out on having your project selected.

Contact us

To find out more about these opportunities contact:

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