College of Engineering

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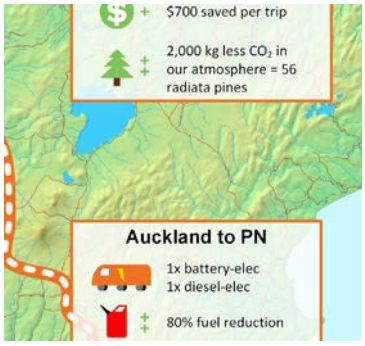
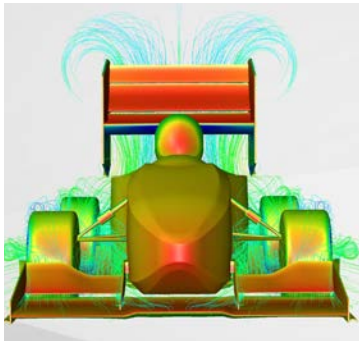
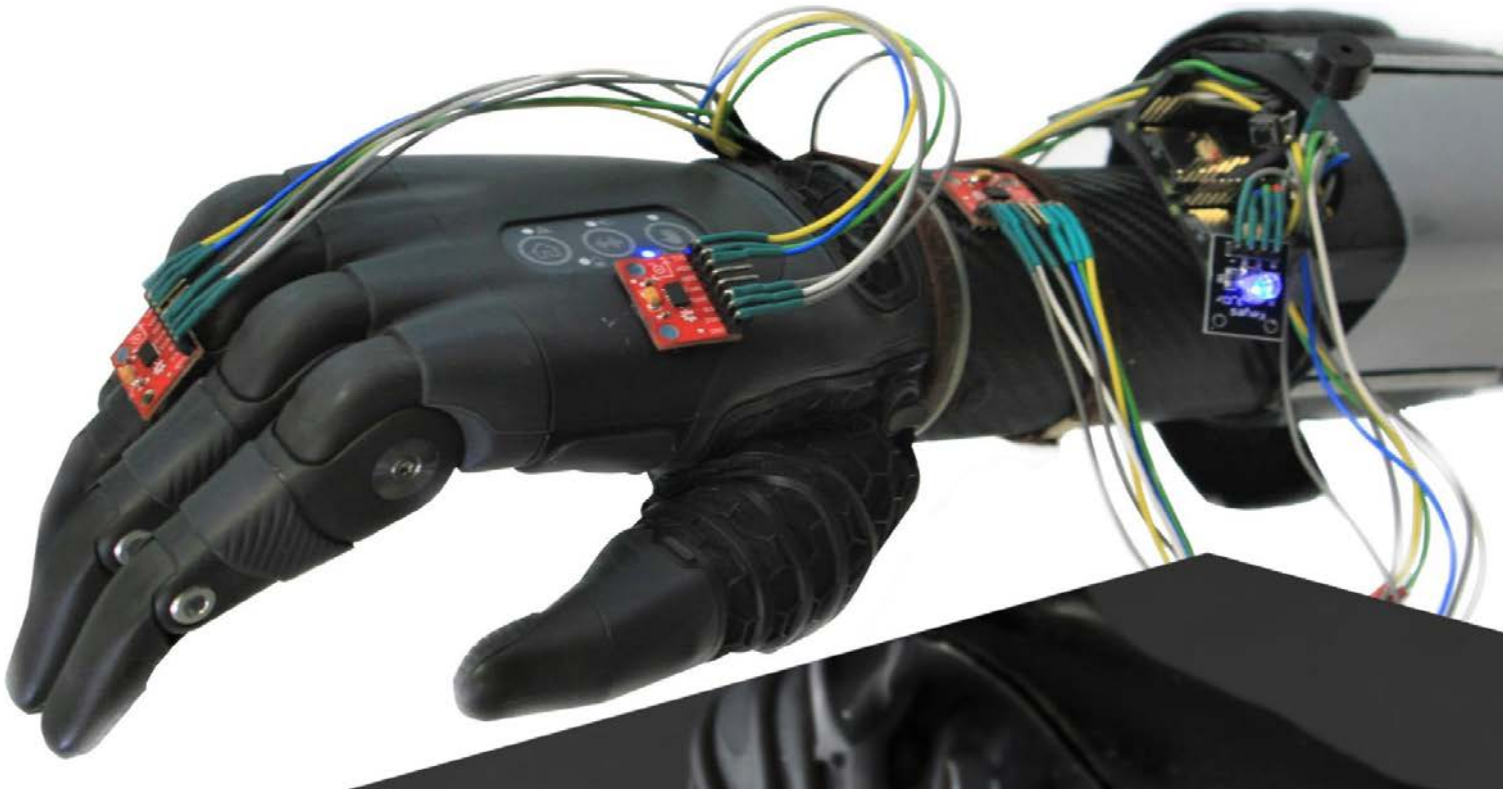
CHRISTCHURCH NEW ZEALAND

Final Year Projects 2019.







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 2019 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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BVT
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Sunshine Solar
Tait Communications
Taska
Tiro Medical
Transpower
TransTech Dynamics
Trimble
UNISON
Venture Southland
Vynco
West Coast Regional Council

The Peoples Choice Award 2019

For the first time this year attendees at the Final Year Project Showcase were able to vote for their favourite project, this was very popular with attendees, and fiercely competitive between some students. The award was announced by Deputy Head of Mechanical Engineering Professor Mark Jermy, and trophies awarded by Deputy Vice Chancellor Professor Ian Wright.

Photograph from left to right:
Deputy Vice Chancellor Professor Ian Wright, BE(HONS) Mechatronics, Robotics, and Automation Engineering student Ben McEwen, BE(HONS) Mechanical Engineering student Freya Dixon, BE(HONS) Mechanical Engineering student Rebecca Lilley, and Deputy Head of Mechanical Engineering Professor Mark Jermy

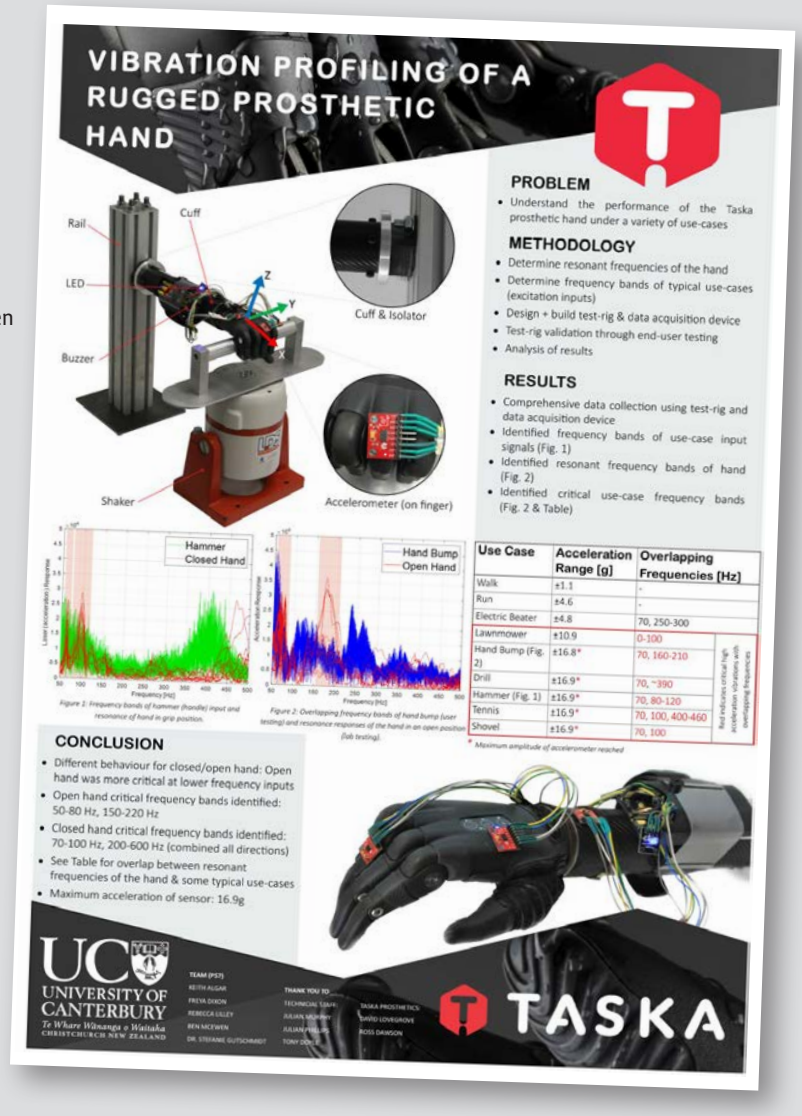
People's Choice Award Winner:

Project Poster:
"Vibration Profiling of a rugged prosthetic hand"

Project Sponsor:
Taska – David Lovegrove, and Ross Dawson

Project Students:
Keith Algar, Freya Dixon, Rebecca Lilley, and Ben McEwen

See more on page 49



Contents


Battery Technology
in Mainline Locomotives
Motivation
The project aim was to investigate and validate battery technology for mainline locomotives to reduce emissions from current diesel freight operations. This would be achieved through investigating battery-electric and hybrid locomotive design concepts and developing mathematical models. The feasibility of the proposed method was simulated through comparing the battery-electric locomotives and diesel-electric locomotives in terms of carbon emissions, fuel savings and cost.
Hybrid Consist and Power Management
Pantograph
Diesel Engine
Alternator
Battery Pack
Wagons
Diesel – Electric Locomotive
Battery Locomotive
The hybrid system modelled in this project is a 'hybrid consist' - two locomotives, one of which is a conventional diesel-electric locomotive, and one which is powered through a battery and overhead lines. Both locomotives contain six electric traction motors which draw power from the power sources located in that locomotive. The simulation manages these sources to optimise locomotive energy use.
Battery Design
600V
20,000kg
2MWh
3120 cells
The locomotive uses a 2MWh battery, equivalent to 550,000 AA batteries or enough to power 104 homes for a day. The battery uses lithium-iron-phosphate chemistry, chosen due to its availability and long life time.
Regenerative Braking
Diesel Electric Locomotive
Dynamic Brake
Resistor Bank
Battery Locomotive
Regenerative Brake
Battery Pack
The battery locomotives investigated replace a 'dynamic brake' with a regenerative brake which recovers braking energy and stores it in the battery pack. A new braking scheme was developed to increase utilisation of the regenerative brake, resulting in a 1% total energy recovery over all routes.
Simulation Results
AUCKLAND
TAURANGA
Auckland to Tauranga
1x battery-elec
Additional overhead lines
100% fuel reduction
$700 saved per trip
2,000 kg less CO2 in our atmosphere = 56 radiata pines
PN to Hawera (and back)
1x battery-elec
1x diesel-elec
80% fuel reduction
$1,600 saved per trip
4,5000 kg less CO2 in our atmosphere = 134 radiata pines
HAWERA
Auckland to PN
1x battery-elec
1x diesel-elec
80% fuel reduction
$4,100 saved per trip
11,000 kg less CO2 in our atmosphere = 332 radiata pines
PALMERSTON NORTH
Team Members:
Chrysteon Dias
Ben McKenzie
Suhao Zhang
Alex Boyd
Academic Supervisor:
Paul Gaynor
Industry Sponsor:
Mark Wilson
KiwiRail
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2019 UC Electrical Engineering Final Year Project E01

Condition Assessment of Aluminum Overhead Conductors

Project Team: David Bredda, Duncan McLeod, Fergus Duggan, Raamkumar Manickavasagam

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Purpose

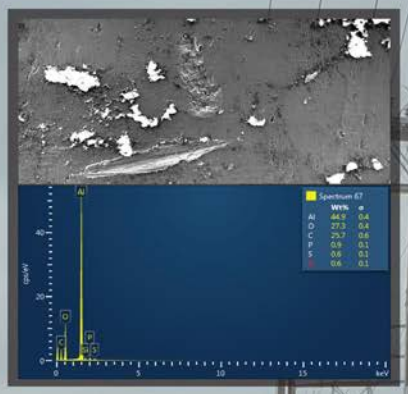
Unison uses almost 1000 km of all aluminum conductor on their network. It is essential that Unison knows the condition of these conductors and how they age over time. The purpose of the project is to carry out a range of tests on conductor samples and provide Unison with measures of their conductors condition. The results of this project will enable Unison Networks to provide a safer and more reliable network.

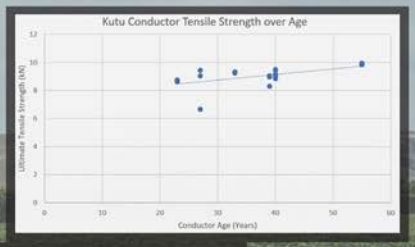
Testing

The following tests were carried out to determine the conductors conditon:

Visual Inspection
Diameter Measurement
Wrap Test
Hardness Test
Electron Microscopy
Electrical Resistance Test
Tensile Strength Test

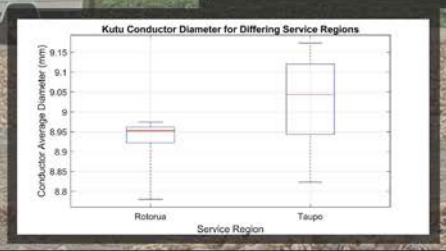
These tests provide key information for Unison to have confidence in their network assets





Results

A selection of preliminary results are shown above and to the right. The data collected from all tests will be compared against the age and environmental conditions in which the conductors were installed. This will allow correlations between condition and environmental factors to be seen.



unison
The Powerlines People

Acknowledgments
Project Sponsor: Unison Networks Limited
Project Supervisor: Associate Professor Alan Wood
Technical Assistance: Paul Agger, Kevin Stobbs, Shaun Mucalo, Nigel Pink, Ken Smart

Student projects: Electrical Engineering and Computer Engineering

TRANSPOWER

IMPACT OF DISTRIBUTED GENERATION ON THE TRANSMISSION NETWORK

PROJECT INTENTION

This project investigates the impact of increased rooftop photovoltaic (PV) and electric vehicle (EV) penetration on the transmission network.

CONCLUSION

This project has determined that even with a low PV penetration level there is potentially significant impact on the transmission network with potentially Power-Flow back onto the transmission network. However, this impact is reduced with battery storage as the batteries act as a load during periods of high generation.

Test PV & EV systems

↓

Model LV network from ICP to 11 kV

↓

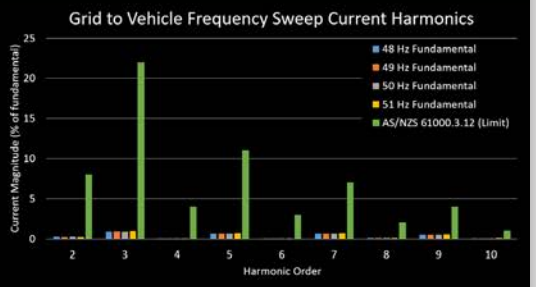
Model power flow from 11 kV to GXP

↓

Determine impact of PV & EV on the transmission network

EV & PV TESTING

As New Zealand shifts to a renewable energy future more households are expected to uptake rooftop PV and EV. The frequency and volt-var response of a modern PV with an incorporated battery system were measured along with the harmonic emissions from a bi -direction EV charger (the first of its kind in NZ). This data was loaded into the model and will be presented as part of a paper at an upcoming IEEE Conference in Dubai.

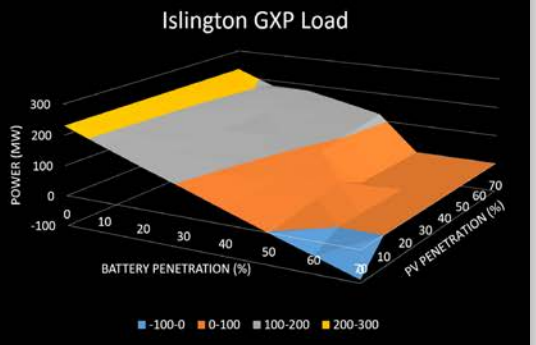


PV Penetration (%)

Battery Penetration (%)	0	10	20	30	40	50	60	70
0	230.18	181.882	135.03	90.51	43.97	-1.86	-45.4	-89.81
10	230.18	184.35	141.83	98.8	55.6	13.24	-	-
20	230.18	187.9	146.51	107.01	65.89	25.98	-	-
30	230.18	190.82	153.13	115.08	76.12	40.7	-	-
40	230.18	194.09	153.62	123.71	87.12	-	-	-
50	230.18	198.72	165.83	132.36	99.38	-	-	-
60	230.18	202.44	172.26	142.47	111.72	-	-	-
70	230.18	180.55	178.98	152	123.58	-	-	-

COMPUTER MODELING

The impact on the transmission network was determined by conducting load flow analysis on a model of the Orion distribution network. This determined Power-Flow at the GXP (where the transmission network and the distribution network meet). The model was run in two parts, part one used data from the testing and determined the loading on each of Orions 10,667 11 kV transformers. Part two took this transformer loading and conducted load flow analysis of the whole Orion network to determine the impact at the GXP. Preliminary results have found that for >50% PV penetration, Islington could have acted as a power source rather than a load at solar noon on Christmas day 2018.



Students

Michael Ellerington Tyler Patterson
Grace Russell

Thanks To

Prof. Neville Watson
Ken Smart
Edsel Villa
Dr Nyuk-Min Vong
Dr Rory Shillington
Rodney Jose

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Passive Radar for Aircraft Detection

Alex Greer
Isaac Bus
Michael Jopson
James Coleman

DAWN AEROSPACE

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Objective

Dawn Aerospace is developing a new platform that provides rapidly reusable rocket propulsion on an aircraft capable of orbital flight. The goal of the project was to investigate the feasibility of a passive radar system that is capable of detecting the light aircraft that often fly within the launch zone.

Passive Radar

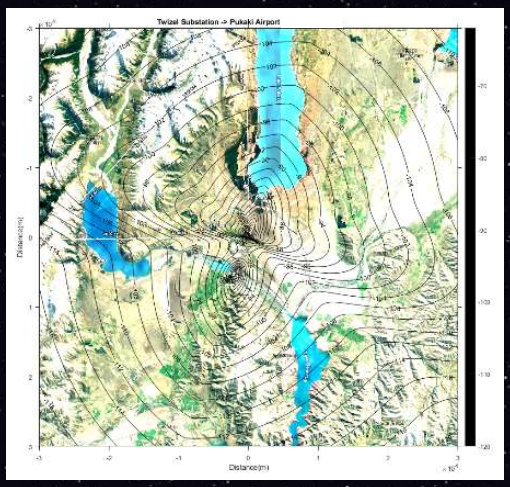
Traditional radar relies on having a transmitter to emit a pulse that scatters off targets. The receiver picks up the reflected pulse and uses the time delay and Doppler shift to calculate the range and velocity of the target. Passive radar relies on ambient signals in the environment to act as the transmitter.

Emitters of Opportunity

A key part of a passive radar system is selecting the most viable transmitter. This is based on both the physical properties of the transmitter such as location as well as the signal such as the ambiguity function. By investigating existing literature we determined the most viable signals where:

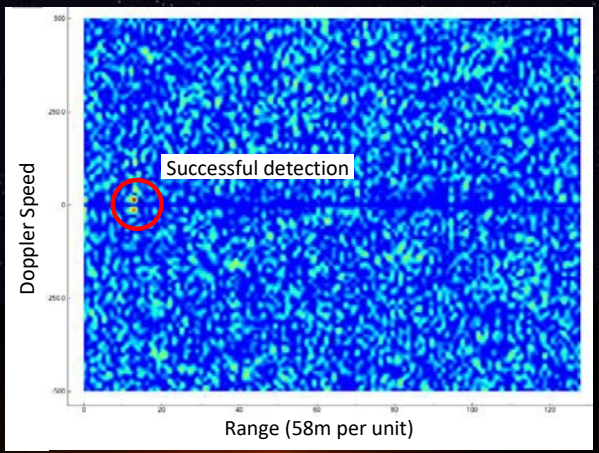
- LTE
- FM
- DVBT

FM was selected as the most suitable as it has the best coverage around the launch site.



Simulation

We developed a simulation based on the radar equation that we could use to comment on the plausibility of the various available solutions. Comment on graph. This allowed us to estimate the signal to interference ratio for the launch area based on the position of the receiver and emitter.



Range Doppler

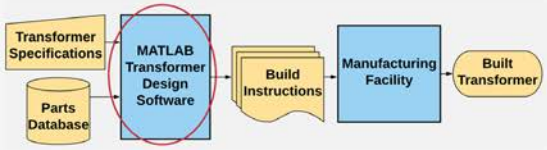
Another simulation was developed to generate range Doppler plots based on the input parameters of reference signal interference ratio, surveillance signal interference ratio, signal to noise ratio, ADC resolution and random noise. When used in conjunction with the signal power maps, this allowed us to predict detection accuracy, detection range and the amount of noise for various configurations.

Future Features of ETEL's Transformer Design Software

ETEL

Motivation

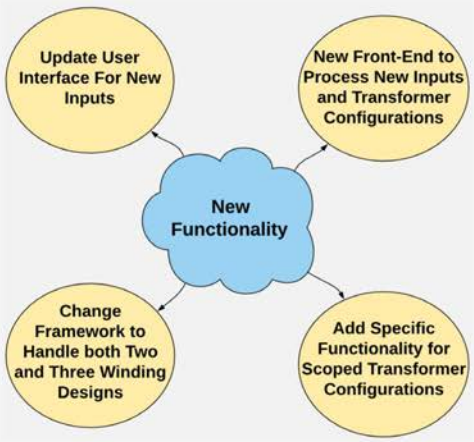
ETEL Ltd designs and manufactures distribution transformers up to 33 kV and 5 MVA. They regularly produce unique designs to match customer needs. This is done by inputting user specifications into a MATLAB software program, which then produces a selection of suitable designs and instructions for building them.



ETEL's MATLAB software program is limited to designing two-winding delta and star transformer configurations, however, ETEL expects an influx in tenures for specialty transformer configurations in the foreseeable future. To meet this demand, ETEL wants to add more functionality to their MATLAB software program. This project is scoped to add design functionality for the core and coils of;

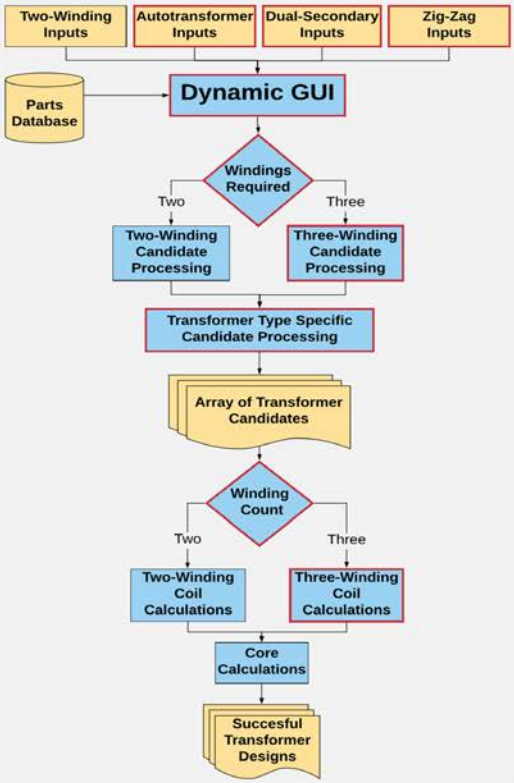
- Autotransformers,
- Dual-Secondary Transformers, and
- Zig-Zag Transformers.

Solution



Results

This flow-chart outlines the new transformer design software framework, with additions highlighted in red.



Conclusions

✓ Implemented functionality for scoped transformers. Produces viable designs for two-winding and dual-secondary transformers.

✗ Further testing is required to verify Zig-Zag and Autotransformer designs.

Supervisor: Professor Alan Wood
Group Members: Jackson Godfrey, Patrick Berry and Greg Bates
Client Contacts: Thahirah Jalal and Hans Wijaya

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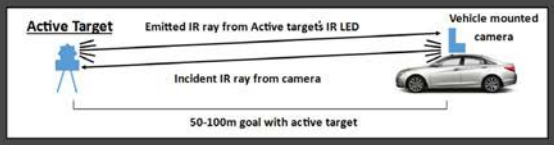
Student projects: Electrical Engineering and Computer Engineering

Long Range Photoelectric Trigger System

Trimble

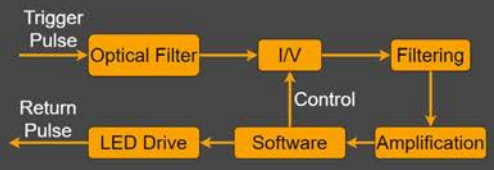
Introduction

Trimble are investigating alternative vehicle positioning systems. Our task is to investigate an active target system. This uses a vehicle mounted camera and IR LED ring in conjunction with targets surveyed into known positions around the worksite. The LED ring flashes in time with camera exposure, the target detects the incident IR from the ring and flashes its own IR LED back to be detected by the camera. Our task is to design and build an active target system in order to achieve a range of 50-100m.



Hardware

The incoming pulse train has a peak wavelength of 850 nm. A narrow passband optical filter has been employed to reduce interference from ambient sunlight. The microcontroller automatically adjusts the transimpedance gain. Some noise removal is achieved by the bandpass filter. The signal is amplified prior to software processing.



A surface mount LED pulsing at 5A is used to transmit infrared light back to the camera to indicate that the active target has been detected.

Client: Peter France

Supervisors: Dr Richard Clare, Dr Andrew Bainbridge-Smith

Technician: Scott Lloyd

Students: Jack Boulton, Jeffrey Chen, Shrina Kumar, Tessa Mann

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Software

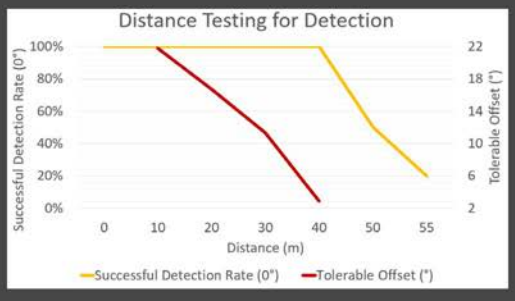
Data is sampled by the ADC following the processing carried out in hardware. The filtering stage implements a matched filter, decimation and a comb filter, which together improve the overall signal to noise ratio. During the prediction step, the system decides if the signal is present and then pre-empts the incoming signal pulses in order to synchronise the return infrared light pulse.

Eye Safety

The final product is required to comply with the photo-biological safety of lamps & lamp standards. The factors that have an influence on eye safety are the number of LEDs flashing and the duty cycle of each pulse.

Results and Recommendations

Through testing we have found that the system works significantly better when in a shady environment with the camera and active target lined up in parallel.



Below, the left signal has 6 V peaks while the right has a noisy envelope of 150 mV. Both use a resolution of 100 ms per division.

Student projects: Electrical Engineering and Computer Engineering

FAR

Autonomous Bird Deterrent Robot

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Purpose

Every year, pest birds cause up to 30 million dollars of loss to the crop industry. Netting, the most commonly used cereal crop protection method, is expensive across wide field areas and is unable to eliminate the issue of pest birds.

Solution

The Foundation for Arable Research (FAR) has proposed the solution of patrolling the field with an autonomous bird deterrent robot. This aims to reduce the cost of cereal crop protection and minimise the loss from pest birds.

Odometry

Sensors in the four brushless DC motors are read in real time to track the distance the robot has travelled. This data is then used to assist autonomous navigation of the robot.

GPS Navigation on the satellite map

Pre-Planned Paths

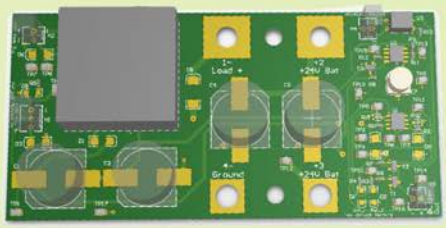
As a demonstration tool, pre-planned paths can be given to the robot. Paths are stored as lists of angles and distances. The position of the robot can be calculated using odometry.

GPS Navigation

The robot's GPS readings are fused with the odometry readings to give a more precise location for the robot in its local frame. A target location, expressed via GPS co-ordinates, is sent to the robot. The robot then calculates the distance and orientation required to travel to the target location before completing the process.

Battery Protection

Battery protection is achieved through a low voltage warning circuit, paired with a low voltage dropout relay. Together, these devices ensure that the user has ample warning when the battery is running low, and that the battery will never be discharged to a damaging level.



Future Development

The robot is now capable of performing basic localisation and navigation in the field. The next step of development is to implement patrolling and a bird-deterring navigation algorithm, allowing the robot to operate effectively.

Students
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Supervisor
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Client Liasons
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Supervisor: Prof. Phil Bones
Industry Sponsor: Dr. Iain McMillan

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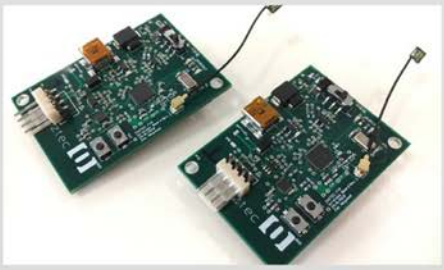
Patient Rehabilitation Inertial Tracker System

Motivation

To improve the way patients rehabilitate, making it easier for them to carry out exercises correctly, track rehabilitation progress, and be monitored by their doctors remotely.

Product—Tracker Pair and App System

Two inertial tracker units communicate over Bluetooth Low Energy and use inertial tracker units (IMUs) to calculate the leg position. The app receives this tracker data.



Test Rig

The test rig was designed to simulate a patient's leg to verify the accuracy of the trackers. Quadrature decoding of the attached rotary encoders calculates the angle of the knee and hip joint. The Tiva Launchpad Development Board was used to process the encoder information, perform required calculations, and send to a Python -written control program to filter and plot the results.

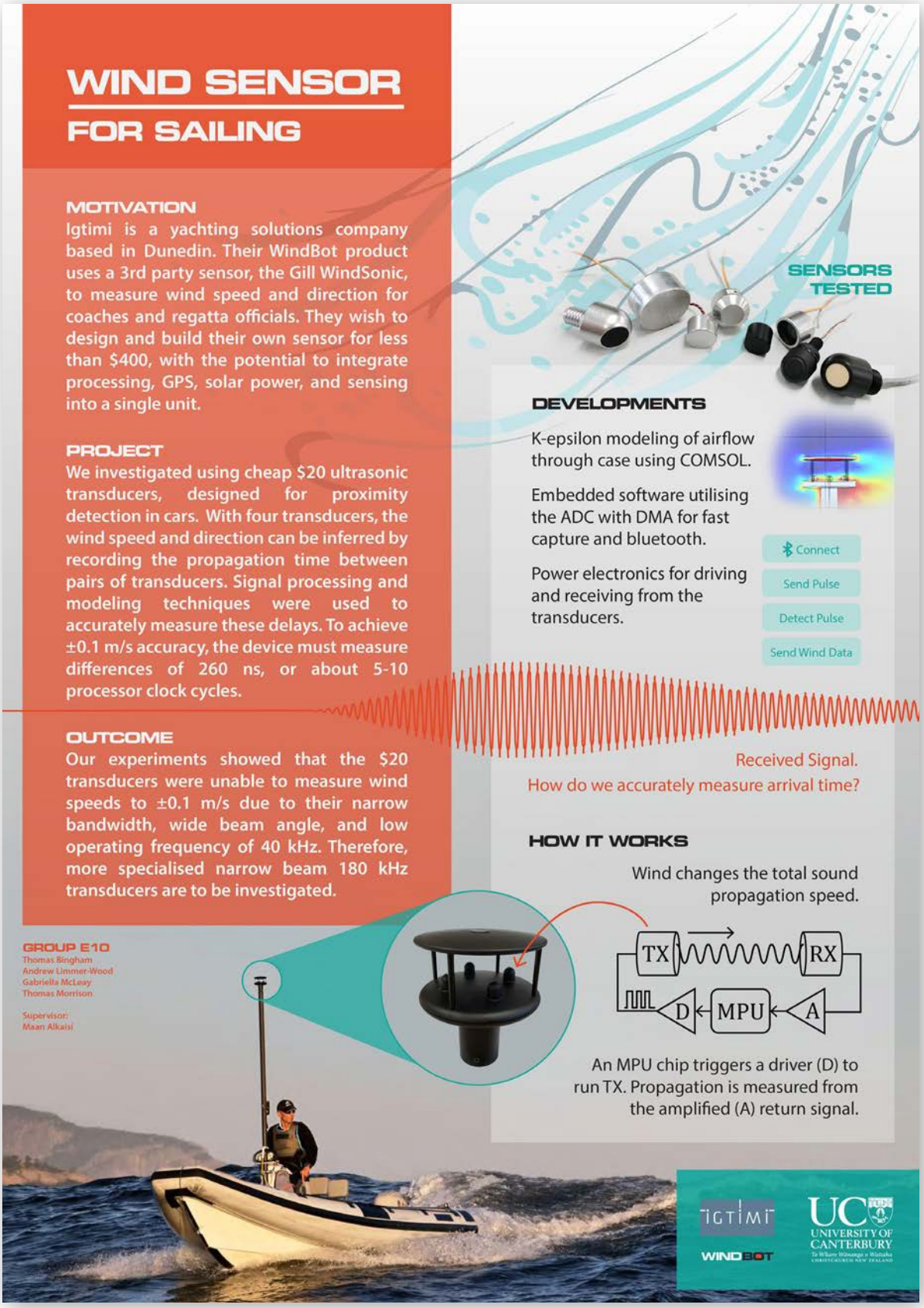
Mobile App

The app communicates with the tracker units over Bluetooth Low Energy (BLE). It guides patients through exercises prescribed by their surgeon. Information about exercises completed is sent to a server so that surgeons can track the progress of their patients, and alter the routine if necessary.

Software Optimisation

A model of the $LiMn_2O_4$ batteries was implemented. This allows the battery's state of charge to be calculated and sent to the mobile app. Data sampling interpolation is used to calculate the patient's leg motion information and send it to the mobile app as often as possible - improving throughput from 43% to 90-100%. A wireless protocol error-handling mechanism is specified to automatically reconnect and if there is an error.

Student projects: Electrical Engineering and Computer Engineering



Student projects: Electrical Engineering and Computer Engineering

methanex the power of agility

Power Factor Correction Analysis and Design

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1. Introduction and Motivation

Methanex is one of the worlds largest producers of methanol, with many methanol refinery plants operating under high electrical loads in the 10's of megawatts. Methanex has a requirement to ensure that the power they consume does not negatively affect other customers on the same line. As a part of this requirement in New Zealand, Methanex must keep the power factor of their plants above 0.95 lagging, which is accomplished through the use of large capacitor banks.

2. Project Aim

The Motunui Methanol Plant owned by Methanex New Zealand has a requirement to replace their existing capacitor banks, which are old and damaged. Additionally, the step sizes in the original capacitor banks are large and can lead to the plant either under or over-correcting depending on loading. The scope of this project involves the investigation, design, and evaluation of a new power factor correction solution for Methanex.

Analysis of existing power factor correction

- A visit to site was arranged and both voltage & currents and harmonic data was collected.
- A steady-state PowerFactory model of the plant was constructed from supplied and measured data.

Proposed solutions

- Analysis of reactive power generation requirements of the power factor correction system.
- Analysis of the distribution of major loads in the plant.
- Proposal of two solutions that meet design criteria.

Harmonic Analysis

- Analysis of existing harmonics at the plant by applying signal processing methods to collected data.
- Calculations to determine required detuning reactor sizes for the proposed solutions.

Arc Flash considerations

- Verified existing protection systems are able to open during a fault with the new capacitor banks.
- Designed a capacitor bank enclosure suitable for the harsh coastal climate of Motunui.

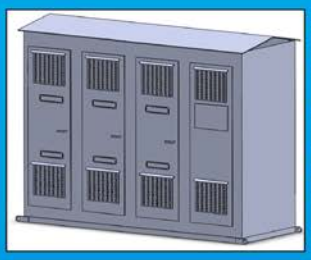


Figure 1: Enclosure designed to house the capacitor banks. The enclosure provides protection from arc-flash as well as a rating of IP55. Positive air pressure is maintained by an HVAC system to keep out contaminants such as dust.

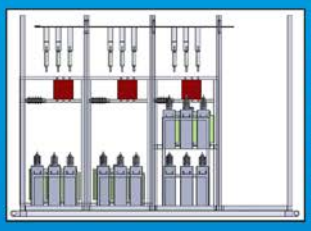


Figure 2: Interior of the enclosure showing placement of capacitor banks, vacuum contactors, detuned reactors, and main fuses. Enclosure is compartmentalised to protect equipment in case of a fault.

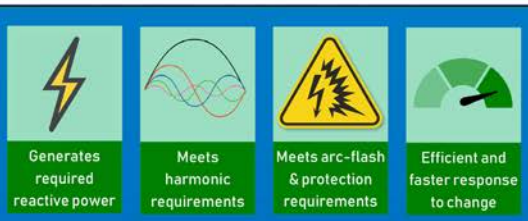
3. Proposed Solutions

Option 1: Replace the existing setup with similarly sized (5.6 MVAR total) capacitor banks using smaller step sizes. These capacitor banks would be placed on the two 11kV busbars.

Option 2: Place capacitor banks close to large loads in addition to two banks on the main feeders for smaller loads (5 MVAR total).

4. Analysis of Solutions

Option 2 provides a more thorough solution to the problem of power factor correction and will result in lower plant losses as well as extension of the life of equipment. This is achieved at the cost of a higher upfront investment, with option 2 costing $500,000 compared with the $300,000 of option 1. Both options meet harmonic criteria and do non breach relevant arc flash standards.



Final Year Project

Electrical and Computer Engineering

Project Team E11

Team Members
David Klein Ovink
Cameron Wyatt
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Najwa Khairul

Supervisor: Prof. Neville Watson

Client: Peter Tait
Leif Warren

Acknowledgements:
Reuben Theobald, Mark Lavus, kVArCorrect Ltd

Meridian.

Air-Insulated Instrument Transformer

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CHRISTCHURCH NEW ZEALAND

Overview

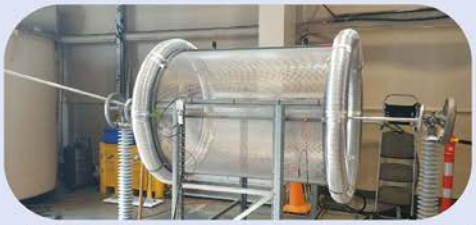
Large generators need to be synchronised in order to connect to the grid. This requires measurements of the grid voltage and current waveforms which is traditionally done using instrument transformers insulated with oil or SF_6. A concept is proposed for a cheaper instrument transformer that uses only air as the insulating material.

Concept

The air-insulated instrument transformer (AIIT) combines a capacitive voltage transformer (CVT) and a current transformer (CT). A series of AIIT prototypes were built and tested in accordance with IEC standards for proof of concept and accuracy. The designed prototypes are scaled equivalents of a 220kV network.

Capacitive Voltage Transformer

A large cylindrical tube surrounding a smaller conductive line acts as part of the capacitor divider in the CVT. The resulting output current signal of the capacitor divider is fed to an op amp for amplification.



Ideal 220kV capacitor parameters depend heavily on the polarity of the streamer discharge process and the strongly non-uniform electric field strength on the curved tube edges.

Rogowski Coil

The CT design is based on a Rogowski coil which can produce a voltage output proportional to the current. A Rogowski coil has no core, making it unable to saturate. This will allow the CT to operate at high current and frequency ranges.

The output voltage is fed directly into an instrumentation amplifier which applies a gain to the signal. The voltage signal is then converted to an equivalent current signal using an integrator.

Voltage Transformer Feasibility

The prototype passes the AC Power Frequency and Lightning Impulse Withstand as per IEC 61869-5. The resulting output from the instrumentation had a voltage magnitude error of 3.5%, outside of the required IEC standard range. The accuracy of this design must be improved upon and further advanced transient analysis of the frequency and phase response is required.

Current Transformer Feasibility

The Rogowski coil resulted in an output signal error of 0.9%. Testing results found that the circuit gain could be tuned as required according to IEC 68169-2. It is therefore suggested a Rogowski coil is capable of producing a signal to meet the synchronisation needs but further testing of the insulation withstand is required to confirm the fault detection ability.

Student Members:
Ben Buckley
Jessica Silcock
Maria Langdale
Mark Struthers

Supervisor:
Andrew Lapthorn

Sponsor:
Rowan Sinton

Hydro Generator Simulator for Verifying PLC Programming

Meridian.

Sponsor: Rowan Sinton
Supervisor: Andrew Lapthorn
Project completed by Emily Adams

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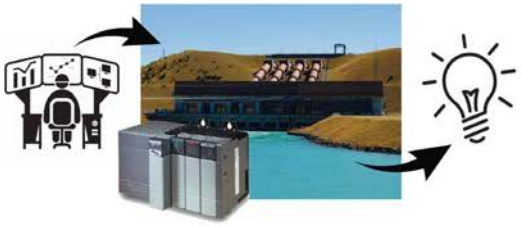
Project Context

Programmable Logic Controllers (PLCs) are used to control and monitor the operation of Meridian's hydro assets. At a Ōhau A Hydro Station, there are PLCs dedicated to each generator unit and the local, station and hydrological services. Successful power generation depends on these PLCs operating correctly, and this relies on good PLC programming. This project involved determining the validity of an alternative PLC programming verification method to on-site testing.

Current Verification Methods

Meridian relies heavily on on-site testing to verify new programming for the PLCs. This method has numerous disadvantages. These include:

- Interrupting normal station operation is expensive.
- Labour and logistically intensive.
- Risky to staff, nearby property and the New Zealand power grid.
- Testing coverage restricted by hardware restraints.



Solution Requirements

The overarching requirements that the solution must adhere to are as follows:

- Determine the feasibility of environment simulation for PLC programming verification.
- Solution must feature a user interface.
- Solution must be scalable for future development.
- Solution must be at deliverable stage by October.

Proposed Alternative Verification Method

Environment simulation was selected as the alternative method to verify the PLC programming. This proposed solution involved communicating between a MATLAB Simulink environment simulation and a Emulate 5000 PLC emulator via Open Platform Communications (OPC) protocol. OPC protocol is frequently used in industry to allow PLCs to communicate with incompatible software.

The PLC emulator runs the PLC programming to be verified, and the MATLAB Simulink program runs the environment simulation, which is optionally configured to have certain fault conditions by the user via a Simulink graphical user interface (GUI). The emulator then communicates the response from the PLC emulator to the MATLAB program which is displayed to the user via the GUI.

Results and Discussion

This solution was implemented to verify the high pressure lube pump (HPLP) control section of the Ōhau A Unit 7 PLC programming. A quasi-steady state environment simulation was developed to simulate the pump start up. This environment simulation ran successfully and illustrated that the PLC programming had no faults, as expected. The specified fault conditions also raised the correct responses when enabled by the user.

These results demonstrate that environment simulation using Emulate 5000 and MATLAB Simulink to verify PLC programming is feasible. However, the testing result reliability depends on the accuracy of the environment simulation. In the case of this project, the environment simulation was quasi-steady state which does not fully encapsulate the real plant behavior.

Conclusion

The solution in its current form would provide a good supplement for current on-site testing, however it is not recommended that it replace on-site testing. A more detailed environment simulation must be implemented. Overall this project has proven the feasibility of environment simulation for verifying PLC programing.

Student projects: Electrical Engineering and Computer Engineering

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UNIFIED VEHICLE PLATFORM REFRESH

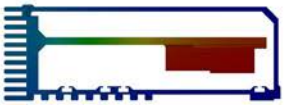
tait communications

OVERVIEW

Tait's Unified Vehicle is an in-vehicle communication platform that unifies connectivity by combining radio, cellular, WiFi, and Bluetooth into one package. The platform refresh project produced a prototype for the next generation of Unified Vehicle, with several key improvements.

ENCLOSURE: Lower cost, higher performance.

The new enclosure provides more space and thermal dissipation, whilst minimising manufacturing cost and complexity.



Key features:

- Extruded aluminium base and cover
- Cast aluminium internal heatsink
- Designed to accommodate an IP65 rating
- Mechanical sliding fastening between base and cover
- -40 to 60 °C operating range

POWER SUPPLY: More power, more resilience.

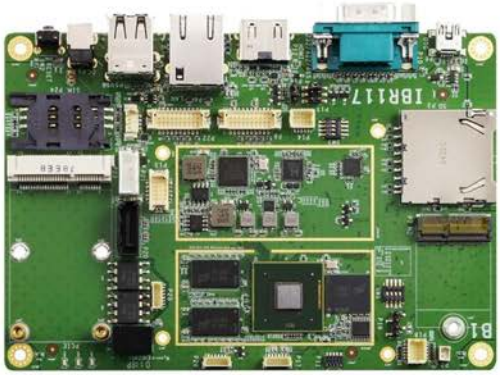
The new step up-step down power supply ensures the required 12V for the compute board, with a synchronous buck-boost converter. The power supply can provide 10A to the compute board, and 2A fast charging to USB devices.

Key features:

- Wide 9-36V input range, 12V, 24W output
- 5V, 10W USB output
- High 94% efficiency
- -40 to 125°C operating range

COMPUTE BOARD: Faster, modular, feature rich.

The compute board has been redesigned with a far superior processor, and a futureproof modular expansion system.

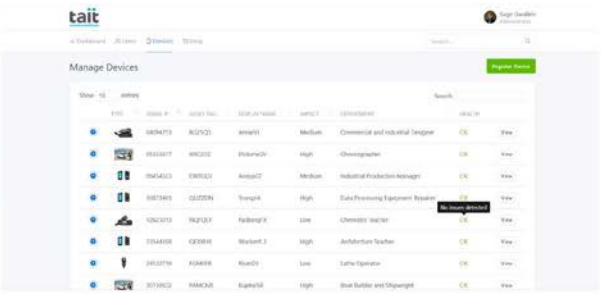


Key features:

- RS485, GPIO, signal and audio conditioning
- Audio injection, compatible with remote control heads
- 2.5x faster CPU, 10x faster networking
- 2x more RAM, 4x more flash storage

USER INTERFACE: Visibility, configuration, control.

An enterprise device management platform to centrally control your Tait Unified device ecosystem.



Key features:

- User authentication and management
- Enterprise ready
- Remote device management
- E-commerce device store
- Fully responsive web application

Group: E13, ENEL400, 2019
Supervisors: Philippa Martin, Mike Shurety
Students: Paul Palitog, Sage Gwatkin, Scott Davidsen, Ronan Fraser

WIRELESS COMMUNICATION FOR ROCKET TELEMETRY

Group E14
Ryan Hall | Sam Pell | Hamish Robertson
Sponsor: Robin McNeill, Great South | **Supervisor:** Dr Chris Hann, University of Canterbury

Overview

Southland regional development agency, Great South, is interested in providing tracking and telemetry services to NZ's growing aerospace sector. They formed a partnership with UC's Dr Chris Hann who is interested in transmitting real –time telemetry data from a rocket for analysing control algorithms. Great South already has a satellite ground station; the missing piece was a compact, low-cost rocket-based radio transceiver and antenna.

1 S-Band Transceiver

- Design began with the OpenLST (***fig. 1***), an opensource UHF transceiver for CubeSats.
- A new S-band transceiver (***fig. 2***) was designed to meet spectrum requirements for aeronautical use.
- Software libraries were redeveloped to protect IP rights

Figure 1 *OpenLST*

Figure 2 *S-Band Transceiver*

- Two-way comms (half-duplex)
- 2FSK Modulation at < 250 kbps
- 2 MHz of bandwidth at 2.08 GHz
- Compact form-factor (fits in a CubeSat)
- Can transmit from orbit (30 dBm output)
- Interfaces with rocket over serial bus

2 Omnidirectional Antenna

- An array of novel circularly polarised patch antennas for omnidirectional coverage (***fig. 3***)
- Circular polarisation allows transmission through the ionosphere and reduces susceptibility to multi-path interference
- Etched on planar PTFE substrate and conformed to the rocket fuselage

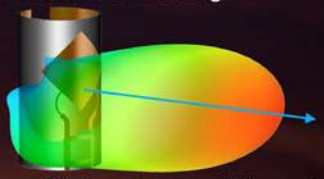


Figure 3 *Single antenna radiation pattern*

3 Ground Segment

- Initial design and spec of a portable ground segment
- Serial-controlled DC motor-driven elevation-azimuth rotator (***fig. 4***)
- Investigated single-antenna rocket tracking methods

Figure 4 *Elevation-azimuth rotator*

4 Future Work—Ad Astra

- Future transceiver revisions to include low power mode for CubeSat applications
- Continue developing software features
- Perform range testing experiments
- Develop ground station tracking algorithms

GREAT SOUTH

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IOT EARTH FAULT SENSOR

Overview

Earth faults on an electrical network can expose the public to hazardous voltages. Mitton ElectroNet have a vision to develop a IoT sensor to detect these faults, allowing asset owners to quantify the risk of an earth fault on their networks.

Fault Detection and Recording

The Earth Fault Sensor (EFS) was designed to record earth voltage rises of up to 250V. A voltage divider network with Zener diodes ensures that the microcontroller is not exposed to potentially dangerous voltages. A fault recording sequence in software is utilized to accurately record key information from earth faults.

Power Supply

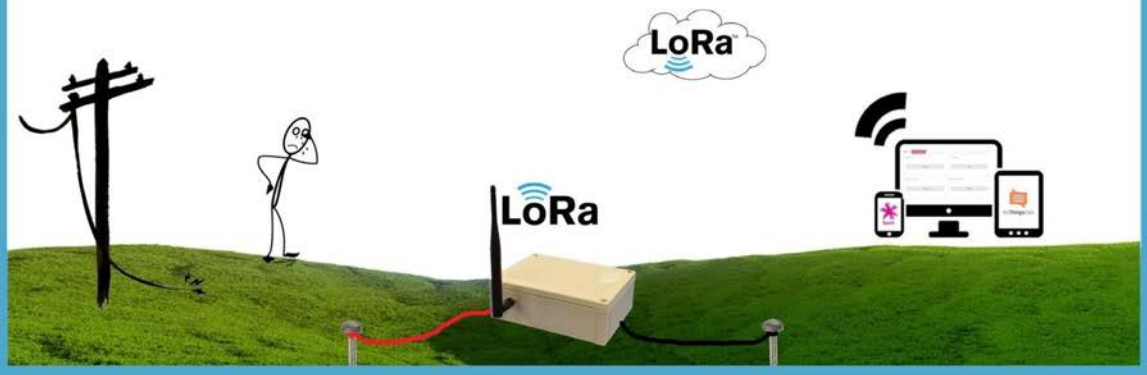
Solar power and a LiFePO4 battery provide the EFS with power in remote locations. A charger with additional protection circuits are implemented to ensure the reliability of the system.

Communications

The communications are done via LoRaWAN, which is a long range low power communication system. Information about the earth fault voltage rise, fault duration and battery condition are packaged using a custom binary language and transmitted wirelessly to a cloud server.

Test Rig

The test rig validates the functionality of the EFS by simulating earth faults. Mains voltage is applied through soil in a protective container where the EFS probes can be placed. A Variac is used to determine the fault voltage and a programmable relay sets the fault duration.



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Team Members:
Daniel de Gouw
Ke Gao
Laura Harding
Jed McDermott

Project Supervisors:
Richard Clare
Andrew Bainbridge-Smith

Mitton ElectroNet

Student projects: Electrical Engineering and Computer Engineering

PROJECT OVERVIEW

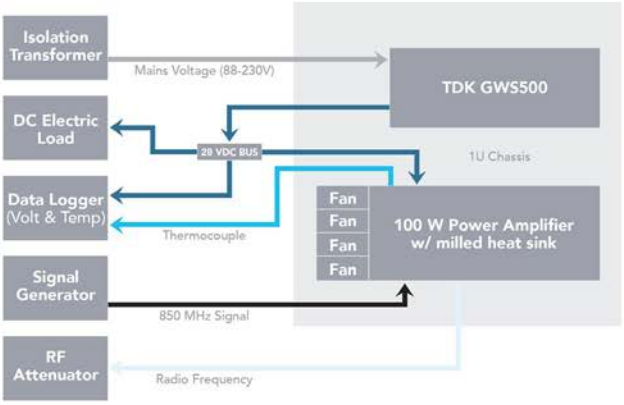
- Tait's current PMU meets the required specifications, however, it is outdated and can be improved upon
- We produced a prototype solution that powers up a TB9300 base station
- We used a test rig to test mechanical, environmental, thermal, EMC safety and power performance

SELECTION

The **TDK GWS500** was selected for testing as datasheets indicated it meets or exceeds the requirements for: **output power** and **voltage, temperature range, form factor, efficiency** and **cost**

TESTING & INTEGRATION

- The test bench was developed for:
  - Thermal and electrical verification of TDK GWS500
  - Determining thermal viability of 1U 100W base station
  - Conducted emissions testing
- Integration with existing Tait hardware was tested and verified
- The GWS500 output voltage was controlled by the existing internal voltage control loop



TESTING RESULTS

	COST ($)	POWER (W)	AUX OUTPUT	TEMPERATURE (°C)	SIZE (MM)	MTBF (HOURS)	EFFICIENCY
GWS500	SINFO	504	NOT APPROPRIATE	-25 TO 70	105*218*41	120K @50°C	89%
REQUIREMENTS	?	✔	✖	✔	✔	✔	✖

UC UNIVERSITY OF CANTERBURY

Students: Isaac Abbot-Martin, Liam Crum, Dylan White, Jack Wilkie
Supervisors: Alastair Christie, Dr Le Yang, Qazi Rooh-ul-Amin

tait communications

Student projects: Electrical Engineering and Computer Engineering

VYNCO

IoT Home Automation

Ash Gupta
Jeena Joseph
Kieran Hitchcock
Michael Brorens

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Project Overview

Vynco Industries are interested in exploring the growing market of home automation. New IoT ideas were explored and prototypes for Smart Lights and Smart Switches were designed and created. These prototypes have a number of features which can automate the control of a lighting system.

The Smart Switch and Light are able to work together, or with non-IoT devices from other manufacturers. Control of each device is achieved either through a prototype phone app or input from a large range of additional sources.

How It Works

Phone App
Users control their smart devices using the phone app

Cloud Server
Firebase connects the phone app and hardware

Custom Hardware
Control Smart Lights and Switches

Features

Touch Enabled Switch
Use a touch controlled slider switch to control lights

InfraRed
Control VyncoHome devices automatically with your TV remote button

Motion Sensing
Turns off VyncoHome device when no motion is detected

Over the Air Update
Developers can push software update to the devices automatically

Scheduling
Allows users to switch on/off Vynco Devices at a given time

Pattern Recognition
Understands your habits and adapts your lights to your lifestyle

Smart Configuration
Easily configure multiple devices with a single click of a button. Takes only 5 seconds per device

Google Assistant
Voice controlled lighting system that works with Google Home

IFTTT Integration
Works with other IoT devices such as Philips Hue, Amazon Alexa, and Nest Cameras

Geo-Fencing
Automatically control lights based on the geo-location from your phone

Fast to set up, Designed for people, Flexible with your lifestyle

Student projects: Electrical Engineering and Computer Engineering

SunshineSolar

Glenthorne Station
Battery Management System (BMS)

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CONCEPT

Energy storage is essential to get the most out of solar power. Sunshine Solar intends to develop a BMS that will utilise old EV batteries. This will make energy storage:

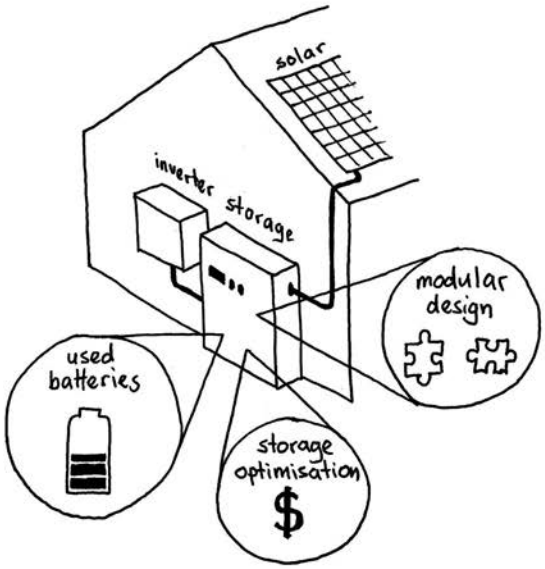
- Cheaper
- More accessible
- More environmentally friendly

PROJECT

Glenthorne Station is a high country farming station looking to install solar panels and energy storage.

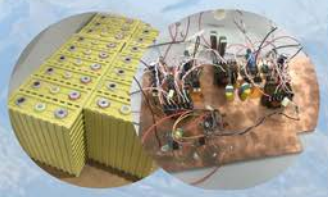
A system was designed for the site and prototyped using a bank of four Li-Ion cells. The key design goals were:

- Effective cell balancing
- Modular design for ease of expansion
- Battery bank isolation for safety
- Charge optimisation for cost savings



CELL BALANCING

Cell balancing provides a uniform charge and discharge of cells within the battery bank. This is critical with used cells as there is an increased chance of imbalance causing over-charge or over-discharge. The cell balancing circuit used for this project utilises a pulse transformer topology that employed MOSFET's to energise windings in a power transformer whereby creating a connection between individual cells. This design is robust because it is capable of balancing large variances in cell charge.



CELL MONITORING

Cell monitoring involves measurement and processing of each cell's voltage and temperature, to protect against thermal runaway. Data acquisition was performed by an Arduino controlled embedded system, designed with modularity in mind. The system includes a WiFi module which hosts a socket server for data transmission to the user's remote device. If there is no connection to a remote device, events are instead logged in system memory and transferred across upon reconnection.

Supervisors	Sunshine Solar	Students	
Steve Weddell	John Wilson	Jesse Baxter	Mike Muldrew
David Van Leeuwen	David Maples	Sam Johnson	Oliver Quarmby

E19: IO PACKAGE FOR SIMULATION HARDWARE

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CHRISTCHURCH NEW ZEALAND

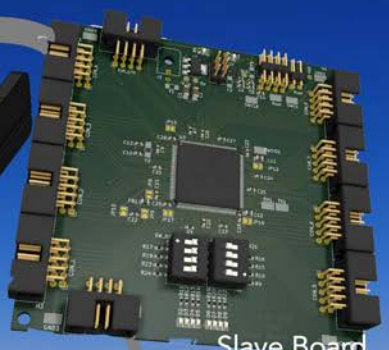
Sponsor: Pacific Simulators
Supervisor: Ciaran Moore
Team Members: Janitha Gunathilake, Shun Lyu, Nicole Smith, Michael Hatton

PROBLEM

In order to produce certified pilot training devices, Pacific Simulators require a system built inhouse to translate signals from the cockpit to the simulator PC. The latency of the round trip must be less than 300ms, and the interface to the PC must be UDP.

SOLUTION

A hierarchical system with breakout, slave and master boards was designed. Each slave board has up to 80 inputs and thus can interface from up to 8 breakout boards. Each master can interface up to 8 slave boards.



The production ready version of the master board has ESD protection diodes on all inputs and outputs to increase robustness.

UART

BOARD TYPE (4 BITS)	BOARD NUMBER (4 BITS)	HW ADDRESS (8 BITS)	HW STATE (8 BITS)

The slave boards use round robin schedulers with interrupts for IO and UART. The master board receives with interrupts and utilizes an RTOS scheduler to send and receive UDP packets.

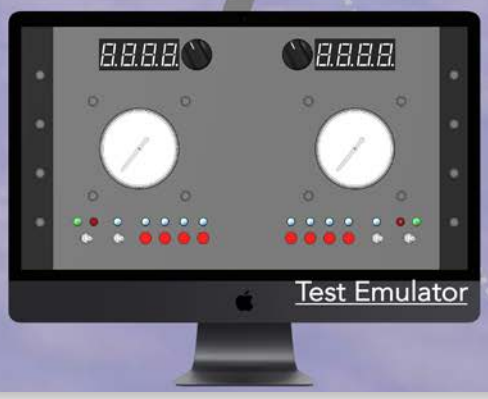
UDP

RESULTS

The average system latency is 25ms, with a maximum of 110 ms thus exceeds the requirement.

CONCLUSION

The solution has proven the concept of the design and allows a foundation to build the product upon in the future.



UDP HEADER
SINLGE DATA PACKET (3 BYTES)
...
SINLGE DATA PACKET (3 BYTES)
UDP TRAILER

PacSim

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WIRELESS TREETAP

A non-destructive tree stiffness measurement device (E20)

Authors: M. Franks, R. Anderson, C. Davidson, K. Olsen Supervisor: M. Hayes

Problem

How do you tell how stiff the wood in a tree without damaging the tree?

Solution

Measure how quickly a shockwave travels through the wood. The stiffer the wood, the faster the wave travels.

Results

- Custom-made device to measure the shock-wave propagation and send the data to a smartphone via Bluetooth
- The smartphone uses signal processing to calculate the stiffness of the tree and stores in an online database with GPS location
- User-friendly app to perform measurements and access database, including a map of the trees and their corresponding data

Conclusions

- Wireless handheld devices increase mobility in the forest and reduces trip hazards, and the included belt strap further aids mobility
- Using maps and a GPS system increases ease and speed of user operation and the locating of trees in the forest
- Cloud data storage makes for ease of post-measurement data access and manipulation

How to measure the stiffness of a tree?

1. Insert probes into tree 1-metre apart
2. Insert and strike stake to induce shockwave in tree
3. Device produces a tree stiffness measurement and stores it in an online data base with corresponding GPS coordinates

Student projects: Electrical Engineering and Computer Engineering

Electrical

UCM19

Electrical Objectives:

- Create easily serviceable systems
- Design components to maximise reliability and performance
- Realise the full potential of the Four-Wheel Drive Powertrain

Tractive System

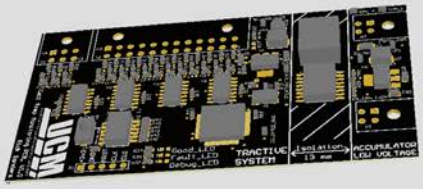
- Revised battery technology offers improved volumetric efficiency while a new accumulator layout affords easier packaging within vehicle and serviceability.
- An increased tractive system voltage brings improved top speed, and high speed power and torque.

Vehicle Dynamics

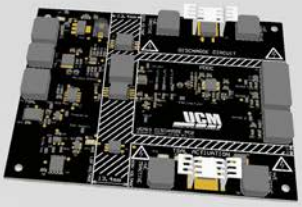
- Torque vectoring intelligently optimises motor torques independently for maximum traction and minimal wheel slip
- Regenerative braking implemented to restore accumulator cell energy
- Advanced automotive-class GPS to track vehicle kinematics
- On-the-fly computation using Vehicle Control Unit (VCU)

Shutdown Systems

- Embedded systems act as low power computers and ensure the car runs safely, efficiently and reliably
- Required the design of PCBs and firmware for cell temperature monitoring, fault detection and electrical isolation



HV Electronics



- Tractive System Activation Light (TSAL) indicates to onlookers when the vehicle LV system is live and when the HV system is live
- Accumulator Voltage Indication Light indicates when a voltage is present on the output of the Isolation Relays in the Accumulator
- Used to precharge and discharge Inverter input intermediary capacitor
- PDOC monitors temperature of precharge and discharge components to detect component failures

UCM
UNIVERSITY OF CANTERBURY MOTORSPORT

Client: University of Canterbury **Faculty Advisor:** Bruce Robertson
Supervisor: Paul Gaynor
Technicians: Philipp Hof, Scott Lloyd, Zac Perston
Students: James McEwen, Matthew Northcott, Rick Sanders, Anthony Watson

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Student projects: Electrical Engineering and Computer Engineering

Shell Eco-Marathon Asia 2020

The Shell Eco-Marathon is a race that is won by efficiency. The Urban Concept class competition focuses on new ideas to bring to cars that one might find in a modern city

Team Members

Lawrence Sheddan
Aidan Prior
Gregor Moonen
Henry Wills
Tom Somerville
Alex Ryde

Supervisor

Dr. Volker Nock

Body

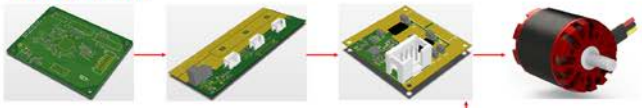
The body of the car was designed to perform well and be environmentally friendly. It is to be manufactured from a wool composite, similar to fibreglass, but renewable, biodegradable and with a unique appearance.

From CFD analysis, the car has a drag coefficient of approximately 0.13, a very competitive figure for an urban concept vehicle.

Chassis

The chassis was designed to provide the stiffness and strength for the car, also being made from bio-derived materials. The runners were made from a biodegradable foam/bamboo plywood sandwich structure, while the panels were made from thicker bamboo plywood.

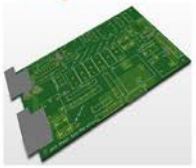
Drive Train



Using Texas Instruments' InstaSPIN-FOC, a signal is fed into the inverter which drives switching currents through the BLDC motor.

The inverter features a modular design which enabled the team to test the design more efficiently. The design also makes use of Gallium Nitride transistors, an emerging, more efficient technology.

Peripherals



The driver operates the peripherals from switches located on the dash board.

The race specifications require peripheral circuitry in the vehicle to compete in the race, replicating a road legal vehicle.

- Functional horn and window wipers
- Functional indicators, hazards, headlights, and brake lights.

The aim of this project is to win the 2020 Shell Eco-Marathon Asia Urban Concept Class race, while upholding the University of Canterbury's innovative reputation.

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SCION FORESTS • PRODUCTS • INNOVATION
BPN Sustainable Bio-Based Technologies
BARRON SURFBOARDS NEW ZEALAND
Woven Bamboo
NEW ZEALAND MERINO

Student projects: Forest Engineering

The Two-Stage Revolution?

An Honours Project by: Tom Rendell (tre43@uclive.ac.nz)
Supervised by Prof Rien Visser & Dr Hunter Harrill

Forestry harvesting is currently heading into many new forests that are first rotation, on steep terrain and with limited infrastructure. Steep terrain forests have an increased harvesting cost due to specialized machinery, difficult roadways, and environmental risks. In smaller woodlots the infrastructure has larger impacts compared to larger scale plantation forests. To mitigate these adverse infrastructure effects some contractors have started two-staging.

Two-Staging

Two-staging is transporting stems or logs from a smaller landings/pad to a larger Superskid to be processed or stacked into log grades, then fleeted onto highway trucks. A two staging system, such as the Tatra truck shown above, can reduce forest roading by increasing the road grade, can reduce landing size by frequent log removal and having a small turn around area for the truck.

Project

- Survey Forestry contractors and managers to establish the drivers both for and against two-staging systems.
- Measure the two-stage infrastructure in the Kenderdine forest and compare to the original conventional plan.

Survey

Surveys indicate there are several different two-stage systems in operation, a skidder, a modified dump truck all the way to a "super forwarder" as pictured above.

The survey process revealed that there are two main groups that use two-staging. Those who are forced to and those who choose to. Those who are forced to saw extra cost as a deterrent to two-staging and mostly used a skidder or shovelling machine to a processing skid that was close to the haul pad. Those who chose to two-stage saw many benefits from the system and mostly used a central processing skid where log trucks did not enter the forest.

Kenderdine Forest

Picture above shows the difference in planed (yellow) and implemented (red) roads. The comparison of the measured infrastructure to the original plan revealed a roading reduction of 2940m which was a %23 reduction. The landings measured ranged from 221 – 3836 m^2 which compared to literature ranges of 1370 – 12540 m^2 shows a reduction of average landing size of 47%.

Acknowledgements

I would like to acknowledge and thank Marcus Musson from Forest360, Trevor Best and Campbell Harvey from the School Of Forestry for their help and contributions to this project.

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Student projects: Mechanical Engineering and Mechatronics Engineering

Firstgas

Noise Attenuation of Gas Regulating Equipment

Introduction

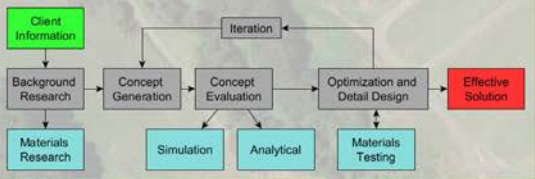
The broadband noise from First Gas pressure regulating equipment at their Te Rapa facility is currently attenuated by an acoustic enclosure. This enclosure has reached the end of its life and requires replacement. The project has focused on finding a customised, modular solution to replace this enclosure. The solution must successfully attenuate noise to ensure compliance at the site boundary.

Scope

The main project requirements focused on:

- Noise Attenuation
- Cost
- Safety
- Compliance
- Ease of Use
- Aesthetics

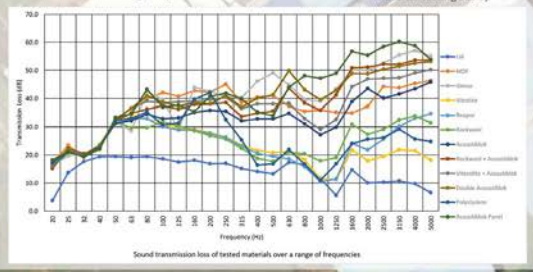
Design Process



Material Research and Testing

The transmission loss of a variety of materials was tested. The results from these tests aided in the material selection process for the final concept. Results are shown in the graph below.

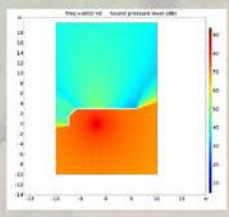
Material testing set up



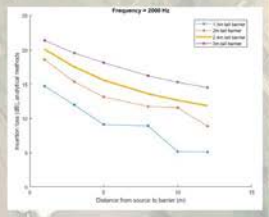
Sound transmission loss of tested materials over a range of frequencies

Modelling

Modelling was completed numerically in COMSOL and validated against analytical equations.



Sound pressure level (dB) with barrier configuration shown in white

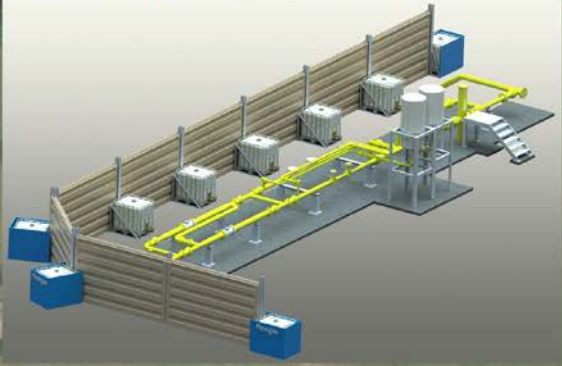


Noise attenuation of barriers of different heights over a range of distances from source

Final Concept

A modular barrier solution using a proprietary acoustic noise wall has been designed. Its required stability and mass is achieved with water filled containers. As required by First Gas the system is easy to move and can be quickly deployed to site.

View of Barrier at Te Rapa Site



Future Work

The final concept has been detailed to allow First Gas to fabricate the design. A trial of the design will be tested at Te Rapa and may result in the system being used at multiple First Gas sites in future.

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Firstgas
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Dan Tan

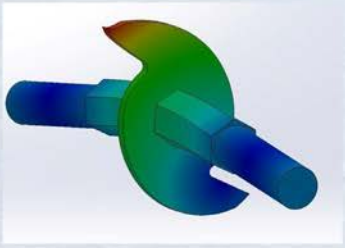
Student projects: Mechanical Engineering and Mechatronics Engineering

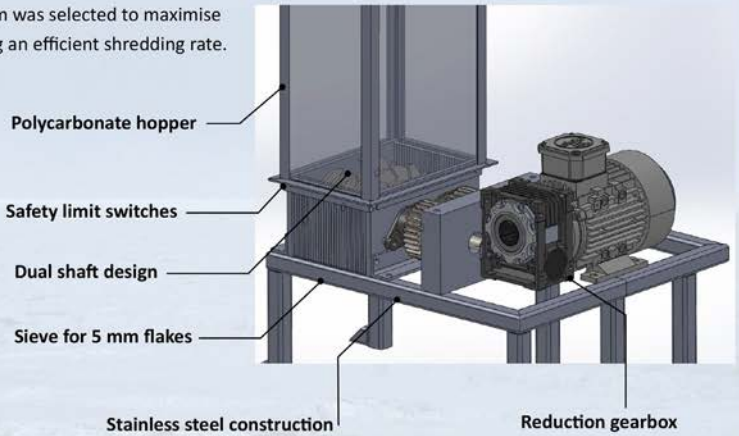
SOLVING THE PLASTIC WASTE PROBLEM AT THE LOCAL LEVEL

Current Problem: Plastic pollution is a major issue with more than 5 trillion pieces of plastic floating in the world's oceans. Many small communities around the world lack formal waste systems, often adding to the problem with waste either dumped in the sea or burnt. One place where this is evident is the small pacific island of Uoleva in Tonga, where plastic washes ashore and is burnt. This project aimed to create a small scale plastic recycling scheme for the island, starting with a shredder.

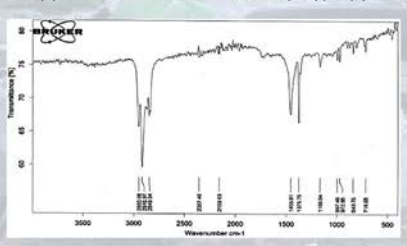
Shredder Design: The Precious Plastics shredder was modified to be a dual shaft design. It had added safety features including the 0.8 m polycarbonate hopper so the shredder blades cannot be reached, and safety interlocking limit switches which ensure the shredder will not run unless the hopper is attached. A speed of 75 rpm was selected to maximise torque and minimise dust produced, whilst retaining an efficient shredding rate.

A common issue for existing shredders is tip breakage on the blades. Simulations and FEA were performed on different blade designs to produce the blade pictured below. This resulted in tip deflection being reduced by a factor of 10.



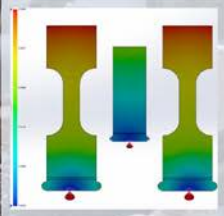


Plastic Grades: A sample of washed up plastic from Tonga was analysed using spectroscopy and determined to be 95% polypropylene (PP), 4% high density polyethylene (HDPE), and 1% low density polyethylene (LDPE) by weight.



Solar Power: A solar power system has been designed to power the shredder in a remote location. The following components will be needed:

- 330 W Solar panel
- Charge Controller
- Deep cycle batteries
- Power inverter (needed for an AC motor, to convert from DC to AC)
- Motor driver (needed for a three phase motor)



Testing Moulds:

A plastic injection mould die with Charpy and tensile specimens was made for material tests of recycled plastics. This will enable future experimentation of plastic compatibility.

Future Work:

Subsequent teams may use the shredder and moulds to test compatibility of different waste plastics. They could also design a small scale extrusion machine for the shredded plastic to produce a useful product. A related project could be the design and build of a handheld spectroscopy device for identifying types of plastic to be recycled.

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Robert Fowler
Adrian Midwood
Precious Plastics
Glen Duncan
Karen Duncan
Rob Upritchard

PLASTIC™ OCEANS
OCEAN AMBASSADORS

ELECTROSTATIC SPRAY SYSTEM

AN OPPORTUNITY

Traditional pesticide spray methods use high volumes of spray to ensure plant coverage.

Electrostatic spraying uses a high voltage to charge the spray droplets, inducing an attraction between the droplets and the plant. This causes a wrap around effect of the plant. We have shown that compared to conventional spraying, this can improve coverage on the back of the leaf by up to 15 times.

Our team's goal has been to create an effective electrostatic spraying system, improving spray coverage, at a lower cost compared to existing electrostatic technology.

ELECTRODE HOUSING DESIGN

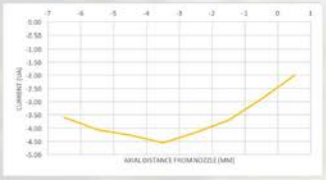
A housing was designed and 3D printed as a prototype, to waterproof the electrode (red) and locate it accurately relative to the nozzle (purple).

ELECTROSTATIC CHARGING

Optimisation

The charging effect was optimised by testing multiple variables and measuring the change in current of the spray cloud

Flow rate, electrode voltage, and electrode position relative to spray break up point had the largest effect on this.

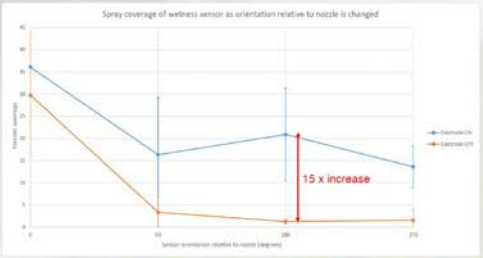


Water pressure of 5 bar, electrode voltage of 3 kV and a position of 3-4 mm between the electrode and the nozzle outlet gave maximum current of -4.5 μA.

Validating charging effect

A prototype electrostatic spray nozzle was compared to conventional spray nozzle in a series of tests, using a dielectric wetness sensor.

The graph below shows the increased coverage due to charging the electrode.



SPRAY DIRECTION CONTROL

An array of nozzles were controlled to conserve spray using low cost components and an Arduino with:

- Ultrasonic sensors for proximity sensing of foliage, chosen for greater robustness to agricultural operating conditions than optical sensors.
- Solenoid valves for switching individual spray nozzles on or off.
- Servo steering was implemented on the middle nozzle to give greater spray penetration into foliage through directional control.
- DC-HVDC low power converter, for high voltage charging of the electrodes.

PROTOTYPE FOR FIELD TESTS

UC UNIVERSITY OF CANTERBURY

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CLIENT
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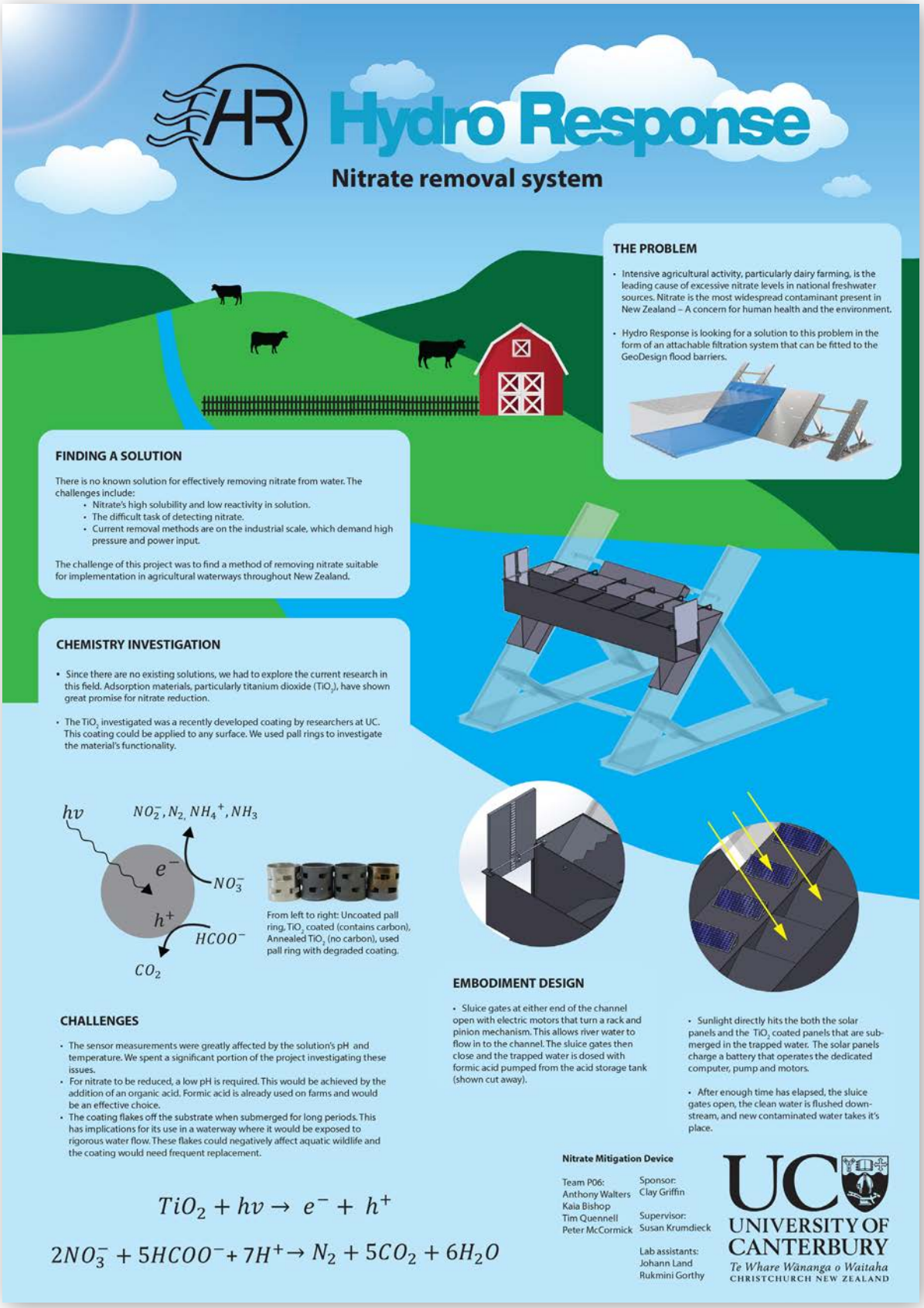
LINCOLN AGRITECH

Student projects: Mechanical Engineering and Mechatronics Engineering



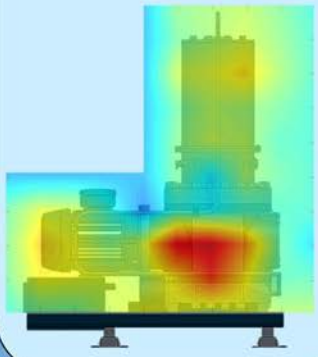
Cryocooler Noise

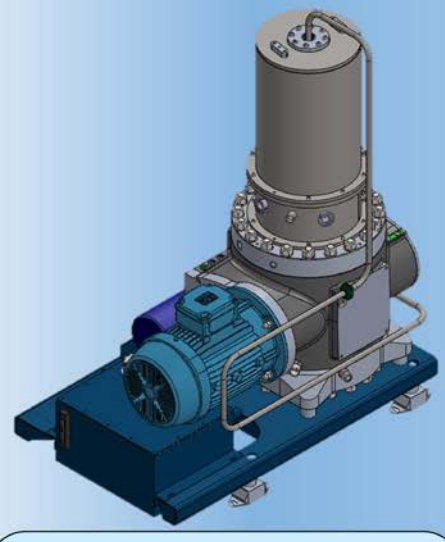
Noise

Sound intensity [W/m^2] was measured at discrete points and the sound power [W] noise map below was created.

This noise map shows that the crankcase produced the majority of the noise.

The total sound power level was 93 dB.





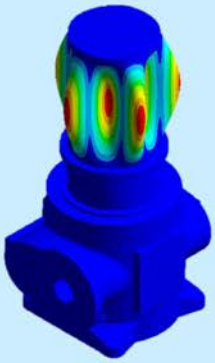
Cryocooler

The cryocooler produces liquid nitrogen from air. It is supplied with and operated within a small shipping container.

Our objective was to reduce the noise produced by the cryocooler.

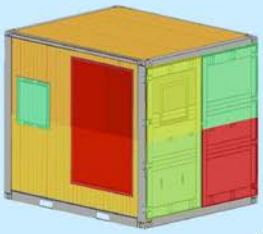
Modal Analysis

- Resonant frequencies and corresponding mode shapes were determined.
- The model compared well with measurements.
- Mode shapes were studied to identify possible solutions.

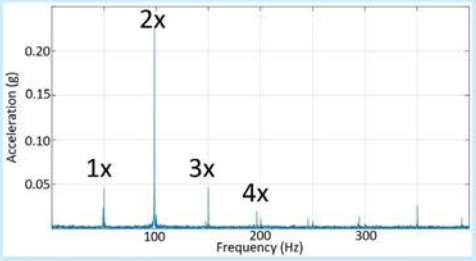


Container Noise

Noise maps showed that louvres were the main transmission path for sound through the walls of the container.



Crankcase Vibration



Effects of 50 Hz motor speed clearly evident.

Source Noise Control

- Reduce force on gears.
- Address system dynamics.
- Address diaphragm dynamics.
- Investigate bearing design.

Enclosing the Source

- Increase transmission loss of the walls with by increasing their mass.
- Reduce the reverberant field with sound absorption material.
- Acoustically treat the ventilation.

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CHRISTCHURCH NEW ZEALAND

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Supervisors: John Pearse, Dan Zhao

Thanks to: Brian Donohue, Michael Nation, Jonas Meier, Aaron Healy

FABRUMSOLUTIONS

Alternative Insulation System for a Cryocooler

Project Goal

The focus of this project is the development of an alternative insulation system for a pulse-tube cryocooler. The system's current setup uses multilayer insulation (MLI). This requires low pressure which is maintained by a vacuum pump running continuously. The pump is undesirable as it draws power and needs maintenance every 6 months. The aim of this project is to develop a cost-effective solution that removes the need for a vacuum pump.

Approach #1: Improved sealing

One possible approach is sealing the vacuum chamber more effectively so a static vacuum can be maintained at a low pressure.

Theoretical calculations [1] identified that 2 O-rings at a helium-vacuum interface likely made the greatest contribution to leak rate.

Testing

Leak rate tests were run on the cryocooler with and without helium in the pulse tube to compare to theoretical calculations.

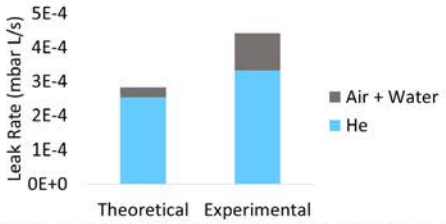


Figure 1: *Theoretical and experimental leak rates into the vacuum*

A test rig was designed and built using blind flanges to measure helium leak through the O-rings.

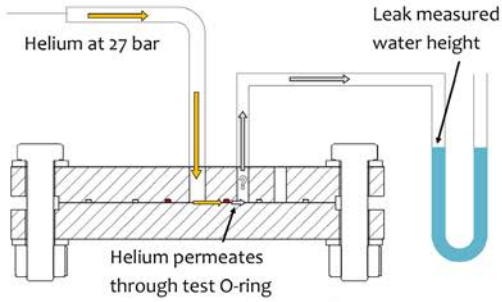
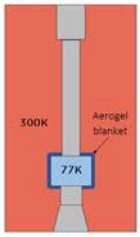


Figure 2: *Set up of vacuum decay test rig*

Testing showed no observable leak through the O-rings.

Approach #2: Alternative Insulation Materials



Another possible approach is using insulating materials that are still effective at higher pressures alongside or in place of MLI. Research showed [2] that the most promising material, taking into account ease of installation, performance and cost, is a Cryogel Z Aerogel blanket.

Figure 3: *Aerogel installed around the coldhead of the cryocooler*

Testing

Cryogel Z was sourced and tests run on the cryocooler with this material installed.

These tests showed that the aerogel performance is consistent across a range of pressures. This could remove the need for a vacuum pump to maintain a very low pressure in the cryostat, required when using just MLI.

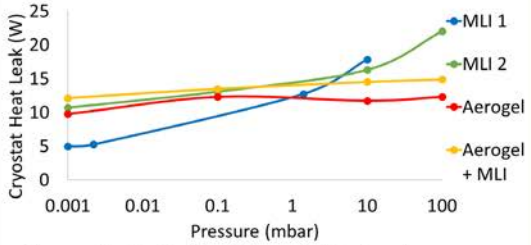


Figure 4: *Heat leak of insulation materials at varying pressures*

Next Steps

- Re-testing heat leak with MLI and aerogel combined.
- Analysis and testing to find agreement between the different vacuum leak rate tests.
- Evaluate feasibility of the alternatives tested.

References: [1] Parker Hannifin Corporation. (2010). *Parker O-Ring Vacuum Sealing Guide.*

[2] Fesmire, J. E. (2015). Layered composite thermal insulation system for nonvacuum cryogenic applications. *Cryogenics*, 154-

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Client: Jonas Meier, Fabrum Solutions Ltd.
Supervisor: Don Clucas
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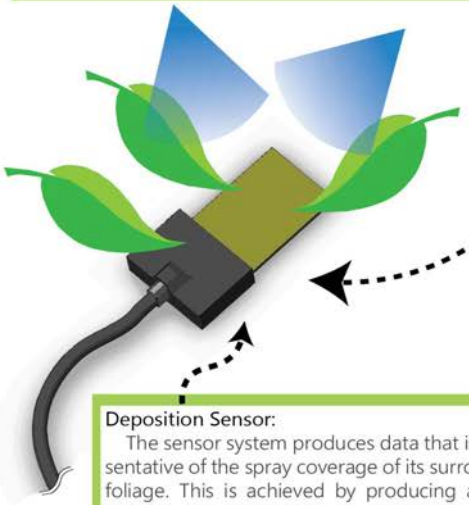
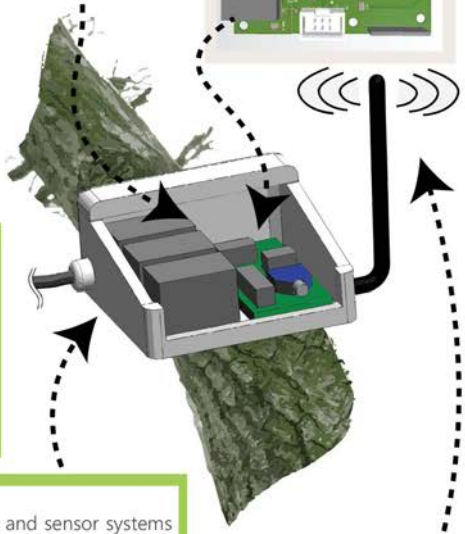
P10: WIRELESS SPRAY DEPOSITION SENSOR

Project Motivation:
Lincoln Agritech wish to develop a system intended for vineyards and orchards that uses sensor technology to measure spray deposition of horticultural sprays. Data collected is wirelessly transmitted to researchers and growers which can then be used in efforts to mitigate spray drift and make assessments on the effectivity of spray operations.

System Layout:
The main enclosure that houses the central processing unit, connecting board, power supply and wireless module fastens to the main trunk of the tree or vine. Independently housed sensors and circuitry extend outward from this and fasten amongst the leaves at the reaches of the branches or vines.





Deposition Sensor:
The sensor system produces data that is representative of the spray coverage of its surrounding foliage. This is achieved by producing a signal that is proportional to the area of the sensor concealed by the spray. The signal is also calibrated through digital processing, converting it into meaningful units that can interpreted by people with minimal technical knowledge.

System Integration:
The wireless communication and sensor systems have been integrated with one another to operate on the same PCB. This has required the design and manufacture of a connecting board to link the two systems and an enclosure to house the componentry.

Wireless Network Implementation:
A Zigbee mesh network is utilized to wirelessly communicate the processed data between the sensors and grower. A central coordinator collects this data whilst updating an online database. By opening up a laptop, phone or tablet, growers will have real time access to data representative to the spray coverage of their crops.

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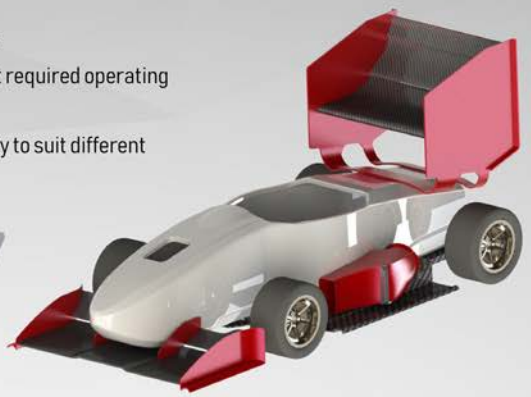
Supervisor: Mark Jermy
Client: Scott Post
Group Members: Tim Ellis, Jed O'Brien, Shawn Kang, Nicholas Krause
LINCOLN AGRITECH LTD

AERODYNAMICS UCM19

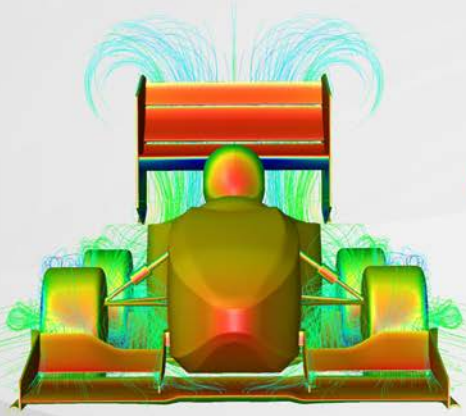
Aerodynamics Objectives:

- Improve vehicle handling through balanced downforce production
- Provide cooling airflow to keep key tractive system components at required operating temperatures
- Designed for low-speed Formula Student circuits with adjustability to suit different dynamic events



INITIAL CONCEPT

- Front and rear wings to create downforce and tune handling characteristics
- Undertray for aerodynamic efficiency—high downforce with low drag
- Radiator ducts on either side of the car for each of the car's two cooling loops



DESIGN THROUGH CFD

- Iterative design approach using ANSYS Fluent
- Poly-hexcore mesh used for computational efficiency and accurate results
- Airflow visualisation and simulated data used to make design changes
- Centre of pressure migration analysed through multiple on-track cases

FINAL PACKAGE

- Varying profile front wing
- Three-element rear wing
- High-efficiency undertray
- Twin cooling ducts

C_L: -2.65
C_D: 0.78
Frontal Area: 1.3m²
Total downforce at 50 kph: 474N
Balance: 54/46 front/rear

UCM
UNIVERSITY OF CANTERBURY MOTORSPORT

Client: University of Canterbury **Faculty Advisor:** Bruce Robertson
Supervisors: Shayne Gooch & Digby Symons
Staff: Natalia Kabaliuk
Students: Cameron Arvidson & Oscar Gittings

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CHRISTCHURCH NEW ZEALAND

Student projects: Mechanical Engineering and Mechatronics Engineering

CHASSIS

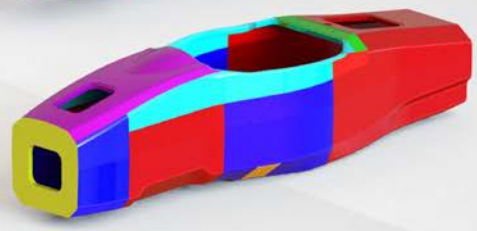
UCM19

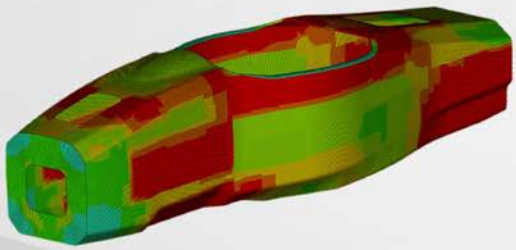
Chassis Objectives:

- Improve driver position and ergonomics to reduce fatigue and improve overall performance
- Research, development and testing of alternative materials
- Advanced monocoque simulation and optimisation to reduce weight
- Reduce vehicle assembly and servicing time through system layout

DESIGN FEATURES

- One piece carbon fibre monocoque with aluminium honeycomb core
- Low density and high compression strength balsa wood front bulkhead
- Reduced driver fatigue though an increase in seatback angle and cockpit width as well as an ergonomic seat back design
- Larger hatches for improved internal access
- 3D printed impact attenuator for lower peak deceleration and 50% reduction in weight compared to the standard attenuator





TESTING & OPTIMISATION

- Three step Altair Hypermesh optimisation process to design the monocoque lay-up. Carbon fibre thickness variation depending on the section loading for an overall reduction in weight.
- Section by section panel testing to validate composite lay-up decisions
- Monocoque torsional stiffness tested and compared to finite element simulation

MANUFACTURING

- Three-axis routed male MDF plugs and carbon fibre female moulds
- Laminated front roll hoop and seat flange
- Single piece construction with autoclave cure

Weight: 24kg
Simulated Torsional Stiffness: 4800 Nm/deg
Measured Torsional Stiffness: 4200 Nm/deg

UCM
UNIVERSITY OF CANTERBURY MOTORSPORT

Client: University of Canterbury **Faculty Advisor:** Bruce Robertson
Supervisors: Shayne Gooch & Digby Symons
Staff: Don Clucas, Garry Cotton, David Read, Kevin Stobbs
Students: Ben Eagle, Ryan Coey, Mason Kennedy

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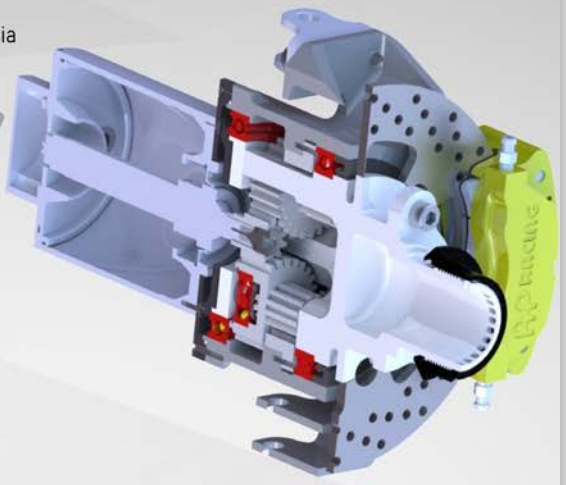
POWERTRAIN UCM19

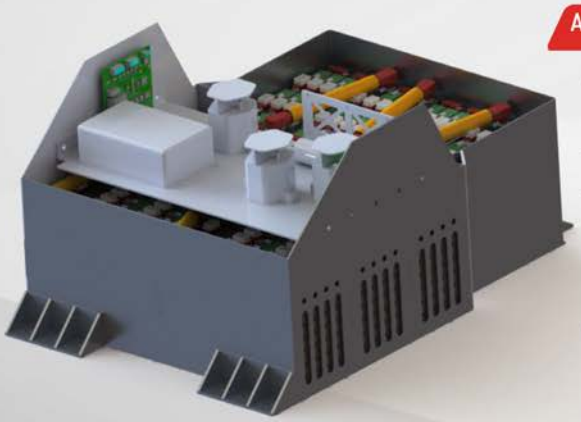
Powertrain Objectives:

- Create easily serviceable components
- Design components without any sacrifice in reliability
- Aim to maximise the number of points achieved at FSAE Australasia design competition



FINAL DRIVE ASSEMBLY

- 9.7:1 compound stage planetary gearbox mounted within each wheel
- Individually designed involute gear profiles
- Centrelock wheel interface
- Integrated gearbox housing with upright assembly
- 10 inch magnesium OZ Racing wheels
- 30kW AMK permanent magnet synchronous motors

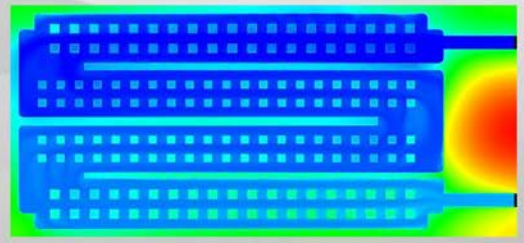


ACCUMULATOR

- Laser cut, TIG welded AL5052 housing with passive air cooling
- 100mm COG
- 966 Samsung 18650 cells provide 596V, 8.69kWh capacity
- Integrated battery management system, individual cell temperature monitoring, and automatic safety isolation system
- Walls lined with polypropylene which is an electrical insulator, UL-94 flame resistant, and moisture resistant

COOLING

- Separate cooling loops for motors and inverter
- Parallel motor cooling loop
- Steady state heat transfer analysis on new inverter heatsink geometry
- New two part inverter heatsink for lower operating temperature
- Festo push-lock fittings used to increase serviceability
- Custom PWR Performance dual- and quad-pass radiators



UCM
UNIVERSITY OF CANTERBURY MOTORSPORT

Client: University of Canterbury **Faculty Advisor:** Bruce Robertson
Supervisors: Shayne Gooch & Digby Symons
Staff: Scott Amies, Kenneth Brown, David Fanner, Zac Perston
Students: Dylan Familton & Nika Ross

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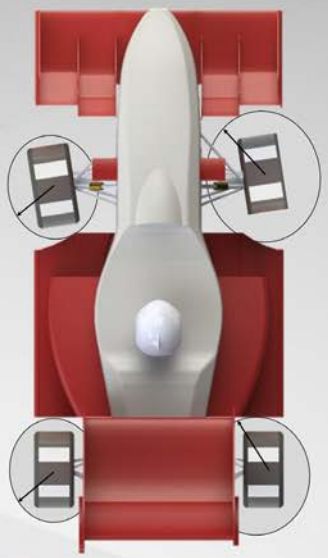
Student projects: Mechanical Engineering and Mechatronics Engineering

SUSPENSION

UCM19

Suspension Objectives:

- Develop a highly effective, lightweight suspension system by using numerical simulations validated with real world testing
- Design for serviceability and adjustability
- Implement software controls to maximise individual wheel traction



SIMULATON

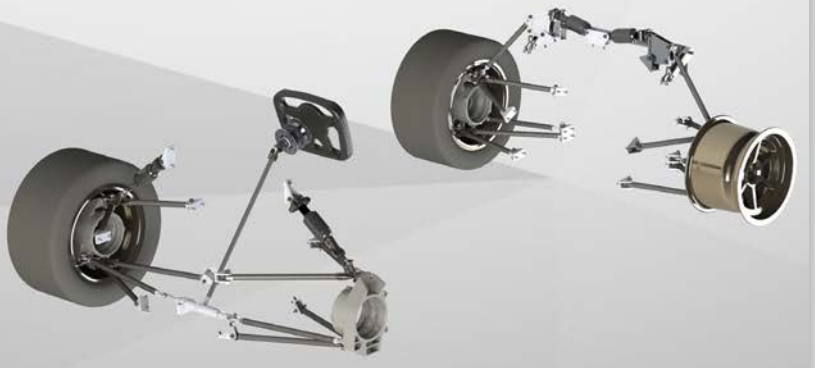
- Kinematics modelled using Optimum Kinematics software
- Lap time simulator (steady-state) developed for high-level design decisions
- Closed-loop torque vectoring and traction control software in vehicle control unit
- Steady-state cornering model in MATLAB and Python
- Air shock stiffness modelled in MATLAB and validated with real-world testing

COMPONENTRY

- Direct acting front suspension
- Cane Creek 4-way adjustable air shocks
- Linkage manufacture with 3D printed Titanium bonded to carbon tube
- Adjustable anti-roll bar for tuning lateral load transfer distribution
- Steering system is simple, lightweight and serviceable

CAR PROPERTIES

Property	Front	Rear
Track width [mm]	1100	1100
Wheel base [mm]	1550	
Caster angle [deg]	10	
Mechanical Trail [mm]	18.2	
Scrub Radius [mm]	23.2	
Ackermann [%]	0	



UCM
UNIVERSITY OF CANTERBURY MOTORSPORT

Client: University of Canterbury **Faculty Advisor:** Bruce Robertson
Supervisors: Shayne Gooch & Digby Symons
Staff: Kenneth Brown, Tony Doyle, Zac Perston, David Read
Students: Paige Cuthbert, Cameron Richards, Ian Talbot

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UNIVERSITY OF CANTERBURY
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CHRISTCHURCH NEW ZEALAND

Student projects: Mechanical Engineering and Mechatronics Engineering

Infant Respiratory Pressure Mapping

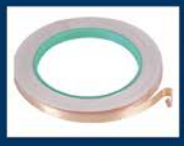
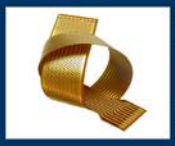
The Project Focus


Existing Interfaces

Some infants have undeveloped respiratory systems and require help to breathe. The most common respiratory interfaces used to administer the respiratory therapy are the masks and nose prongs seen on the left. These can be on the infant's face for multiple weeks which can result in pressure sores and blisters. Our task was to develop a device to measure the pressure distribution an interface applies on an infant's face to aid the product development process.


Pressure Sores

Pressure Sensors

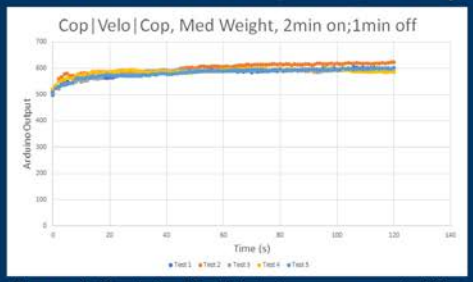
	Considered		Considered		Chosen	
Element		Tactillus FSR • Spatial Resolution too low • Non flexible • Not sensitive at low pressure values		Digital Image Correlation • Lack of Expertise • Complicated • Static		Velostat • Sensitive at low pressures • Simple • Flexible • Exhibits Drift
Connection Type		Conductive Paint • Resistance too high (2kΩ) • Inconsistent application		Copper Tape • Internal Resistance low (0.2Ω) • Easily damaged • Hard to set up		Flexible PCB • Internal Resistance low (0.2Ω) • Durable • Flexible

Structure

From this we decided that the best possible pressure sensor would incorporate PCBs as the contact pads and Velostat as the pressure changing resistor. PCB was chosen as a low internal resistance is required so that overall circuit resistance can be reduced. Using this setup, a voltage divider was used to analyse the change in resistance exhibited in the Velostat to give the pressure applied.

Testing

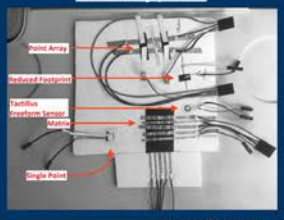
Velostat was tested for drift and repeatability. All testing used a standardised weight of around 10g with a 5x5mm load area.



The graph illustrates the Velostat sensors repeatability and drift over 5 tests. Values converged to ~600 after 2 minutes. From this it was deemed that drift was not a factor at low time values and, that it was repeatable.

The graph shows the percent error of the data over a 300 second span. After around 30 seconds the graph stays in the region of around 1.5 -2% minimum value. The noise level was determined to be acceptable.

Prototype 1



Final Prototype

Final Prototype Features

- 3D Face
- Whole Nose Area Sensing
- User Interface
- User Manual
- Reduced Drift and Crosstalk
- Repeatable and Robust

From first prototype to final prototype there were many changes of the make up of the sensor with it changing from copper connection to Flexible PCB.

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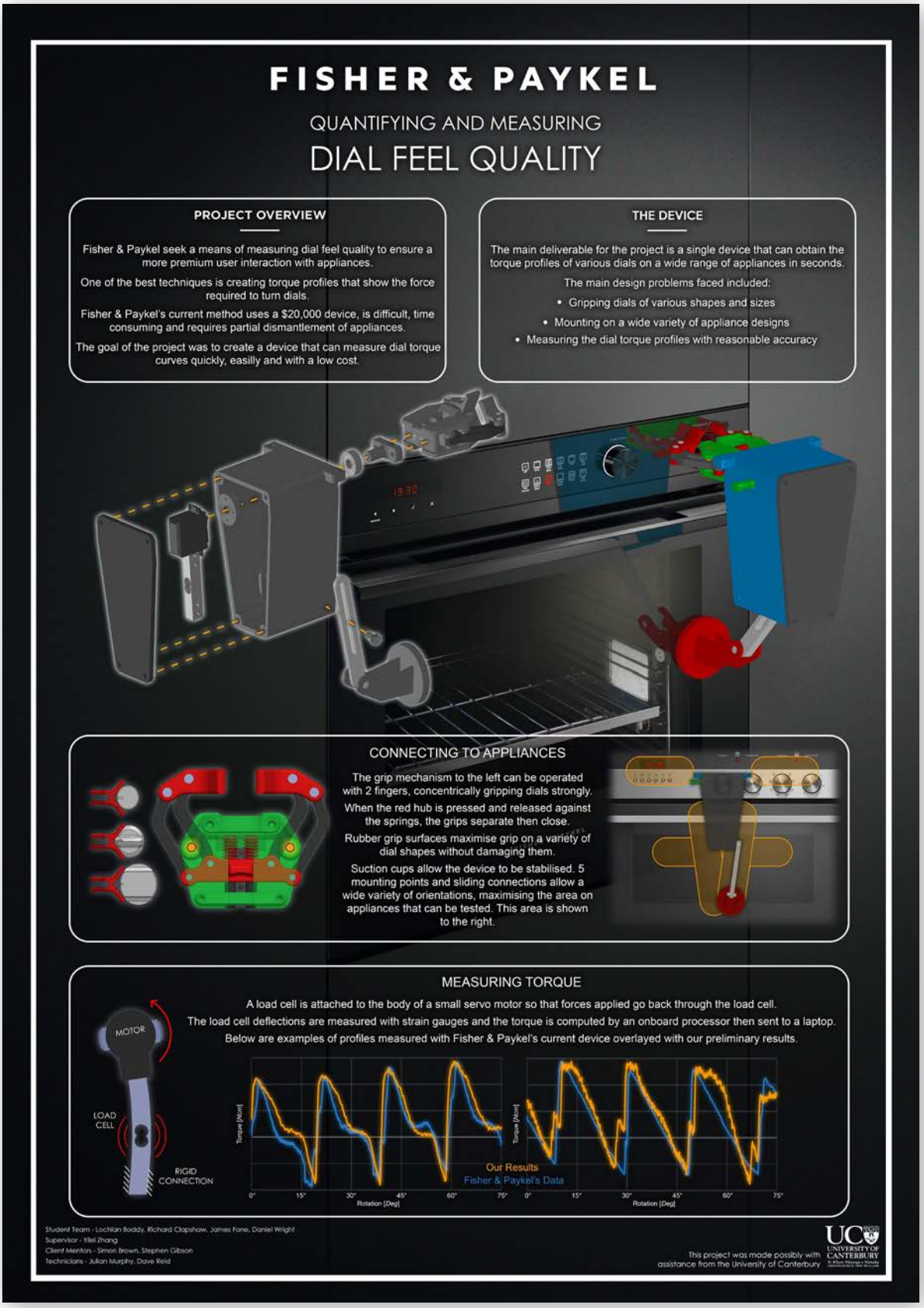
Students: Ezilna Feldtmann, Vincent Flusk, Cherie Vasta, Lucas Toovey

Fisher and Paykel Healthcare Clients: Andrew Hilliard, Leon Stanley

Supervisor: Professor Mark Jermy

Fisher & Paykel HEALTHCARE

Student projects: Mechanical Engineering and Mechatronics Engineering



DISHDRAWER™ LINK SYSTEM SIZE REDUCTION

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PROBLEM DESCRIPTION

The current link system contains a fill hose, drain pipe and wiring. This is located at the back of the DishDrawer™ tub, and supplies it with water, power, and removes the waste. Space in the DishDrawer™ is restricted, therefore Fisher and Paykel want to decrease the size of the system so that additional features can be added.

CURRENT

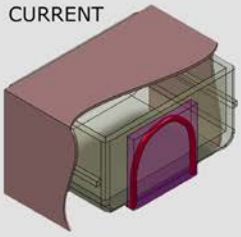


Figure 1 - Rear view of DishDrawer™ with tub exposed. Volume occupied by current link system shown in pink. Current Link hose shown in red.

TARGET

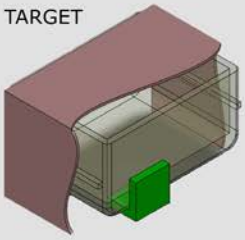


Figure 2 - Rear view of DishDrawer™ with tub exposed. Green volume shows the proposed area for the new solution.

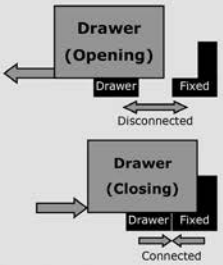


Figure 3 - Side view schematic of DishDrawer™. Top drawer shows the connection coming apart when opening. Bottom drawer shows the connection closed.

Only the drain and fill water connections were considered for this project. The proposed solution to reduce the volume of the Link System is a connect -disconnect system detailed in figure 3. The goal was to reduce the volume taken up by the Link System by 75%.

This project consisted of designing and building prototypes for the connect-disconnect system to fit within the green volume in figure 2.

TESTING PROCESS

1. Prototype is secured to the rig. The test rig uses the drawer rails and latch from the DishDrawer™ to replicate the opening and closing dynamics.
2. Tap water flows from right to left as shown in figure 4. The flowmeter is used to set the desired operating conditions.
3. Whilst the water is running, the prototype is checked for any leaks. Inlet and outlet pressures are measured.
4. The water is shut off and the drawer is opened. The loops for drip tests in figure 4 are used to replicate the residual head experienced by the coupling as it will be placed under the tub. Any drips are measured

The concepts detailed below are the chosen ideas that the team developed. The ball valve and pinch valve concepts were used to stop the dripping upon opening. A garden hose connector was used in conjunction with both prototypes to create a secure connection to withstand the high pressure of the water. Both concepts perform these functions well, and with further development can be used by Fisher & Paykel Appliances in the future.

CHALLENGES

- Minimize drip leakage after disconnecting the coupling. Less than 20mL.
- Prevent high pressures from breaking apart the connection by using a latch mechanism. Up to 250kPa.
- Fully mechanical system.
- Should not be affected by the drain water.

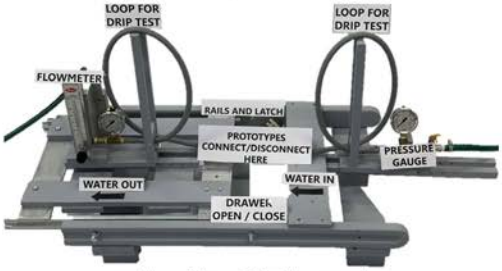
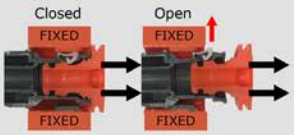


Figure 4 - Layout of test rig components

PROTOTYPE IDEAS

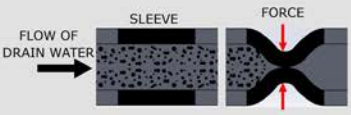
BALL VALVE

Ball valves are a durable and robust method of sealing. There is no obstruction of flow when valves are open and it is a compact, fully mechanical system.



GARDEN HOSE CONNECTOR

This was used to seal and latch the connection together to resist the force from the water pressure. The latch can be unlocked if the collar is fixed and the coupling is pulled.



PINCH VALVE

A force pinches a soft sleeve to stop flow. These are typically used for fluids with solid particles such as cement, waste water and food production. Therefore applicable to the drain water of the DishDrawer™.

FISHER & PAYKEL

TEAM M17		CLIENT	SUPERVISOR	UC TECHNICIANS	
Patrick McCallum	Ziyang Wang	Adam Liberatore	Dr. Sid Becker	Gary Cotton	Julian Murphy
Nathan Walker	Edward Popham	Matthew Cosgrove		David Read	Eric Cox

Student projects: Mechanical Engineering and Mechatronics Engineering

FLOOD MITIGATION IN WESTPORT

Westport experiences periods of heavy rainfall that can cause significant damage to the township. With climate change, these events are expected to increase in intensity and frequency.

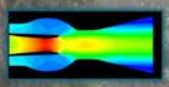
To help mitigate the level of flooding, pumping solutions were to be investigated; established pre-existing pumps and solutions that were of a more innovative nature. To power these solutions, the Buller River was to investigated as a potential power source.

It was found that rainfall amounts that cause significant damage range from 52mm to 126mm (sometimes falling in a matter of hours). A pumping solution that provides a capacity of between 500L/s – 1000L/s would be ideal to help remove the pooling water, with a minimum of 150L/s.

Buller River Hydrograph (MatLab)

The Buller River was investigated as a source of power for the pumping solutions. It was found to be unsuitable as the velocity was not great enough for the power required, and damming it was not a viable option.

Piston Pump (SolidWorks)



Jet Pump–CFD (ANSYS)

Pumping solution ideas that were developed by the team were a piston pump, and a venturi type–jet pump–solution.

Jet Pump Schematic

Jet Pump

The following table shows the pumping capacities of each developed pumping solution. Where the capacity does not meet the minimum requirements, duplicates will be placed so the requirements can be met.

Solution	Piston Pump	Jet Pump	Jet Pump (CFD Analysis)
Pumping Capacity [L/s]	42	75	98.8
Required Power/Inlet Flow	2.9 kW	176 L/s	174 L/s

ETec Moviltec

Several portable pumps were investigated and brought forward. 2 of the options are shown here: ETec Moviltec, and BBA Pumps BA400G D500.

Solution	ETec	BBA Pumps	MWI Pumps	Gator Pumps	DODA	MacEwans
Pumping Capacity [L/s]	875	830	568	950	350	400

BBA Pumps BA400G D500

Greymouth (ArcGIS)

Westport (ArcGIS)

WCRC oversees Greymouth as well as Westport and both places experience similar climatic behaviour. When it rains, the areas that hold water were found for both townships.

The project brief has been fulfilled in that the Buller River was investigated and found to be unsuitable, and pre-existing and innovative pumping solutions were investigated. Over and above this, flood-prone areas were also found for Westport and Greymouth.

UC UNIVERSITY OF CANTERBURY

Team members: Erika Gollnick, Badrul Hashaim, Isaac Wilkinson, Leo Wright

Supervisor: Professor Mathieu Sellier

Client: Randal Beal (West Coast Regional Council)

Acknowledgments: John Thyne, GIS Manager – Computer Support, Department of Geography

THE WEST COAST REGIONAL COUNCIL

Student projects: Mechanical Engineering and Mechatronics Engineering

BVT ENGINEERING PROFESSIONAL SERVICES

AUTOMATION OF INTERIOR FIT-OUT DESIGN

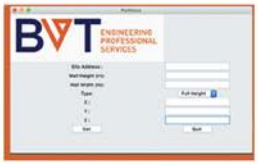
P23 2019

The purpose of this project was to take the current system that BVT use in their seismic interior fit-out design process and streamline it to maximise value for BVT's clients while minimising the time taken to finalise the design into a design producer statment (PS1).

The possible solutions for each of the module in the flow chart below were extensive researched by all group members, and presented to BVT with different possible solutions. From there, a path was decided upon and developed. Where routes were needed to link outputs to inputs for each module, these were created using python code.

GUI

A user-friendly graphical user interface is used to collect the initial variables needed for the seismic design process. eg. For a partition, the address, wall type and basic dimensions.



GEO-LOCATING

By locating a job using the address given by the client, it provides important seismic information such as regional wind speeds and building importance levels that are considered int he design calculations.

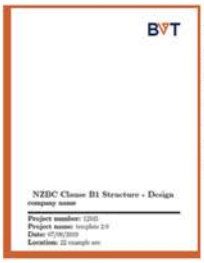
DATABASE

The cloud SQL database acts as a repository for the collected information. The design modules that follow pull and process the collected data before returning the results to the database for storage.

CALCULATIONS

Calculations from design standards are written into python functions and used to guide and optimise engineering design choices. We iterate through stud spacing and stud types to find the best value for the same design safety and quality.

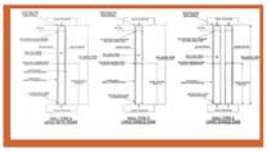
ENGINEERING DOCUMENTATION



A multipage PDF document would be generated by retrieving results from previous modules within the database and the dynamic drawings. This document is approved by a chartered engineer and sent to the client, marking the completing of the design process.

TECHNICAL DRAWINGS

Engineering drawings are automatically produced from the calculation results.



RESULTS:

	company process	our process
Execution time:	8:11 mins	~2 mins
Manual steps:	all	3 steps

FUTURE DEVELOPMENT:

- Iterate for a specified stud gauge to determine minimum stud spacing
- Compare trade off between building material price and structural integrity
- Expand automation to include more job types, eg. ceilings

Group Members: Tom Goodman, Luke Doyle, Irfan McQuinlan, Oli Knopp, Jintao Wen, Danny Humm, Gerard Evans
Client mentors: Zac Andrews, Josh Van Sant
Client: Matt Bishop **Supervisor:** Dirk Pons

3D PRINTING MDF-RHDPE COMPOSITE

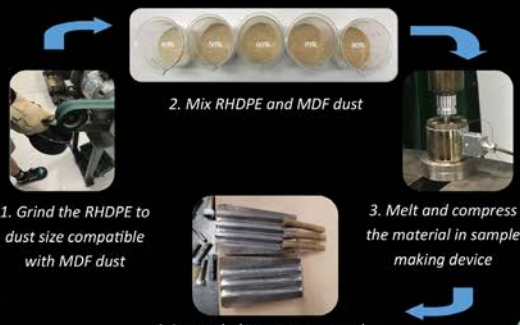
Problem Statement: To develop a novel product from the waste produced by Daiken NZ's MDF plant in Sefton.

MATERIAL DEVELOPMENT

Our Wood Plastic Composite (WPC) material is made from:

- Recycled HDPE from milk bottles
- Daiken NZ's waste sanding dust
- 3 wt% Paraffin oil (Lubricant Additive)

Production method for making test material:



1. Grind the RHDPE to dust size compatible with MDF dust

2. Mix RHDPE and MDF dust

3. Melt and compress the material in sample making device

4. Let cool, then remove samples

WHY A WOOD-PLASTIC COMPOSITE?

WPC vs. Wood property benefits:

- Moisture resistance
- Insect resistance
- Potential additive benefits (i.e. flame resistance)
- Resistant to fungal attack
- Weld-ability
- Better UV resistance compared to plastics

Potential products:

- 3D Printing fibre
- Outdoor decking
- Other non-3D printed bulk material applications (i.e. fence posts)

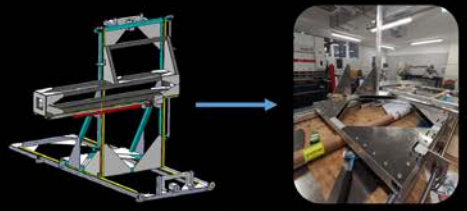
MATERIAL TESTING

Early proof of concept device. Made large billets

Current sample creation device. Makes 3 WPC cylinders per use.

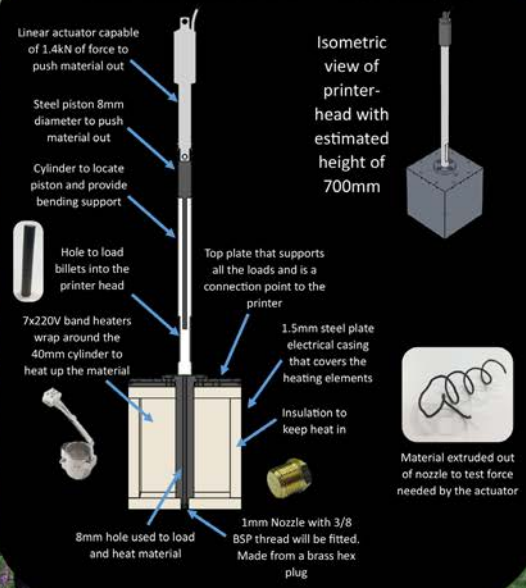
Plate compression mould device for making flat tensile test specimens.

3D PRINTER DEVELOPMENT



- Moves in x, y and z directions and is capable of 3, 1.5 and 1.5 m of travel respectively
- Printer head is interchangeable depending on the application
- Aluminium gussets provide a robust design that can be easily taken apart and changed based on demand
- Uses stepper motors and ball screws to move the device
- Prints MDF - RHDPE composite
- Capable of making large, complex shape parts

PRINTER HEAD AND CONTROLS



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

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Supervisor:
Dr. Don Clucas

Client Supervisor:
Hiroshi Naka

Thanks to:
D. Read
T. Doyle
K. Stobbs
K. Brown
J. Phillips
T. Perigo
Alto Plastics
Comspec

DAIKEN NEW ZEALAND LIMITED

Thrust Bearing Failure Prediction

Background

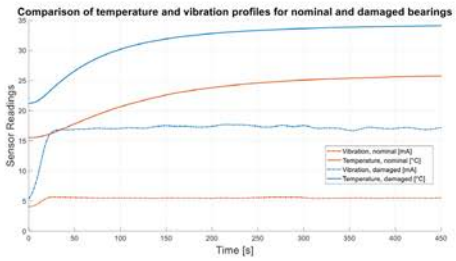
Some of Hamilton Jet's customers have experienced unexpected bearing failures in their waterjets. Hamilton Jet want to know if such failures can be predicted using temperature and vibration sensors.

Procedure

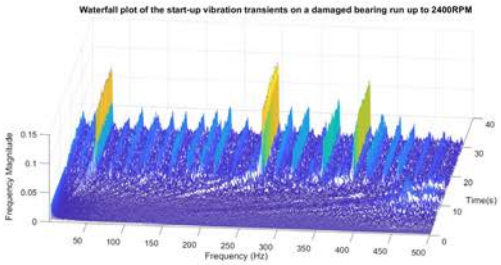
1) Sensors were selected to interface with Hamilton jet's HJ241 waterjet, using National Instruments hardware and software.
2) Data was collected from 44 tests under varied conditions and motor speeds using a water tunnel test rig.
3) Tests that were run include nominal, damaged, overgreased, undergreased, contaminated, rusted, and misaligned bearings.
4) This data was analysed to determine whether the sensors are suitable for failure detection.

Results

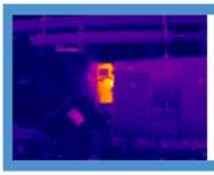
A comparison of temperature and vibration profiles shows that both increase significantly when the bearing is damaged.



An accelerometer was used to analyse vibration spectra, and showed a peak at 258Hz that coincides with the bearing's inner race failure frequency.



The VTV122 vibration transmitter consistently measured higher RMS vibrations for non-nominal test cases. Temperature sensors on both the bearing housing and the outer race were also indicative of irregularities when correcting for changes in the ambient temperature.



Infrared imaging was used to understand the temperature profile of the assembly for the different test cases.

Conclusion

Using temperature sensing has potential for predicting bearing failure, but must be corrected for varying ambient temperatures. Further testing in the field and/or right up to failure will improve the temperature models from this investigation. Vibration sensing accurately and consistently detects irregularities in jet operation. Despite being more expensive than the temperature sensors, a vibration sensor could add a level of reliability to a failure detection system.

HamiltonJet

Supervised by Professor Milo Kral

Team Members:
Christopher Bull
Jake Shields
Blair Masters
Nicholas Lam

Client Liaisons:
Nick Thurley
Craig Eustace

Special Thanks:
Julian Phillips
Julian Murphy
Stefanie Gutschmidt

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

Student projects: Mechanical Engineering and Mechatronics Engineering

ACCESSIBLE INSULIN CARE

P49 Team: Max van Empel, Aurelio Crestanello, Connor Benton, Ted Lerios, Josh Lowe

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

Canterbury District Health Board
Te Poari Hauora o Waitaha

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THE PROBLEM

Hyperglycemia and diabetes pose significant health complications, and with this comes significant healthcare costs. Some patients could be expected to spend 20-40% of the median annual household income for treatment. These high costs result in effective care being unattainable for those with low income. There is thus a clear need for more accessible and affordable diabetes management tools.

INSULIN ADSORPTION MODELLING

Insulin adsorption to plastic tubing often results in only 20-80% of the intended insulin to be delivered in the first few hours of therapy. This study quantifies insulin adsorption to delivery line material surfaces as a first step towards informing clinical practice.

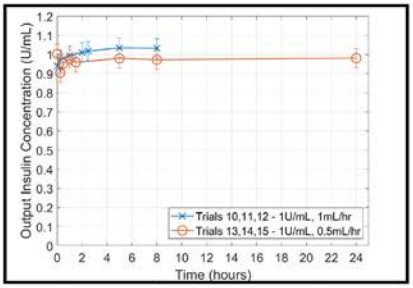


Figure 1: Insulin Adsorption Experiments

A clinical insulin infusion has been recreated in the lab (Figure 1), and a discretised compartment model models the amount of material-bound (B) and 'free' insulin (F) in solution. This model (Figure 2) is fit to clinical data using Gauss-Newton methods.

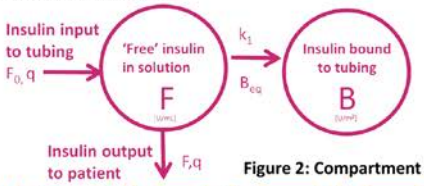


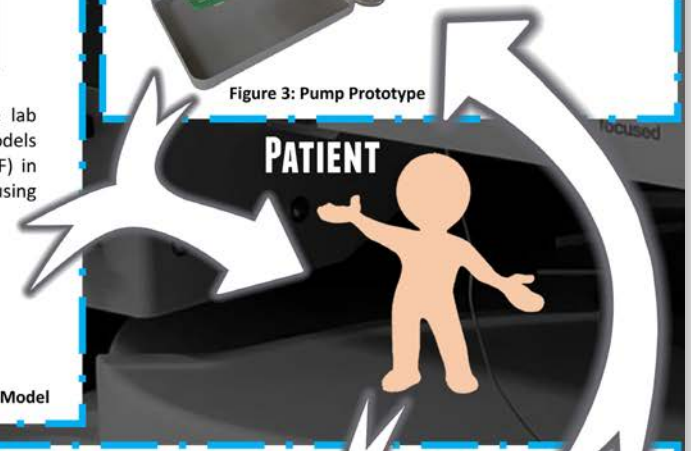
Figure 2: Compartment Model

ULTRA-LOW-COST INSULIN PUMP

Current market options for insulin pumps cost upwards of $5000. A prototype pump (Figure 3) was developed to drastically reduce this cost while still providing the features required of an effective insulin pump.

Through careful design and motor validation, the current prototype revision costs under $250 to produce.

Figure 3: Pump Prototype



GLUCOSE CONCENTRATION DETECTION

A non-invasive sensor (Figure 5) was developed to determine the concentration of glucose in blood. Molecules have unique absorption characteristics, and so by measuring the reflected light from an LED array of varying wavelengths, the concentration of glucose could be inferred.

Measurements were taken using the sensor on a sample of pigs blood with varying glucose concentrations. After verifying the glucose concentration using existing methods, a calibration curve relating the detection of 1450 [nm] and 1550 [nm] to glucose concentration was determined (Figure 4), validifying the non-invasive sensor.

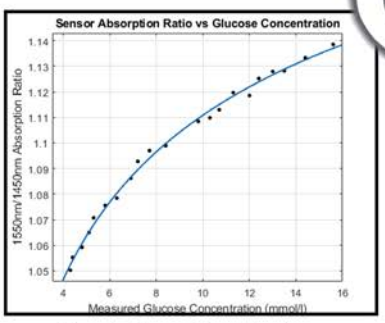


Figure 4: Glucose Sensor Readings

Figure 5: Glucose Sensor PCB

Tiromedical
Next Generation Breast Cancer Detection
through vibration

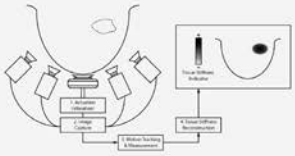
BREAST CANCER AND THE DIET SYSTEM

ONLY WOMEN AGED
45 TO 69
RECEIVE MAMMOGRAPHIES

HOWEVER
6% OF PATIENTS
ARE YOUNGER THAN 40

MAMMOGRAPHIES ARE
EXPENSIVE AND INVASIVE

THE DIET SYSTEM USES VIBRATION AND COMPUTER VISION TO DETECT DIFFERENCES IN BREAST TISSUE.



MOTION ANALYSIS AND MODELLING

METHOD

1. Nodal Point Reference: Considering one node over all time steps.

2. Travelling Waves: Considering all nodes in breast segment over one time step.

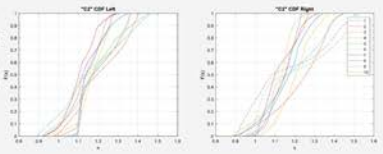
PROCESS

1. A curve was fitted to the motion response of each node over all time steps. The coefficients of these curves were then plotted.

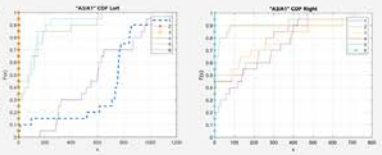
2. The breast was segmented into six segments as shown on the left and a sine function was fitted to the motion response data. The coefficients of these functions were then plotted.

RESULTS

The right breast from the right hand plot has a tumour. This is indicated by the shape of the dashed CDF curves 4 and 5.



The dashed blue line in the left hand graph indicates that a tumour is present in segment 1 in the left breast.

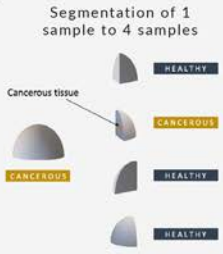


MACHINE LEARNING FEASIBILITYW

PRIMARY OBJECTIVE

1. Massive data packets produced by DIET machine. Machine learning suggested for processing.

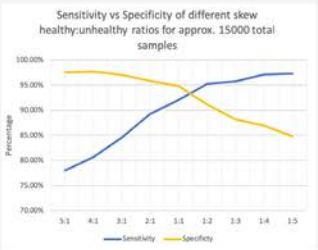
2. Existing datasets too small to implement machine learning. Testing segmentation feasibility.



RESULTS

1. Skewed data resulted in bias, negatively effecting sensitivity, true postive rate, and specificity, true negative rate.

2. Implied model needs to be adjusted to account for bias of input samples.



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rpb® ADVANCING YOUR SAFETY

Universal Safety Headtop

Description

The project aim, is to research the current safety equipment market and design an RPB Safety first ever universal respirator headtop to work in tandem with an existing air filtration system (eg. RPB Safety PX4 Air). For use in conditions with a high level of particulate matter (e.g. dust) in the atmosphere. The headtop is intended for the general public, hobbyist and DIY folks.

Main Objectives

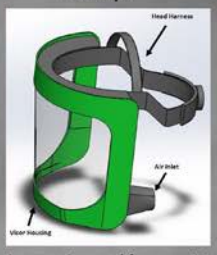
- **Comfortable**—suitable for prolonged use (8+ hours)
- **Lightweight**—total weight ≈ 600—800 grams
- Maintain positive air pressure inside the respirator (220 Pa target)
- Compatible with the RPB PX4 air filtration system
- Prototype head top respirator designed and manufactured for less than $1500
- Designed for mass production

Secondary Objectives

- Compatible with PPE — earmuffs, hardhat etc.
- Non futuristic appearance
- Able to be put on and off with one hand
- Compatible with RPB accessories—RPB L4 Lights
- Compatible with existing safety visor from RPB Z-Link headtop

Prototype 1

Concept



Prototype 1 was the first step to a lightweight easy-to-use headtop. It was inspired by existing designs in the market, simplicity and user needs. Prototype 1 consisted of a visor covering the face, attached to the head with a ratchet head harness, an elastic seal around the chin and an air inlet on the side of the face.

Creation

Lessons Learned from prototype 1:

- The side mounted air inlet would constantly "pull" the user's head in one direction causing an uneven strain to the neck, problematic if used over an extended period (8+ hours).
- The head harness ratchet design provided a good solid fit with even weight distribution around the head but could be optimised for simplicity.
- The chin seal design was more comfortable, lighter and simple than the larger shoulder cape.

Prototype 2

Concept

Based on the new insight from prototype 1, the inlet was moved to the back of the head for stability and the head harness was simplified to an elastic band. The four team members focused individually on four separate work streams.

- The visor and visor housing
- The front forehead mounts
- The back of the head air inlet and chin seal (fabric)
- The overhead air supply route (fabric)

These parts were uniquely designed and 3D printed. The overhead air supply route and chin seal are removable and machine washable. The visor is also removable to allow a variety of visors, such as a tinted visor for the outdoors or a clear visor for the indoors.

Creation

Prototype 2 Benefits:

- Lightweight ≈ 600 grams
- Compact - Flexible airflow duct allows the prototype to collapse for easy storage
- Air supply inlet at the back of the head for even weight distribution and comfort.
- Stretchable elastic strap and soft material forms to the user's head geometry

Next Steps

Further refinement is needed before market introduction,

- **Accessory integration capability:** LED mounts, communication devices, welding mask mounts.
- **Enhance comfort:** Optimise for maximum comfort e.g. super soft padding (memory foam), direction of airflow.
- **Optimise based on user needs:** Hypoallergenic fabric option, tinted/non-tinted visor, range of sizes, different colour schemes.
- **Manufacturing optimisation:** Assembly is secured with tool-less fasteners.

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P55 Project Team: Julian Alexander, Nathan Arscott, Ben Rowan, Teck Soon

Project Supervisor/Mentor: Dr Sid Becker

Client Representatives: Sam Kelly—Engineering Manager, RPB Safety

Special Thanks: David Read—Technical Officer, RPB Safety Staff

VIBRATION PROFILING OF A RUGGED PROSTHETIC HAND

Cuff & Isolator

Accelerometer (on finger)

PROBLEM

- Understand the performance of the Taska prosthetic hand under a variety of use-cases

METHODOLOGY

- Determine resonant frequencies of the hand
- Determine frequency bands of typical use-cases (excitation inputs)
- Design + build test-rig & data acquisition device
- Test-rig validation through end-user testing
- Analysis of results

RESULTS

- Comprehensive data collection using test-rig and data acquisition device
- Identified frequency bands of use-case input signals (Fig. 1)
- Identified resonant frequency bands of hand (Fig. 2)
- Identified critical use-case frequency bands (Fig. 2 & Table)

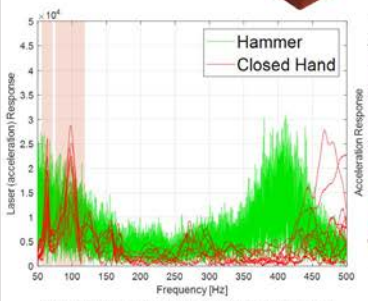

Figure 1: Frequency bands of hammer (handle) input and resonance of hand in grip position.

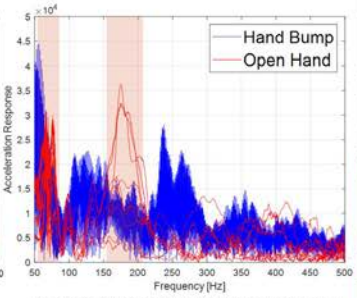

Figure 2: Overlapping frequency bands of hand bump (user testing) and resonance responses of the hand in an open position (lab testing).

Use Case	Acceleration Range [g]	Overlapping Frequencies [Hz]	
Walk	±1.1	-	
Run	±4.6	-	
Electric Beater	±4.8	70, 250-300	
Lawnmower	±10.9	0-100	Red indicates critical high acceleration vibrations with overlapping frequencies
Hand Bump (Fig. 2)	±16.8*	70, 160-210	
Drill	±16.9*	70, ~390	
Hammer (Fig. 1)	±16.9*	70, 80-120	
Tennis	±16.9*	70, 100, 400-460	
Shovel	±16.9*	70, 100	

* *Maximum amplitude of accelerometer reached*

CONCLUSION

- Different behaviour for closed/open hand: Open hand was more critical at lower frequency inputs
- Open hand critical frequency bands identified: 50-80 Hz, 150-220 Hz
- Closed hand critical frequency bands identified: 70-100 Hz, 200-600 Hz (combined all directions)
- See Table for overlap between resonant frequencies of the hand & some typical use-cases
- Maximum acceleration of sensor: 16.9g

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TASKA

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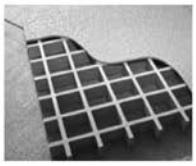
SEMI-AUTOMATED CNC ROUTER

AUTOMATED GRID DETECTION AND ROUTING OF FIBREGLASS TRENCH COVERS

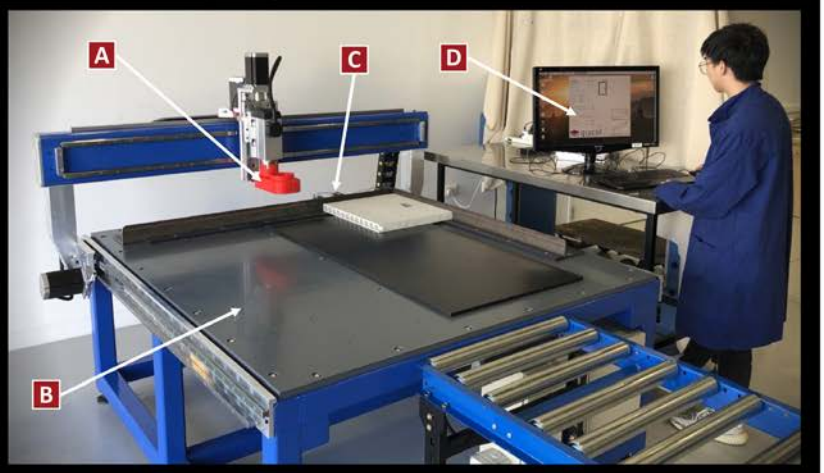


PROBLEM STATEMENT

- Develop a computed-aided manufacturing solution that produces handgrips in fibreglass trench covers.
- Handgrips must align with grid of reinforcing webs, which are shown top right.
- System must be reliable, suitable for a workshop environment and able to accommodate varying trench cover sizes.
- Minimise dust and improve upon the current manual method, which is time consuming and labour intensive.

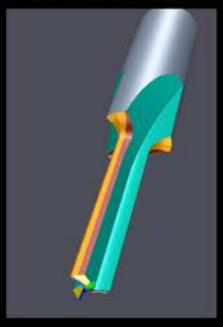
OUTCOME

- An innovative system was developed that is suitable for trench covers up to 1220 x 1400mm and varying thicknesses (37-74mm).
- A time-of-flight sensor scans an edge of the panel and identifies the web locations. Input from the operator via a graphical user interface then produces the G-Code to control the spindle.
- A custom carbide router bit then makes the cut and applies a fillet to the top edge. The panel is then turned over and the process is repeated.



A Custom Carbide Cutter

- A custom router bit was developed to increase productivity.
- The bit can plunge, create the slot and apply a fillet in a single pass.

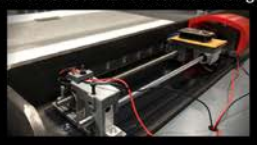


B Compressed Air Float System

- Compressed air is used to float the largest (120kg) panels, making them easy to position with a single operator.

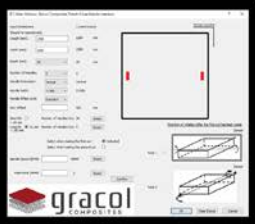
C Time-of-Flight (ToF) Sensor

- ToF sensor measures cell depth, which is used to locate the inner grid.



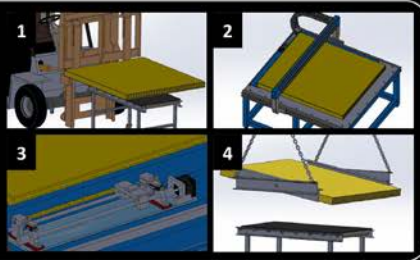
D Graphical User Interface (GUI)

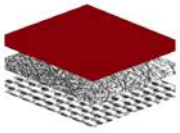
- Custom GUI enables operator to control system, enter panel dimensions and select handle locations.



Production Sequence

1) Largest panels (120kg) are loaded onto roller table using a forklift.
2) Operator uses air float system to assist in correctly locating the panel on the table.
3) Sensor and GUI data control the router, which cuts the top half of the handgrip.
4) Winch system is used to turnover the panel and steps 2 and 3 are repeated to complete the handgrip.





gracol COMPOSITES

Mechanical Engineering Department
Final Year Project (P59) 2019

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Acknowledgements: Anne-Marie Galyer, Brett Cottle, Dr Chris Pretty, Paul Zimmerman, Mike Drummond

P56: MAGNETIC LEVITATION OF HOUSES

Students: Alex Towse, Amy Strang, Wei Shen Chia, Dylan Davy
Supervisors: Geoff Rodgers, Geoff Chase, Cong Zhou,
Client: Dr Richard Strahan, **Technician:** Julian Murphy

Problem

Damage occurs to houses during earthquakes which may cause injury or loss of life. There can also be significant economic loss such as $40,000-50,000 per house on average from the 2011 Christchurch earthquake.

Opportunity

Test technical and economic feasibility of using magnetic forces to levitate a structure to minimise vertical forces and/or provide horizontal control to an isolated structure.

Isolation: Vertical

Introduction: Concepts were developed for base isolation of a structure through magnetic levitation. Due to this being emergent technology a prototyping process was taken to test the technical feasibility of the designs and calculations were done to find trade offs.

Electromagnet Reluctance Plate Prototype:

- An electromagnet provided an attractive upwards force to a permanent magnet.
- PD control was implemented with inputs from a hall effect sensor to "float" the magnet.

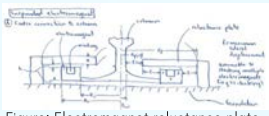
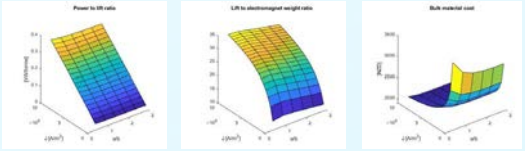


Figure: Electromagnet reluctance plate concept by Dr Richard Strahan.

Figure: Electromagnet reluctance plate prototype. Scan QR code to see video.

- Calculations found the trade off between cost, power:lift and lift:weight ratios when cross sectional area of the winding in the electromagnet was varied.



Halbach Array Prototype:

Figure: Halbach array prototype. Scan QR code to see video.

- A Halbach array is an arrangement of permanent magnets with an asymmetric field.
- Spinning the array over a conductive plate induced an opposing magnetic field, giving lift.
- Different array sizes and motors were tested.

Control: Horizontal

Introduction: It was important to control the horizontal movements of the structure relative to the ground to ensure it could not reach the edge of the base isolation system. A modelling approach was taken to test the technical feasibility of the design.

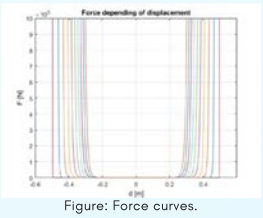


Figure: Force curves.

Different types of force curves (modelled as 'barriers') were designed to model horizontal force provided by magnets to a frictionless structure during an earthquake.

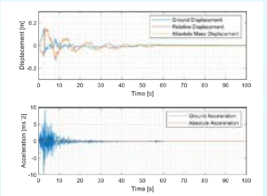


Figure: Displacements and accelerations of the chosen force curve.

The desired force curve had to limit the structure within chosen parameters.

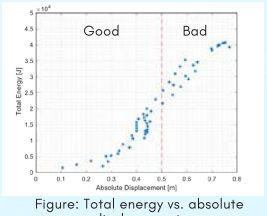


Figure: Total energy vs. absolute displacement.

By comparing all the functions modelled, the ideal function was chosen which provided the best displacement energy ratio.

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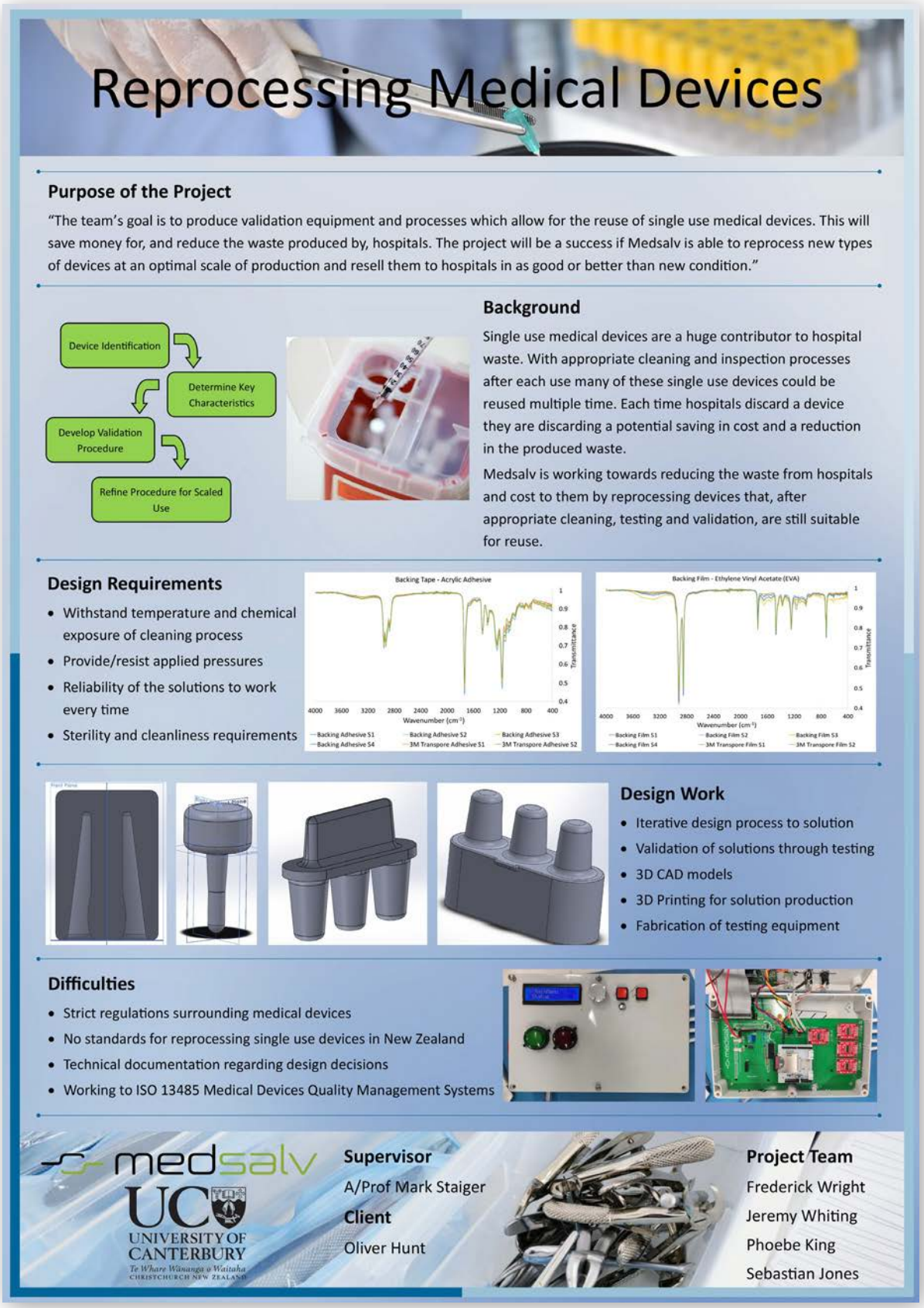

Track Cycling Start Gate System

Problem Background

The Canterbury Track Cycling Club are in need of a start gate system for their velodrome as there is a need for high grade equipment for competitions.

Project Goal

The Cycling Gate Team has designed a solution and produced an affordable and reliable track bike starting gate and timing system to a professional standard. This includes an identical pair of pneumatic cycling start gates, a timing unit to accompany each gate, and a central control unit to provide user control to the system.

Final Product

Design Specs

- Synchronous gate release.
- 10-year life expectancy.
- Gates are equipped to handle over 300 consecutive releases.
- Gates are easily transportable.

Frame and Pneumatics

- Pneumatic clamping running off Nitrogen gas is easily refillable and safe to use.
- Adjustable for bike sizes, wheel types, and track angles.
- Rapid removal from track on race start.
- Easy transport to and from storage.
- Provides support for bike and rider.
- Each gate can be operated independently.

Control and Timing

Timing unit consists of a speaker, LED strip light, and a large 2-digit display. Can be mounted to extendable stands and control the bike release with a solenoid valve pneumatic controller.

Each part of the system is mounted inside a strong plastic case. The control unit has a high definition touchscreen and a four colour coded button interface.

We would like to thank UC technicians Julian Murphy, Rodney Elliott, Garry Cotton, Ken Brown, Tony Doyle, and John Jones Steel.

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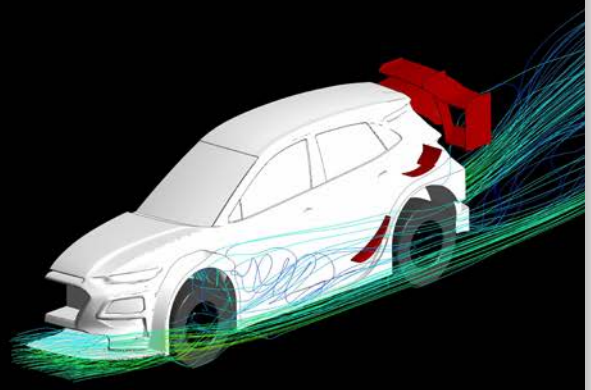
Client: Canterbury Track Cycling

Supervisor: Mark Garnich

Canterbury TRACK CYCLING

Development of Rally Car Aerodynamics

Introduction/Scope
- Paddon Rallysport's world first EV rally car
- Aerodynamics package for Hyundai Kona EV
- Design, Model, Validate and Manufacture



Wind Tunnel Validation
- Using a 1/3rd scale 3D printed model.
- 0.83% difference in downforce.
- 10% difference in drag.
- Tested up to 200 Km/h

CFD Modelling
- Modelled and meshed using ANSYS Fluent
- 1050N of downforce at 100 km/h
- 19:1 Lift to drag ratio on overall aerodynamic gains

Rear Wing
- Selig S1210 wing profile
- Swan neck design with 12° variability in angle of attack
- 433N of downforce produced at 100 km/h
- Lift to drag ratio of 6.05 at 8° attack angle

Front Aerodynamics
Splitter, dive planes and bumper

Side Aerodynamics
- Front, rear guards, and side skirts.
- Primarily used as a functional part.

has been developed to produce downforce.

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Prof. Natalia Kabaliuk
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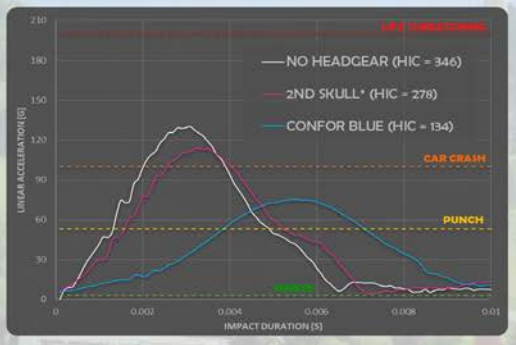
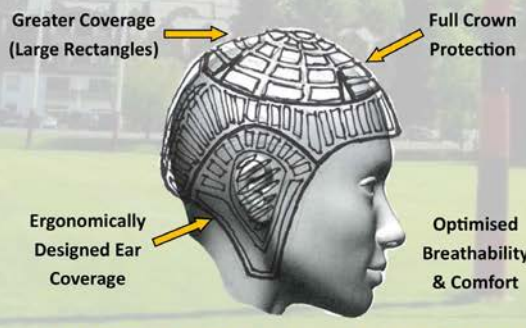
Jono Kidson

paddon RALLYSPORT

PROTOTYPE RUGBY HEADGEAR

(1)





INTRODUCTION

Concussion or Mild Traumatic Brain Injury (MTBI) has the highest match day injury incidence rate in rugby, at 0.8 per game. ACC had 2603 new and 3082 existing claims made from July 2017-June 2018.

OBJECTIVES

Select or manufacture impact protective materials that can be implemented into the headgear to help mitigate the traumatic effect of head impacts common in rugby.

DELIVERABLES

- 1x headgear that complies with world rugby relations.
- 1x headgear that is more effective but does not comply.

TESTING AND DATA PROCESSING

- Materials were collected from a wide variety of worldwide suppliers, and experimentally tested via the drop tower.
- Impact accelerations (linear and rotational) were measured via tri-axial accelerometers and gyrometers embedded in the headform.

INJURY SEVERITY CRITERIA

HIC (Head Impact Criteria) and RIC (Rotational Impact Criteria) were used to interpret the severity of linear and rotational impacts. The lower the HIC and RIC index scores, the less risk there is of a traumatic head injury occurring (HIC of 300 ⇒ 50% risk of MBTI).

$$HIC = \left\{(t_2 - t_1)[(t_2 - t_1)^{-1}\int_{t1}^{t2} a(t)dt]^{2.5}\right\}$$

$$RIC = \left\{(t_2 - t_1)[(t_2 - t_1)^{-1}\int_{t1}^{t2} \alpha(t)dt]^{2.5}\right\}$$

(where α is rotational acceleration)

SPECIFICATIONS

The World Rugby Union (WRU) has strict regulations regarding the design of headgear (Section 12):

- Maximum density (45 ± 15 kg/m^3).
- Maximum material thickness (10 ± 2 mm).
- Maximum fabric thickness (1mm each side).
- Homogeneous material structure and layering.

CONCLUSION

Pending the arrival of the two prototype headgear supplied from a professional rugby apparel manufacturer.

Over the coming summer, there will be further research into other complex materials, as well as the testing of the prototype headgears to verify their effectiveness

(1) https://www.rugbypass.com/news/the-fascinating-stats-leading-to-calls-for-mandatory-headgear-in-rugby/

* 2nd Skull claims to be the best WRU compliant headgear currently on the market.

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TEAM MEMBERS

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ACKNOWLEDGEMENTS:

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PROJECT SUPERVISOR: PROF. KEITH ALEXANDER
ASSISTANT SUPERVISOR: DR. NATALIA KABALIUK
TECHNICIAN: JULIAN PHILLIPS

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Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

Heavy Vehicle Drawbar Design

Problem Statement:

The purpose of this project was to design for manufacture a new concept of heavy trailer drawbar to be fabricated in under one hour. This was to be achieved by utilising a design with standardised joints and couplings for an A-frame configuration. Finite element analysis was conducted to ensure the design will meet industry standards and last 2 million cycles. We have optimised the design of the drawbar using FEA and with the manufacturing process in mind.

Towing Eye End:

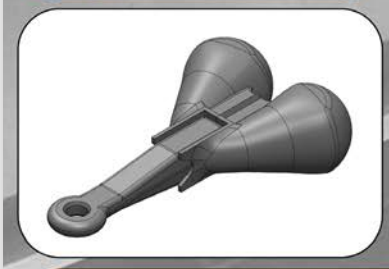
- Cast out of high strength ST52-3 steel
- Incorporates standard off the shelf towing eye
- Ball and socket design to allow 125 NB steel pipe to be welded to curved surfaces
- Designed using FEA to optimise design

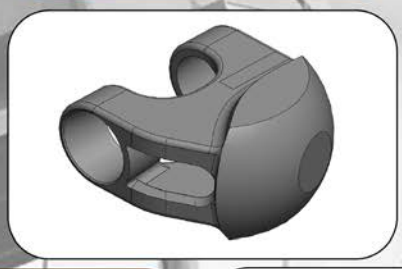
Trailer Hinge End:

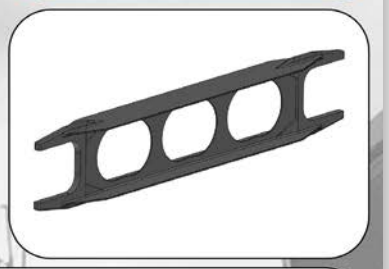
- Cast out of high strength ST52-3 steel
- Attachment point for I Beam cross member
- Incorporates rubber bushings in the hinge
- Ball and socket design to allow 125 NB steel pipe to be welded to curved surfaces

Cross Member:

- Cast out of high strength ST52-3 steel
- Designed to fit three standard widths
- Welded connection between the two trailer hinges
- Designed using FEA to optimise design and weight



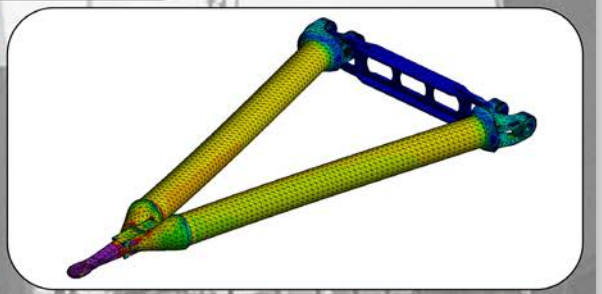




Finite Element Analysis (FEA):

ANSYS and SolidWorks were used to optimise the components of the drawbar

- Material distribution optimised for minimal stress concentrations
- Designed to be as lightweight as possible
- Iterative process between design and FEA
- Simulated for several different geometry configurations of the drawbar



Final Drawbar Design:

- Refined existing designs from TransTech Dynamics
- Designed to industry standards NZS 5446, AS 3990, BS 5400
- FEA used to optimise design and weight of drawbar
- Design stresses informed by performing a fatigue analysis of drawbar
- Designed to optimise manufacturing process and time

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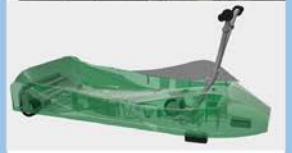
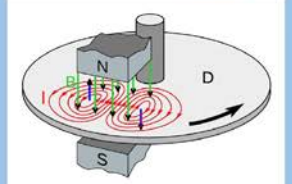
TRANSTECH DYNAMICS LTD
CONSULTING ENGINEERS

Skyline Luge Cart Redesign

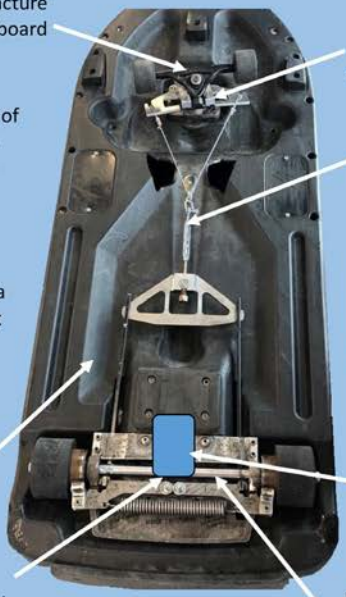




Project Background

This project further developed Skyline's prototype of a four wheeled luge cart. The main issue that Skyline wished to address was increasing safety by limiting excessive speeds and increasing stability of the Luge cart. We were asked to:

1. **Limiting the speed of the four wheel cart mechanically**
2. **Making the cart more ergonomic over a greater height range**
3. **Improving the stability and handling of the cart**
4. **Improving ease of maintenance**
5. **Maintaining the same thrill that riders have when using the carts**



Design and manufacture of mount for skateboard trucks.

Design, manufacture and testing of adjustable front wheel housing.

Determined the height of riders at which their knees interfere with handlebars.

Modification of the brake system to fit the live axle.

Site visit to Skyline Queenstown and Rotorua to test carts and conduct research.

Surveyed users to a baseline for the handling and comfort of the current cart.

Body design to increase legroom and comfort for riders of all heights.

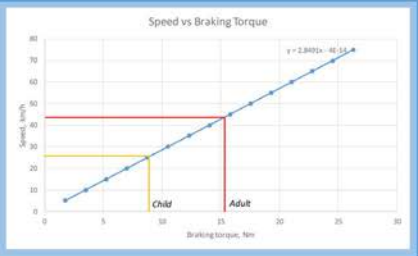
Design, manufacture and testing of eddy current brake.

Research and calculations for speed limiting options.

Design, manufacture and testing of new rear assembly to incorporate live rear axle.

Speed Limiting Options

1. Centrifugal clutch
2. Fluid brake
3. ***Chosen Option: Eddy current braking***
   Eddy current brakes use the electromagnetic principle of eddy currents, which are generated in a conductor when it is moved through a magnetic field.

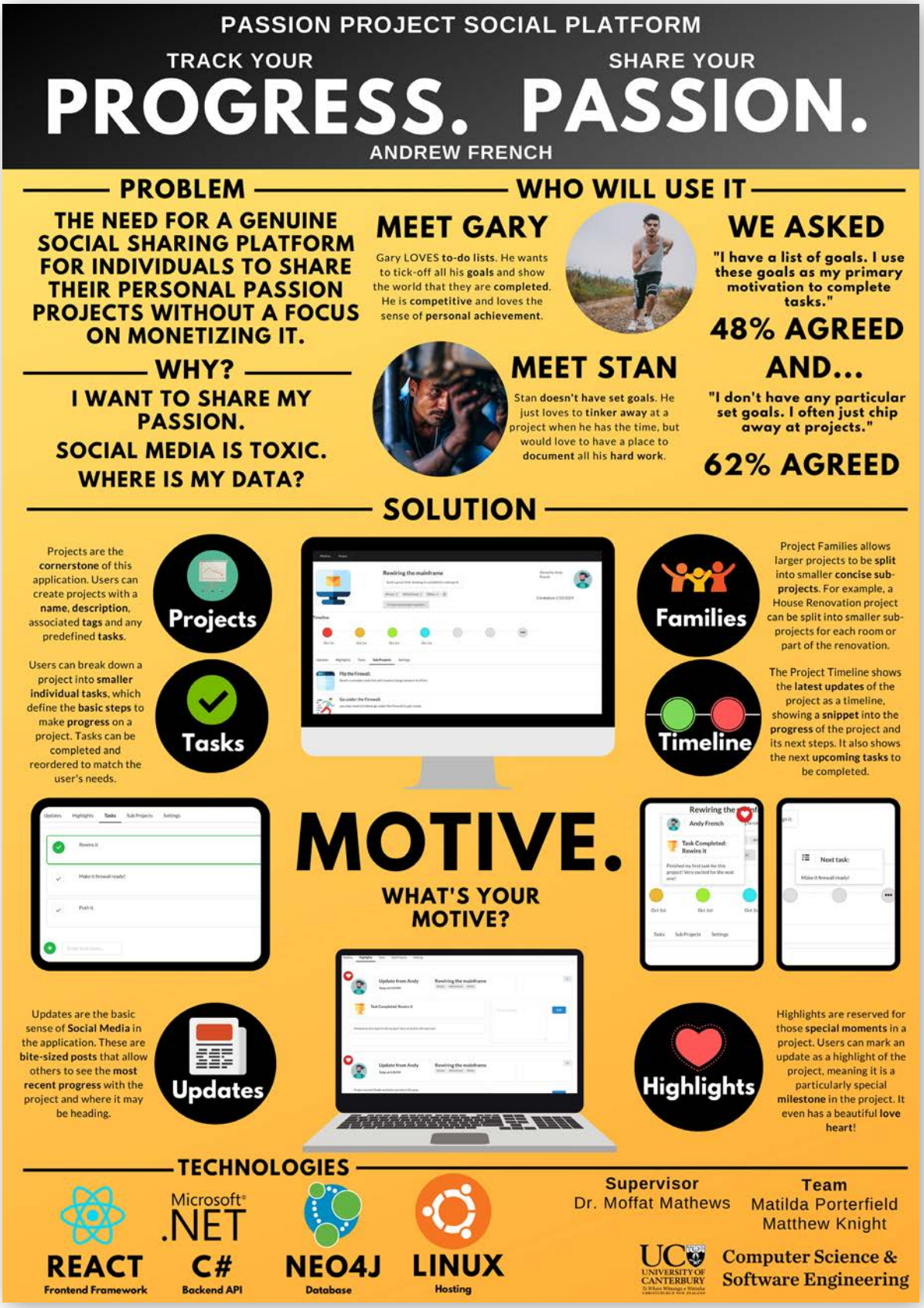


Sponsor: **Skyline**
Client: **Ryan Williams**

P107 Team Members:
Max Attwell, Charles Christey, Daniel Fariuz, Isabella Strang, Cory Sutherland

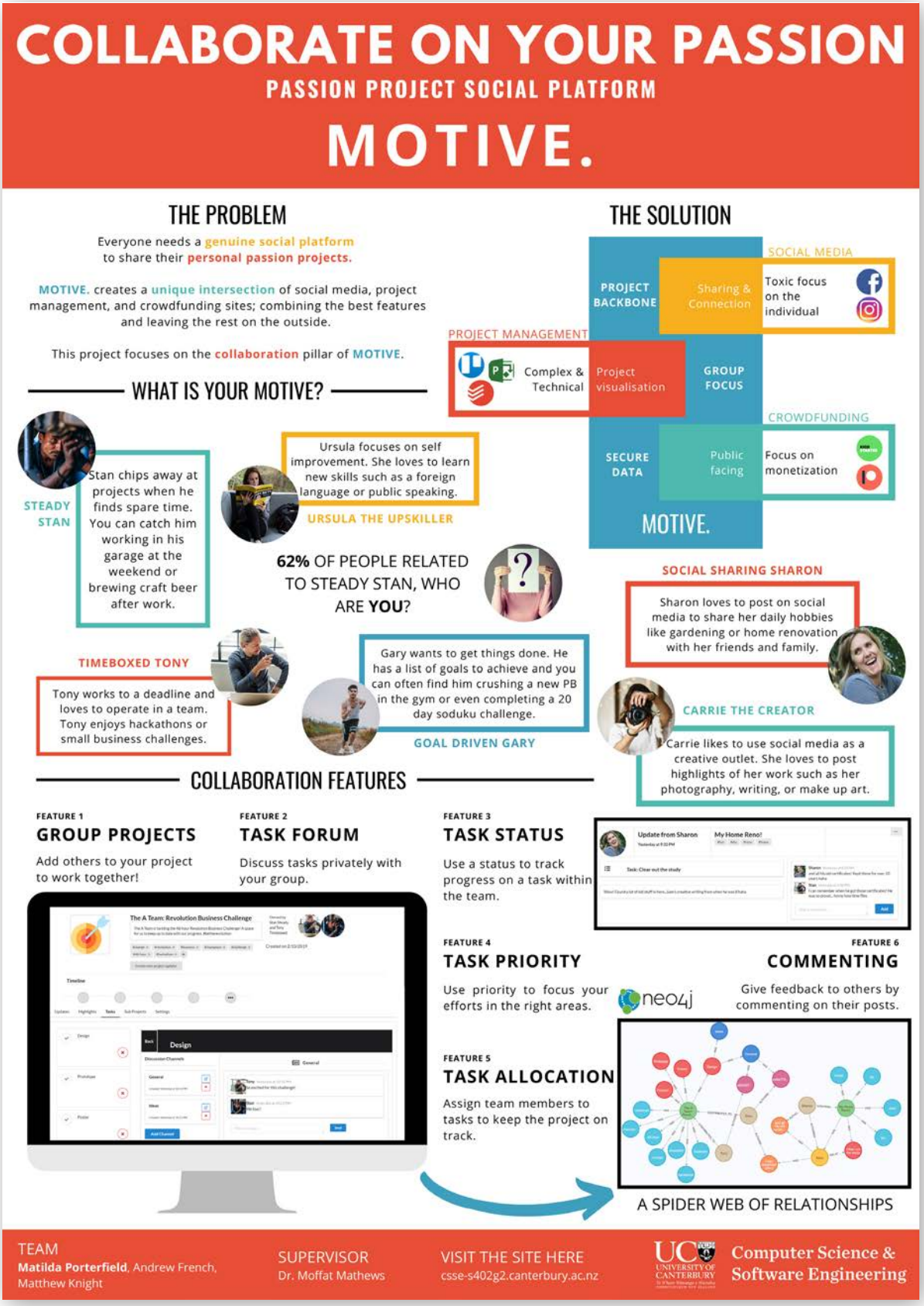
Project Supervisor:
Dr. Keith Alexander

Student projects: Software Engineering



Student projects: Software Engineering

Student projects: Software Engineering



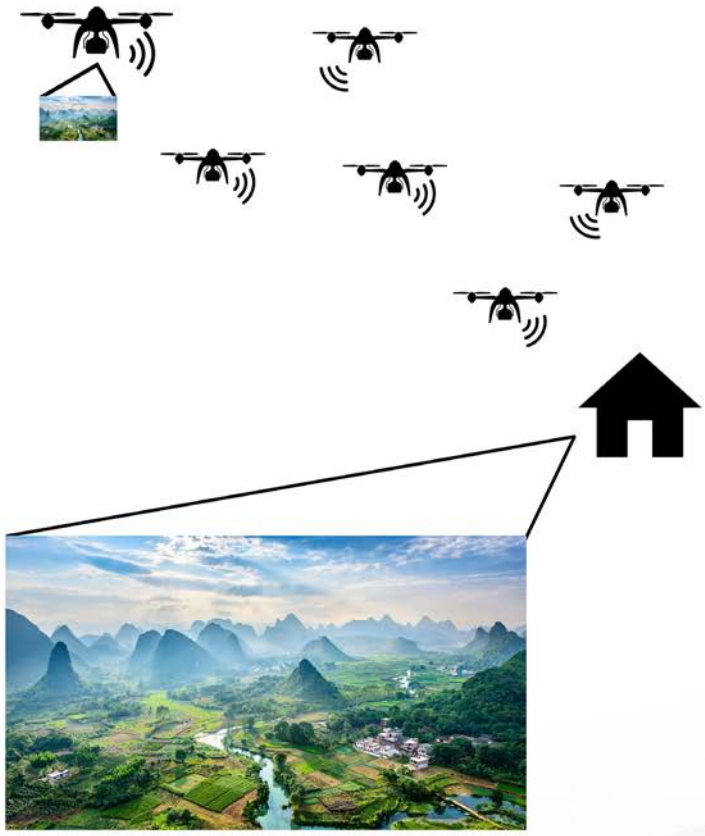
Student projects: Software Engineering

VIDEO TRANSMISSION IN WIRELESS NETWORK OF UAVS

BENNY SCHMIDT, BROOKE RAKOWITZ AND TOM KEARSLEY
SUPERVISOR: ANDREAS WILLIG

WHAT'S THE OBJECTIVE?

We want to send a reliable and high quality camera feed from a remote drone to our home base through a network of other drones. To achieve this we need to establish a camera stream, determine how to send the footage to our home base, and figure out where to place our other drones. Our home base will also have to determine how good the video quality of the stream is and tell the drones to make adjustments to improve our feed.



SOLUTION

Before working with the real world, it is good to test a solution in a simulation. OMNeT++ is a tool that has been used to simulate environments for our network. Our video streaming process is powered by GStreamer, a popular multimedia tool. This tool allows us to adapt the video encoding and decoding process. Machine Learning techniques have been performed to determine the video quality, allowing us to further improve the stream. This has been created with OpenCV, a powerful computer vision tool, and developed with datasets provided by Netflix.

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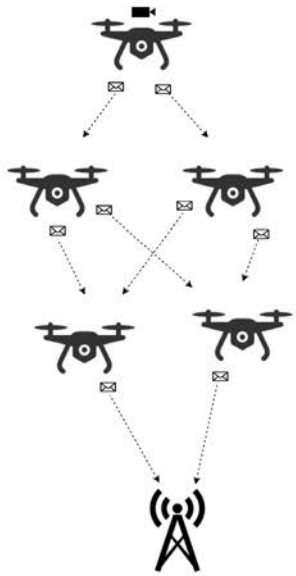
PROTOCOL ARCHITECTURE IN WIRELESS NETWORK OF UAVS

BENNY SCHMIDT, **BROOKE RAKOWITZ** AND TOM KEARSLEY
SUPERVISOR: ANDREAS WILLIG

WHAT'S THE OBJECTIVE?

To implement a solution that allows for the reliable transmission of high quality video feed from a source drone to a home base station through a network of relay drones. To achieve this three components are required: the establishment of a camera stream, the reliable transmission of the camera stream through the relay drones to the base station, and the placement and movement of all drones in the UAV network. The key objective of the protocol architecture implemented in the drones is to find and maintain a good quality route between the source UAV and the ground station.

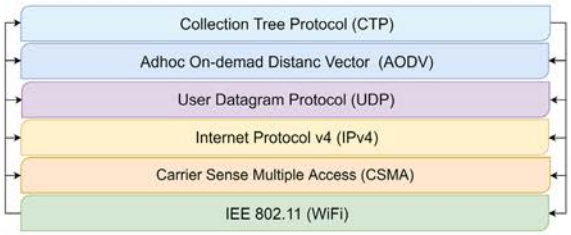


SOLUTION

To achieve a good quality route between the source drone and base station through the relay drones, multiple protocols have been defined in the network stack. The wireless communication between drones is simulated in OMNeT++ over a WiFi medium using the IEE 802.11 standard. Access to this medium is managed by CSMA. Drones carry out CSMA to determine whether transmission is possible. This is achieved by listening to the medium to determine if it is free to begin their own transmissions.

IPv4 is the implemented network layer protocol, allowing 32-bit network layer addresses to be assigned to each drone and the base station. UDP is the transmission protocol. Combined with IPv4, these two protocols are connectionless and do not guarantee successful transmission. AODV is used by drones to maintain good quality routes to all other drones in the network as well as the base station. This is for the purpose of maintaining and updating drone positions.

CTP is implemented with the purpose of maintaining a good quality route between the camera drone and the base station through the relay drones. This is with the main objective of performing reliable video transmission. It is a hierarchical protocol, each drone maintaining the shortest route to the base station.



FUTURE PLANS

*The effectiveness of this solution is purely **theoretical** and based off of related research into these individual protocols in the network stack. Future steps would be to define performance metrics and run simulations to evaluate the solution based on these. This would allow for validation of the solution and subsequent optimizations to be made. Following this, integration of the video quality and mobility sub-projects would be carried out.*

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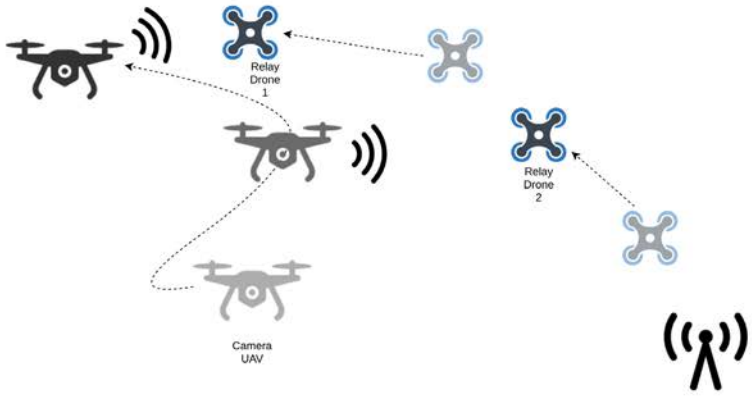
Student projects: Software Engineering

DYNAMIC ROUTER UAV PLACEMENT

TOM KEARSLEY, BENNY SCHMIDT AND BROOKE RAKOWITZ
SUPERVISOR: ANDREAS WILLIG

WHAT'S THE OBJECTIVE?

Drones are incredibly useful tools for numerous different applications specifically, camera drones can be used in a wide variety of different scenarios from capturing landscape footage to providing assistance in search and rescue operations. The objective of this project is to allow the movement of a camera UAV, while maintaining a quality connection to a series of relay drones and a ground station. The camera UAV should be able to freely move around and the intermediary drones should autonomously adjust their distance from the camera UAV while maintaining a good connection between each other and the base station.



RESEARCH

The main component of research involved investigating various different mobility models to decide how the drones will reach their destination location. This involved looking at a variety of different algorithms varying from critically damped springs to PID controllers. There was also significant time spent on deciding on a simulation framework that would provide the necessary network communication and be programmable in C++. Eventually, it was decided to build the simulation using OMNet++ and use a vehicular network simulation framework known as Veins to simulate the drones movements and interactions.

SOLUTION

The final product was built within a simulation framework known as OMNeT++, this is a C++ simulation library and framework used for building network simulators. This was used in conjunction with Veins, built for running vehicular network simulations, and SUMO a road traffic simulator. This allowed routes to be created for the drone network to travel along and had pre-built traffic collision simulation and detection. The system can be configured to have as many drones as necessary and it designed to have the camera UAV broadcast its position when it changes to the relay drones which in response, move to a new location that provides a better connection.

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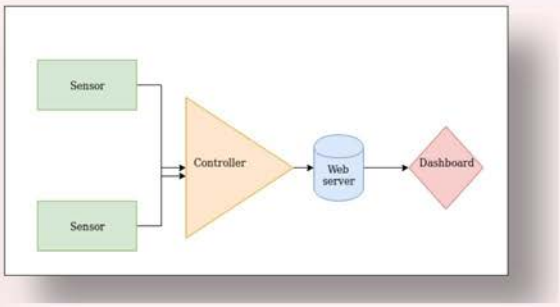
Student projects: Software Engineering

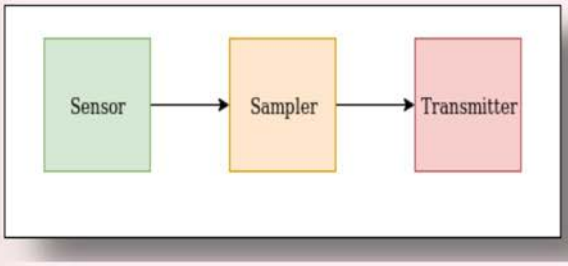
Cat Connect Opportunity Information Funnel Hardware Interface

Increases in the ability of networked sensors now allows for realtime monitoring of conditions inside operational machinery. Prolonging the lifetime of the machinery and increasing the effectiveness of maintenance.



Using **Internet of Things** and **Machine to Machine Communication**, this data can be be displayed to the relevent technical experts, allowing their skill set to protect the assets remotely.

Using an **Arduino** micro-controller this information is extracted and forwarded on to a **webserver**. Allowing the results to be displayed to users world wide.



Joshua Burt
Supervisor: Tim Bell
Associated Projects by: Patrick Laffey, Tyler Kennedy

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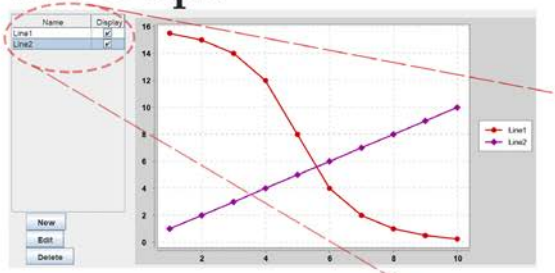
Computer Science & Software Engineering

Cat Connect Opportunity Information Funnel

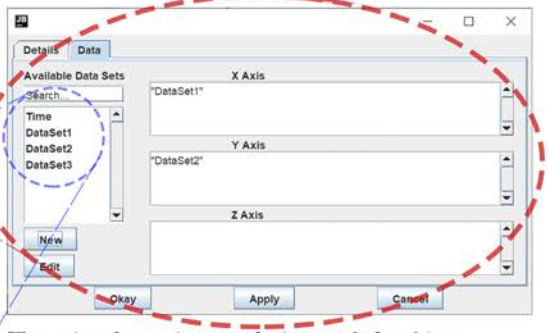
By Patrick Laffey

The Graph



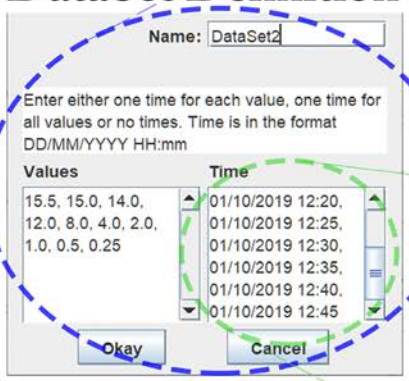
The graph can display any number of lines at a time. Each line is individually defined and can be hidden. All data is stored in an internal data, meaning that all changes made will be automatically saved.

Line Definition



The value for each axis of a line is defined by a calculation. These calculation can contain any basic mathematical operators, numbers or DataSets. The Z axis is displayed as a change in colour of the line once the value is between set threashold values. The details tab allows the user to define the name, colours and Z threashhold values of the line.

DataSet Definition



A DataSet is defined as a set of decimal values with a corresponding time value. When no time value is provied, the data is marked as not time dependant. If only one time value is provided then it will use that one time value for all values.

Time Depandant Data

When data is graphed, only the points on the X/Y axis that have correlating time values are plotted. Specifically within a DataSet the data is ordered by the time values. When joining two or more DataSets, the individual points are only joined where the time values are equivilent.

Cat Contributors: Ian Pendal, Simon Buttery, Sofio Abela, Cody Cooper

Supervisor: Tim Bell
Associated Projects: Josh Burt, Tyler Kennedy

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Student projects: Software Engineering

GOUGH GROUP CAT CONNECT OPPORTUNITY INFORMATION FUNNEL

CLOUD SYSTEMS AND DATA ANALYSIS

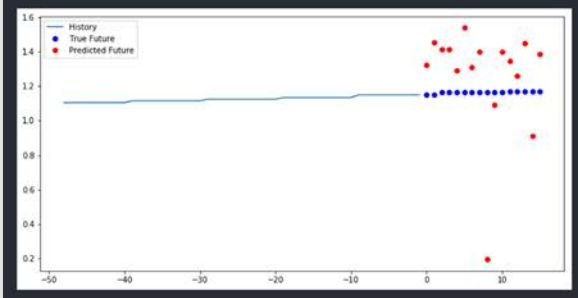
Overview and Motivation

Gough are the largest and oldest dealership for CAT heavy machinery in New Zealand. The Christchurch site contains the head office, a servicing/workshop area and a laboratory which carries out a variety of tests on oil samples. This oil lab is widely used by a number of Gough customers as the condition of the oil can often indicate whether a machine is in need of servicing. In general, there is a large amount of data that is being produced by the varying fleets of machinery, very little of which is being recorded, let alone used in any meaningful way. The original scope of the project was to improve this, however it has been narrowed to oil condition monitoring to aid and partially automate the current laboratory process.

There are three sections in this project:

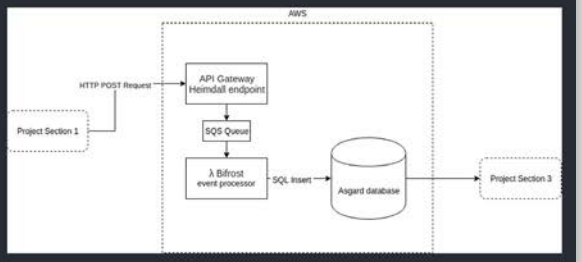
1. Using an embedded device to extract data from sensors and send it to cloud storage
2. Creating cloud systems to aid in storage and data analysis methods to predict future values
3. Creating a visualization tool to display raw results and predictions

This poster covers the second section.



Outcomes

A preliminary cloud system has been created and deployed. This accepts an HTTP request from the embedded device and inserts the request content into the relevant database tables. This database can be accessed by any authorized user to perform analysis, visualization ,etc.
An initial script has been created using a neural network and clustering algorithm to predict future values of oil parameters and identify this as being "ok" or "not ok".



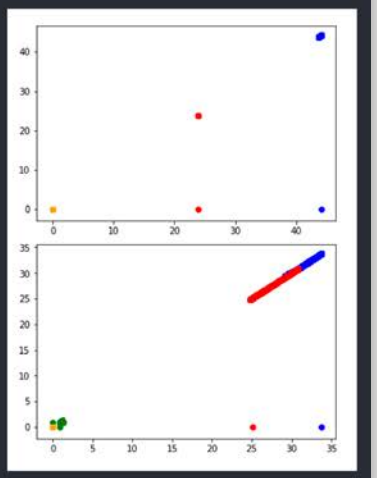
Cloud Architecture

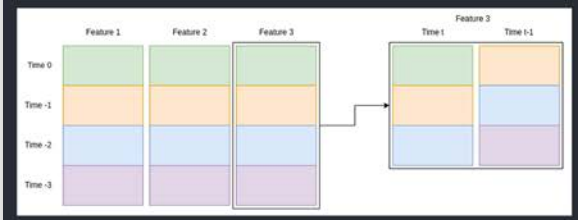
Any POST request messages sent to an endpoint is pushed into a queue. From there, the event processor takes the message and extracts useful information. This information is reformatted and inserted into the database. This database can be accessed at will by any authorized user for tasks such as analysis, prediction, or visualization.

Neural Networks and Predictions

The neural network being used leverages LSTM cells. This takes in a small piece of historical data and attempts to predict the next several values in the sequence. It can be trained such that it can identify the start of a spike in a particular feature. The training process takes a large amount of time and data to be accurate (along with tuning a variety of parameters of the model itself).
An example set of predictions can be seen above.
These predictions can be passed to the clustering algorithm to allow it run on "future" data.


```
clustering script output...
source: merged/test-file.csv
tuple size: 2
distance threshold: 75
window size: 48
----------
without predictions:
Feature 1 is ok: False
Feature 2 is ok: False
Feature 3 is ok: True
Feature 4 is ok: False
Feature 5 is ok: True
----------
with predictions:
Feature 1 is ok: False
Feature 2 is ok: False
Feature 3 is ok: True
Feature 4 is ok: False
Feature 5 is ok: True
----------
```





Clustering - Ok or Not Ok

The first step of the clustering is using time delay embedding to reshape the input data (see left). Every point is paired up with the point before it. From here, the pairs can be graphed, treating time t and t-1 as the axes (as shown in the two images above). If the points do not change drastically over time, tight clusters will form around an average/centrepoint. If the points vary over time, they will stray away from this centrepoint. This can be seen in the lower image as the red and blue features tend towards the top right (both increase over time).
By applying an algorithm that forms cluster based on the distance from a centrepoint, we can count the number of clusters that form. One cluster is expected but if more form, some concerns should be raised.

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Computer Science & Software Engineering

Student: Tyler Kennedy
Supervisor: Tim Bell
Related Projects: Joshua Burt, Patrick Laffey
Industry Contacts: Ian Pendle, Simon Buttery, Sofio Abela

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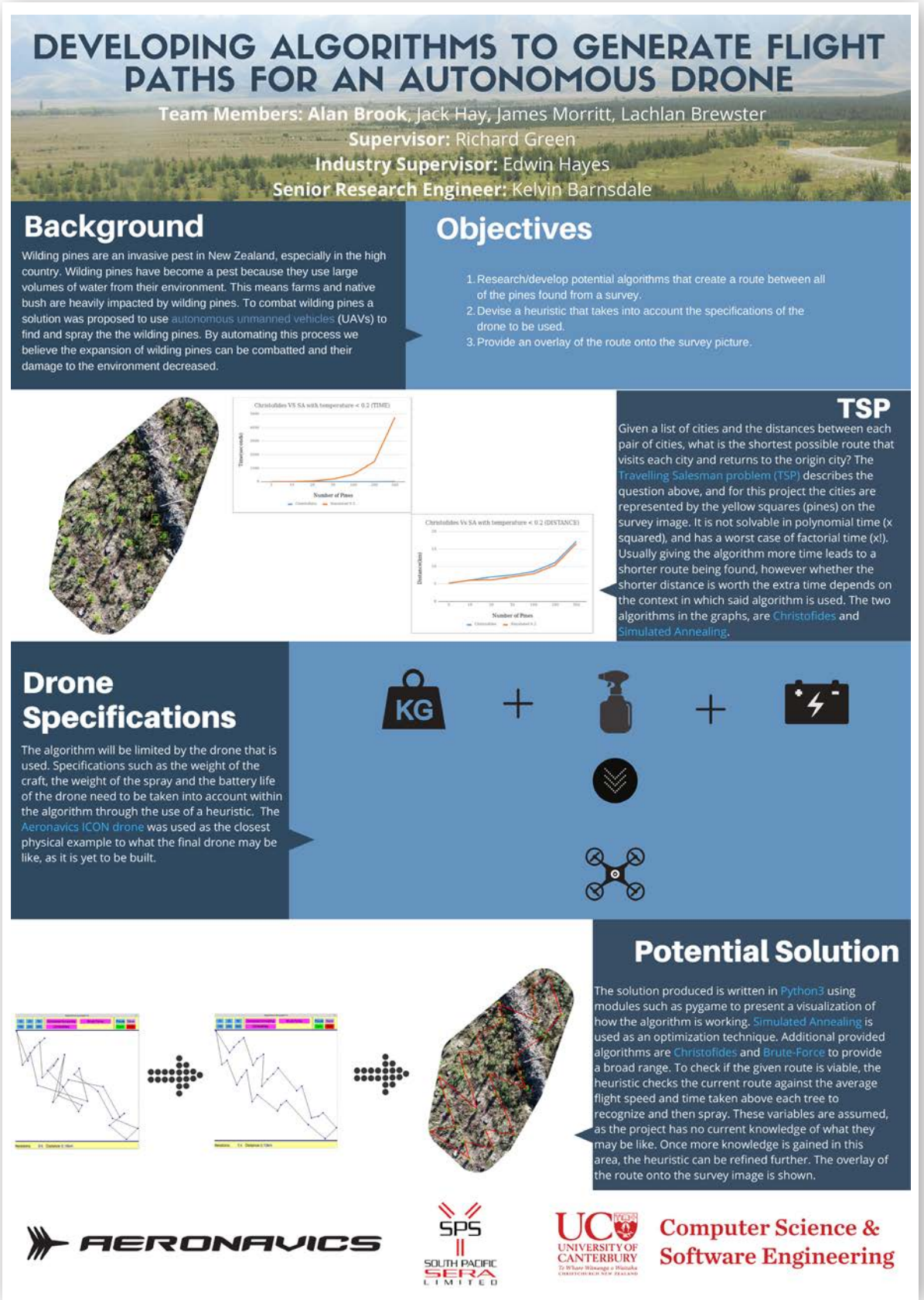


Student projects: Software Engineering

DETECTING WILDING PINES USING DEEP LEARNING

Team Members: Jack Hay, Alan Brook, James Morritt, Lachlan Brewster
Supervisor: Richard Green
Industry Supervisor: Edwin Hayes
Senior Research Engineer: Kelvin Barnsdale

Background

Wilding pines are an invasive pest in New Zealand, especially in the high country. Wilding pines have become a pest because they use large volumes of water from their environment. This means farms and native bush are heavily impacted by wilding pines. To combat wilding pines a solution was proposed to use autonomous unmanned vehicles (UAVs) to find and spray the the wilding pines. By automating this process we believe the expansion of wilding pines can be combatted and their damage to the environment decreased.

Objectives

- Detect pines in a range of images to demonstrate versatility in the solution.
- Seamlessly process images that are larger than 200MB.
- Detect the most central pine in an image in under 1 second for an image no larger than 5MB so that the drone does not shift while processing.

TensorFlow™

PyTorch

Tools

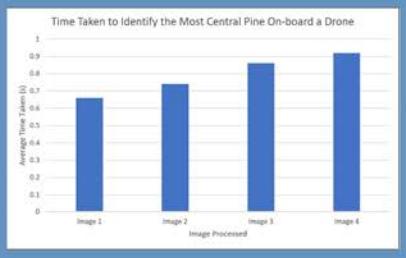
Two deep learning frameworks were used in this research; PyTorch, based on the Torch framework and supported by Facebook,and TensorFlow by Google. Both libraries were open source and provide extensive documentation on how to setup a deep learning environment.

The annotation software used assisted in efficiently annotating a dataset of pine trees by predicting and automatically annotating the objects in the image before they are manually annotated.

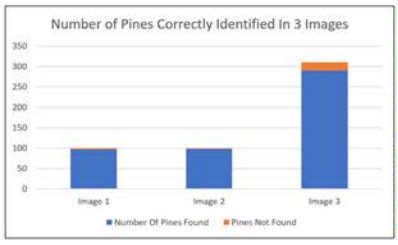
Performance

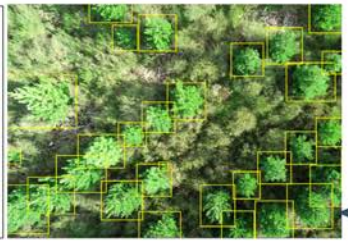
The software was configured for a nuc that could be used on-board an Aeronavics drone. 4 images ranging in size from 1MB to 5MB were analysed 3 times each to get the average time taken to identify the most central pine in each image. The average time taken over the 4 images was 0.79 seconds per image.

To get the closest pine to the centre of the image, the Euclidean distance of each pine to the centre pixel of the image was calculated, with the shortest one being the most central.



Accuracy





The accuracy of the software when run on the 3 images is 95%, with the lowest accuracy being on the larger survey image. The inaccuracy on the largest image is not surprising as the accuracy of a convolutional neural network decreases when the object has fewer pixels. Most of the missed pines in the least accurate image were small saplings.

The pine detection software has shown promising results when analysing images where pines overlap, pines are in shadow and sun, and where pines are casting a shadow on the ground.

AERONAVICS

SPS SOUTH PACIFIC SERA LIMITED

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Computer Science & Software Engineering

Student projects: Software Engineering

Student projects: Software Engineering

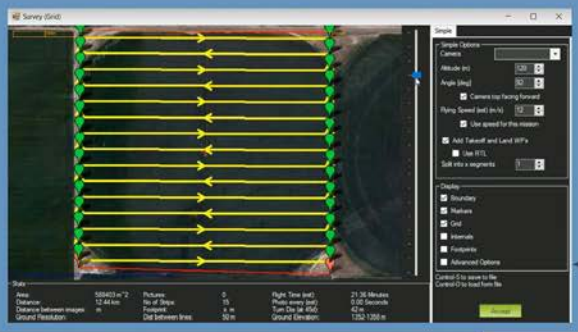
AUTONOMOUS DRONE SURVEY AND IMAGE STITCHING

Team Members: **James Morritt**, Jack Hay, Alan Brook, Lachlan Brewster
Supervisor: Richard Green
Industry Supervisor: Edwin Hayes
Senior Research Engineer: Kelvin Barnsdale

Wilding pines are an invasive pest in New Zealand, especially in the high country. Wilding pines have become a pest because they use large volumes of water from their environment. This means farms and native bush are heavily impacted by wilding pines. To combat wilding pines a solution was proposed to use autonomous unmanned vehicles (UAVs) to find and spray the the wilding pines. By automating this process we believe the expansion of wilding pines can be combatted and their damage to the environment decreased.

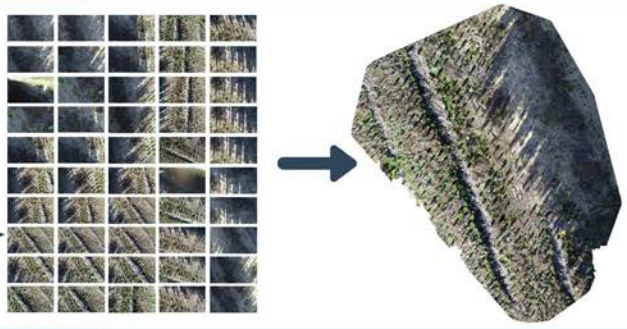
The objectives of my part of the project were:

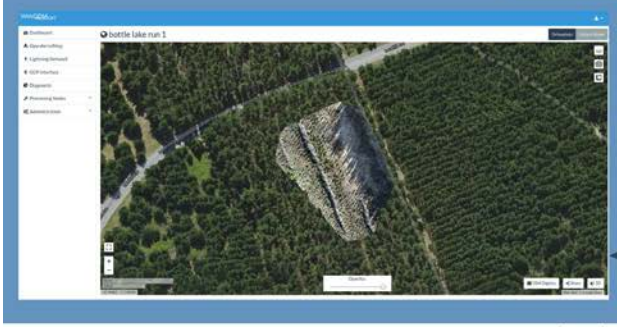
- Create a path for a UAV to follow to conduct a survey
- Create a single ortho-rectified geotagged image from all of the survey images
- Automate this process of creating ortho-rectified geotagged images



1 The first step in this process is to create a path for the UAV to follow. This was done by using ArduPilot. ArduPilot allows us to outline the area to survey on a Google maps like interface and it automatically creates a path that will cover the entire area. This is calculated based on the height that you want the drone to fly at, the camera that is on the drone and how much of an overlap that you want for the images.

2 The next step was to create a single ortho-rectified image from all of the survey images. This was done using OpenDroneMap, a drone mapping software that can be used to create 3D models, point clouds and maps from drone images. This process has been automated from start to finish, so the user only has to copy the survey images into an image dump folder and the process automatically starts and produces the ortho-rectified image and archives the survey images.





3 OpenDroneMap allowed for the creation of an ortho-tiff from the survey images. An ortho-tiff allows every pixel in the image to have a corresponding GPS coordinate. This meant that any wilding pines found in the image can easily be found by the spray drone from the GPS coordinates extracted from the ortho-tiff. This also allows this images to be overlaid on to google maps, which allows the user to gain a clearer understanding of where the survey is situated and how to get there.

AERONAVICS

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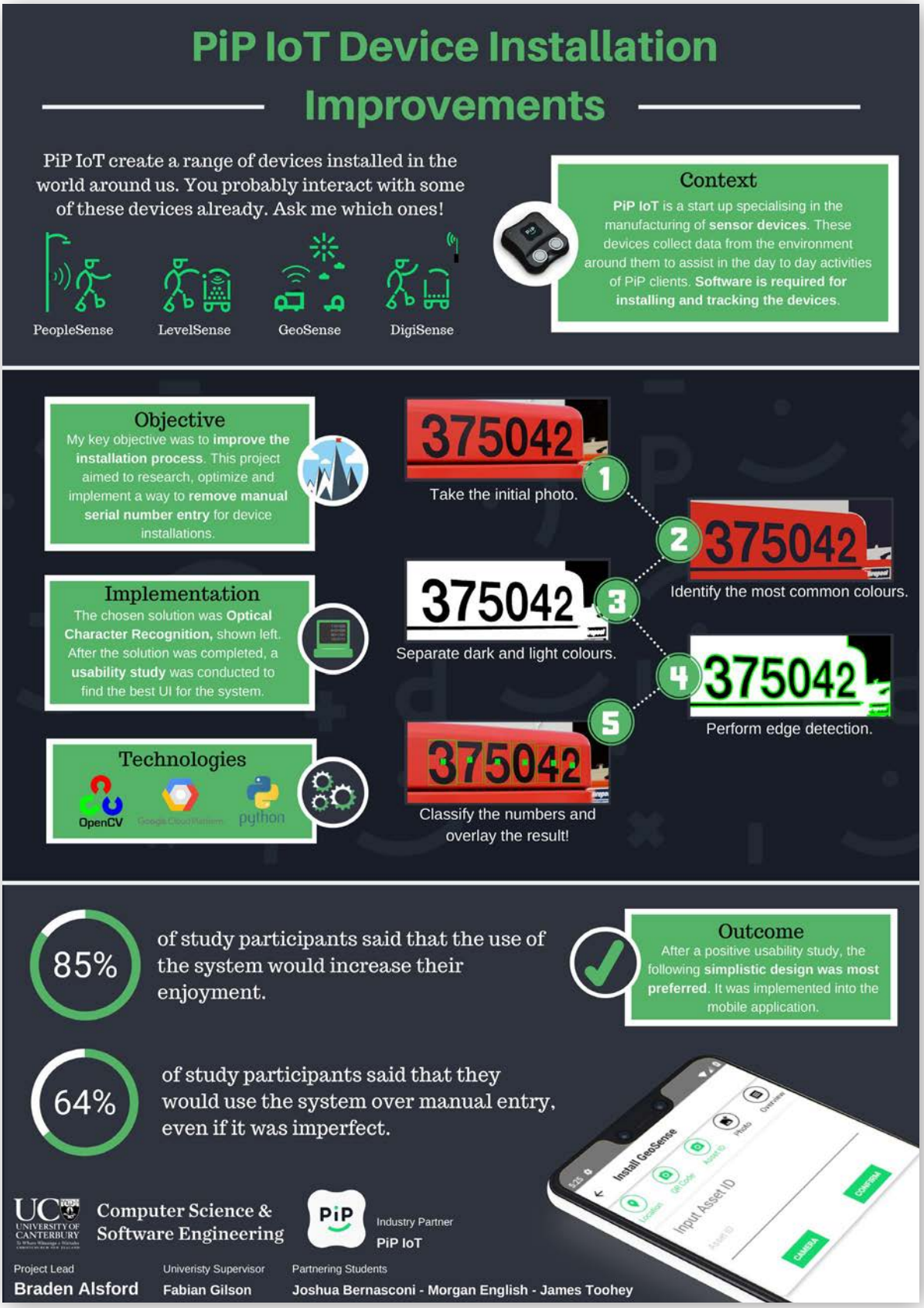
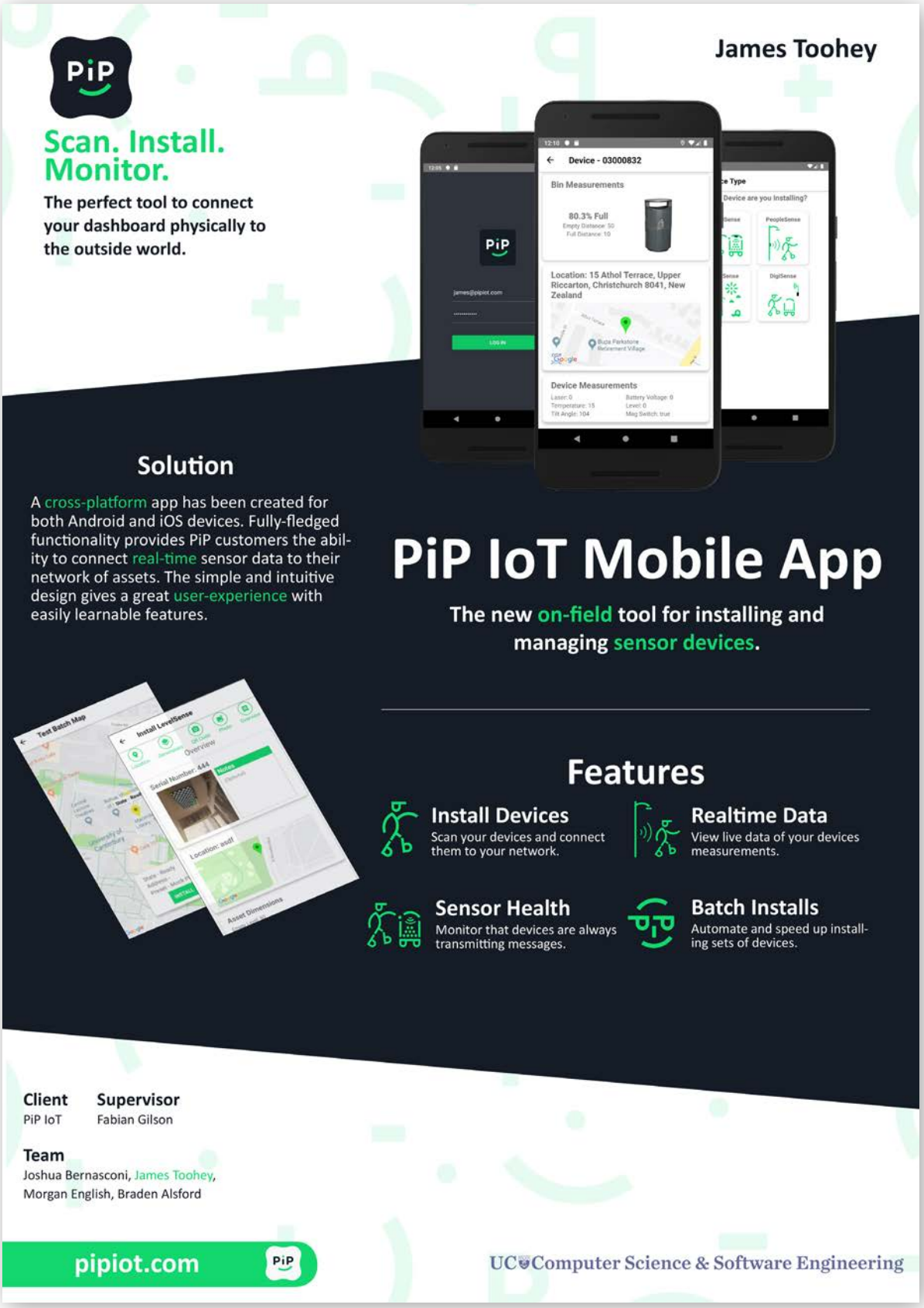


Student projects: Software Engineering



Student projects: Software Engineering

PiP IoT Device Management System

PiP IoT is a start-up company manufacturing various devices that take and report measurements continuously and automatically.

PiP's devices include:

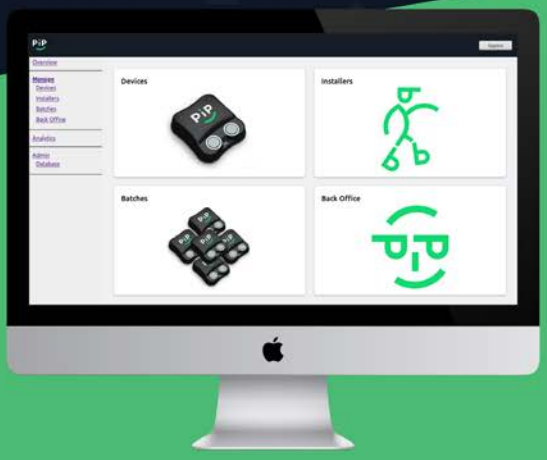
- LevelSense
- GeoSense
- PeopleSense
- DigiSense

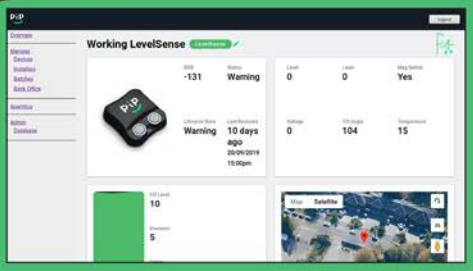
The Problem

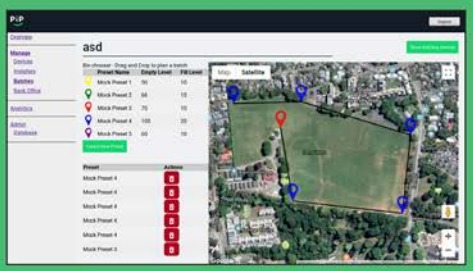
The existing DMS has a few shortfalls and a complete redesign was necessary.

The Solution

A new web application dedicated to back-office and administrative tasks.







Key Features:

- Search for devices
- View device information
- Edit installed device details
- Batch creation and modification
- Manage users

Joshua Bernasconi

UC University of Canterbury — Computer Science & Software Engineering

Tech

University Supervisor
Fabian Gilson

Industry Partner
PiP IoT

Student Team
Braden Alsford
Joshua Bernasconi
Morgan English
James Toohey

Student projects: Software Engineering

Internet of Things Asset Measurement and Analysis Ecosystem

Braden Alsford, Josh Bernasconi, **Morgan English** & James Toohey

Academic Supervisor: Fabian Gilson
Industry Partner: PiP IoT

PiP IoT

PiP creates IoT devices that pair with client assets to provide real-time information.

The Project

A multipart software solution allowing PiP's clients to install, manage, and analyse devices.

Existing Solution

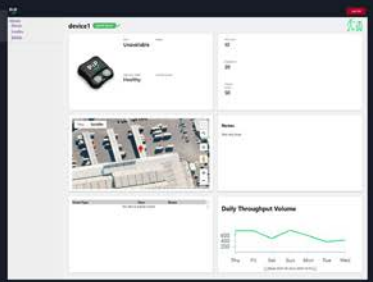
PiP's exisiting solution provided a poor user experience and lacked analytic support.

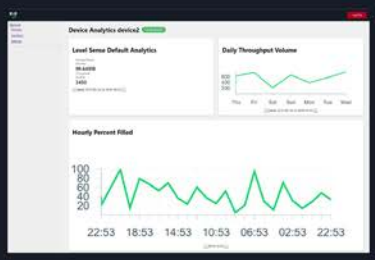
Tech Stack

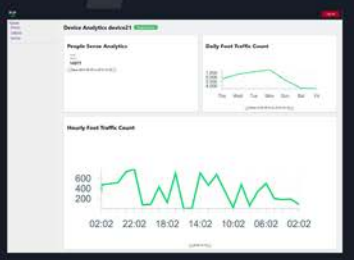
.NET Core, C#, MySQL, React, TS, Microsoft Azure

The Solution

A simple to understand interface that shows analytic trends in device measurements in an easy to understand graphical format. Specifically detailing the count and distance measurements recorded by the LevelSense and PeopleSense devices over set periods of time.







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PiP PIPIOT.COM

Student projects: Software Engineering

SEEQUENT

DIGITAL GEOLOGICAL MAPPING

SENG402 Software Engineering Research Project

THE PROBLEM

Geological mapping is a process that results in the creation of a map which details the geological features of the area. Geological maps have various applications ranging from assessing the ground-water quality to predicting mineral deposits at candidate excavation sites. Structural geologists are currently burdened by the need to carry multiple tools into the field. The use of these analogue tools to capture accurate data requires an extensive amount of time which results in a compromise between the quality and quantity of the recorded information. In addition, the manual recording and post-trip processing of data is subject to human error.

THE SOLUTION

The developed iOS mobile application replaced the need to use multiple analogue tools which streamlined the overall process. A planar geological structure can be described by recording its dip, dip direction and location. This would have roughly taken a minute and needed a compass (adjusted for the local magnetic declination), inclinometer and a GPS device. The same amount of information can be captured in an instant by resting the phone on the structure's surface and pressing a button.

Implementation Overview

Swift
Programming Language

SnapKit & GeoPackage
External Libraries

(B)VIPER
Architecture

Evaluation

The accuracy of the mobile application was evaluated by comparing the captured values to a SILVA compass and inclinometer. Different sections of a geological structure was measured at Halswell Quarry, Christchurch. The results are shown in the table below. The captured dip direction at point D was considered invalid since the phone was not properly calibrated.

Data Point	Silva Compass		iOS Application			
	Dip Direction	Dip	Dip Direction	Difference	Dip	Difference
A	245	66	240.7655	-4.23453	66.93171	0.931713114
B	251	64	264.0434	13.04337	65.83973	1.839726523
C	244	62	248.172	4.17196	61.73762	-0.262375906
D	249	64	Invalid Data		64.63035	0.630352984
E	251	61	250.671	-0.32897	62.85628	1.856284502
F	252	68	258.0594	6.059381	66.93065	-1.069347246
G	242	66	244.2727	2.272672	68.11743	2.117434661
H	230	48	226.3485	-3.65151	50.24839	2.248392562
I	231	51	221.1644	-9.83564	51.01397	0.013971503
J	245	60	247.8984	2.898354	60.02012	0.020115546

Considering the analogue compass and inclinometer had a resolution of ± 2° the captured dip was considered to be a good representation of the geological structure. The same could not be said for the dip direction with residuals as high as 13°, whereas the limit for field orientation measurements is approximately ± 5°. This was due to the inaccuracy of the reported bearing, relative to true North, provided by Apple's Core Location framework.

Data Point	Silva Compass		Captured Measurements with Post-Processing			
	Dip Direction	Dip	Dip Direction	Difference	Dip	Difference
A	245	66	239.6060022	-5.393997838	67.32260786	1.322607861
B	251	64	247.6135337	-3.386466322	66.27966373	2.279663726
C	244	62	240.9038521	-3.09614788	61.90127738	-0.098722618
D	249	64	243.0775943	-5.922405663	65.19346269	1.19346269

An alternative capture method with post-processing was investigated. The phone was rotated on the structure's surface to capture measurements at varying orientations. A sample of the measurements were taken and outliers were removed before the measurements were averaged.

Industry Relations

From the very start of the project there has been plenty of support provided by the Seequent team. Special thanks to everyone involved, your involvement has been greatly appreciated.

Tim Schurr
Product owner and main company contact for the project.

Ryan Lee, **Mike Stewart**, and **Zachary Hynd**
Geologists who have provided their expertise about the domain when answering questions and during Rapid Application Development (RAD) sessions when designing the mobile application.

Matthaus Woolard and **David Knight**
Senior developers that have provided technical guidance and who have performed code reviews throughout the course of the project.

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Computer Science & Software Engineering

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Student projects: Software Engineering

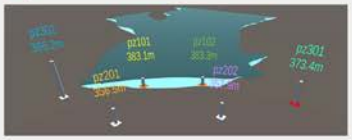
Dam Monitoring Digital Twin

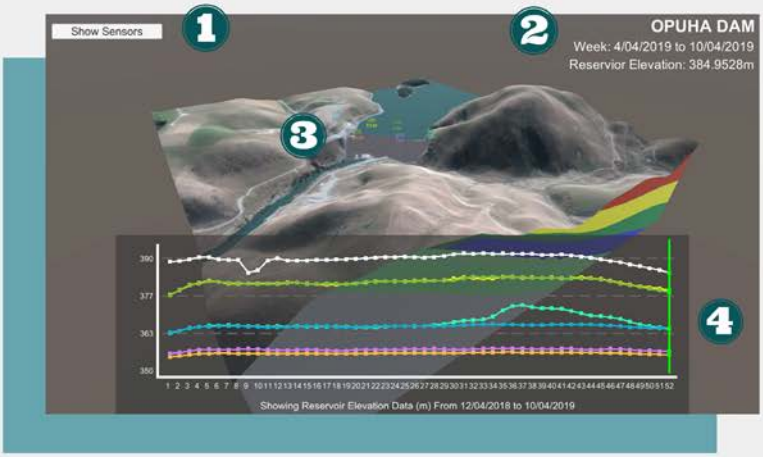
Student - Rebecka Cox, Supervisor - Andy Cockburn, Industry Contact - Tim Schurr

Dam Safety Engineers are employed to monitor the behaviours of dams over time. To do this they have to interpret graphs from sensors in and around the dams and interpret what this means holistically. This is time consuming, as there are many data sets that need to be consulted and no simplistic way of seeing the information sets in relation to the location of the sensors and the status of the dam at the time. Seequent wants to change this – enabling Dam Safety Engineers to have a virtual model of the dam showing the status of the dam and the sensors within the dam, as well historic data.

1 Sensor View

The button in the top left of the screen changes the view to the sensor view. In this view the engineer can see the water levels on each of the sensor holes. The squares are also used to show when the water height detected by the sensor is higher than expected.



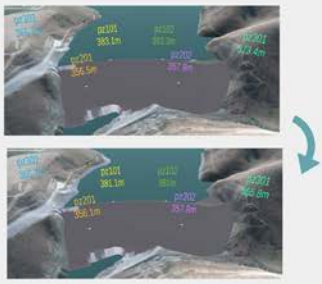


2 Dam Information

The information on the top right of the scene concerns the dates that the graph information has been collected as well as the average reservoir height recorded between the two dates. This is information the engineer cannot get from the graph or the model.

3 Dam Model

The dam model is interactive as the user can move through the scene. When a point on the graph is selected, the model updates to show the dam at that point in time. This includes showing the height of the dam reservoir (as seen on the figures to the right), as well as the water level on the sensors in the dam (seen in the sensor view of the dam).



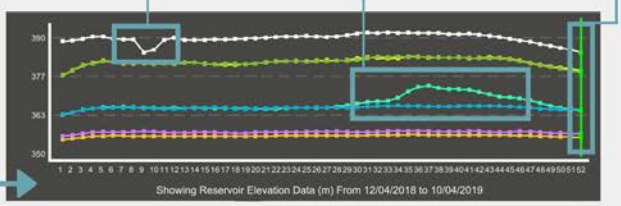
4 Graph

The graph shows the data collected from the sensors for each week of a year as well as the average reservoir height on the dam for the specified week. The graph can be used with the model in several ways, which are highlighted on the figure on the right.

Anomaly Detection: When there are significant changes in one reading but nowhere else there may be an error with one of the sensors.

Potential Slippage: Slippage occurs when the water from the dam leaks into the surrounding soil. This can be seen on the graph when one of the sensors has a gradual increase in water level.

Week Selection: When a point on the graph is selected (from any set of points) the week selection for the model is updated to that week and the line selector moves to the selected week.



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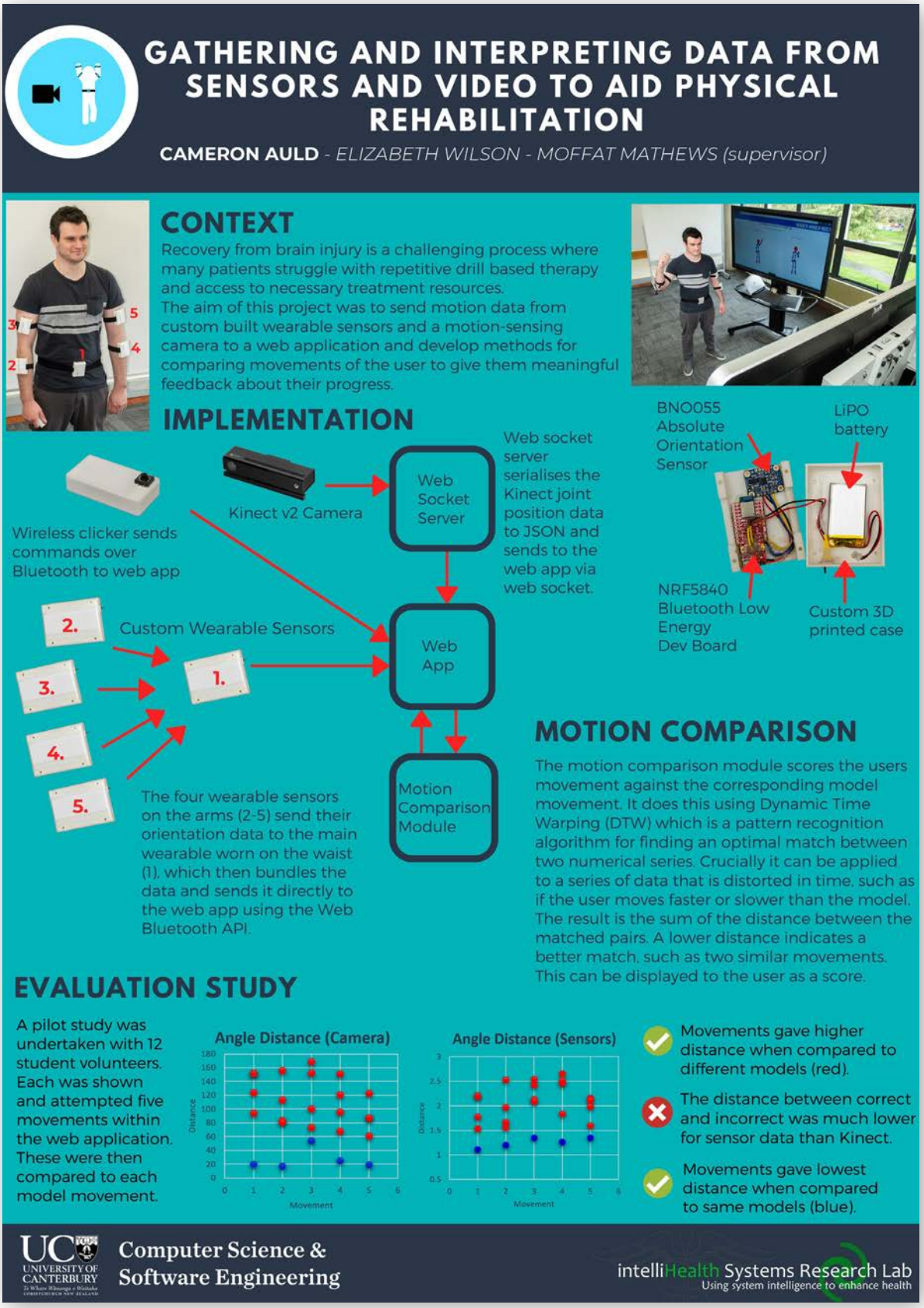
Student projects: Software Engineering



Student projects: Software Engineering

WEB-BASED PHYSICAL REHABILITATION

ELIZABETH WILSON, CAMERON AULD
MOFFAT MATHEWS (SUPERVISOR)

MOTIVATION

Brain injury patients often struggle with repetitive drill based therapy and access to treatment. Beginning physical therapy early and often gives patients the best chance at recovery.

Major challenges to recovery:

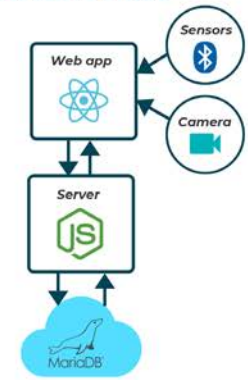
- *Disparity - Socioeconomic differences mean that not everyone has access to treatment resources*
- *Slow progress - Patients can struggle to see their progress, affecting engagement with the treatment*

SOLUTION

A web application based rehabilitation system allows users to complete some treatment from home. This allows more frequency in their treatment.

- *Tracking movement data helps both physicians and patients to monitor their progress over time*
- *Record users movement and score against a model movement*
- *Real time feedback and scoring to increase engagement*

SYSTEM ARCHITECTURE



USABILITY STUDY FINDINGS

- ***92%*** *of participants were motivated by the scoring, and were interested in how their scores compared to others*
- *A clearer view of the session flow would be beneficial to aid users understanding*

DURING A SESSION

Users can complete rehabilitation routines using the web app

- *Model movement - shows the ideal exercise*
- *Your Movement - shows the users movement in real time*

FEEDBACK AFTER SESSION

After completing a session, users receive a summary of their scores

PROGRESS OVER TIME

Users can see their progress on the History page, which shows graphs of exercise scores over time

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intelliHealth Systems Research Lab
Using system intelligence to enhance health

Student projects: Software Engineering

OBLIQUE PRO | JUST WATCH ME

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Computer Science & Software Engineering

User Experience Study for Oblique Pro's Website

Student - Aidan Smith, Supervisor - Miguel Morales

Context: Oblique Pro is a small company looking to combine high fidelity sensors with machine learning technology to animate and identify scooter tricks. They are looking to use their website to increase their brand presence before launching their new technology.

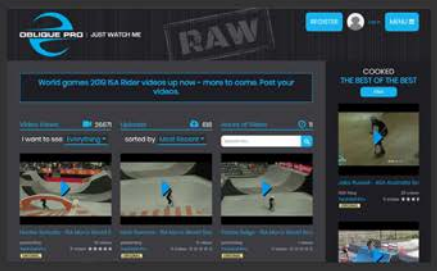
Objectives: A usability analysis needed to be conducted on Oblique Pro's website. Ultimately, this needed to provide recommendations on ways they could improve their user's experience.

Method: Participants performed one of two experiments. In both experiments participants were shown 17 screenshots of the website. They were then asked questions about what they thought that page was for and any details that stood out to them.

Experiment 1 - Five Second Test

Partcipants performed five second tests where each of the 17 screenshots was shown for 5 only seconds. In addition, their gaze was being recorded through eye tracking technology. They attempted to describe the main purpose of the page. Many understood this screenshot.

What do you think this website does?



Experiment 2 - Greeked Text

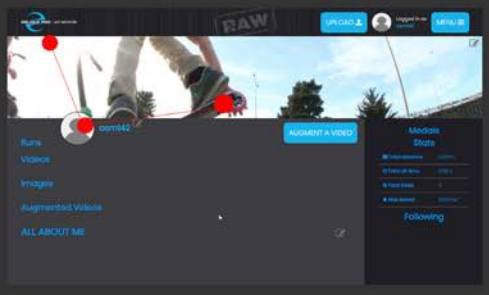
Participants were shown 17 screenshots where all the text was changed into nonsense words (or greeked). They were ten asked about the main purpose of the page, as well as other smaller details. Only a few were able to understand this screenshot.

What do you think this page is for?

Eye Tracking

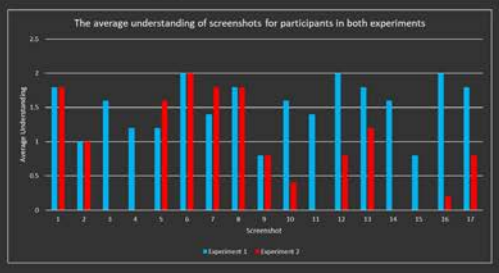
Participants' gaze was tracked and recorded. Participants understood what they looked at and didn't understand what they missed. In addition, they were not easily distracted by irrleveant details.

How do you scan this screenshot?



The Results

- The results were very different between the five second tests and the greeked text. Participants only understood forum screenshots when they could read the titles.
- No one understood the statistics shown in the screenshots.
- Search results were expected to be shown in the same page as the search bar.



Recommendations

1. Remove the forum side of the website. Replace this with comments for community engagement with videos. For company interaction with users, create a sub-reddit.
2. Remove the misunderstood statistics, they only serve as a distraction. More meaningful statistics can always be added later.
3. Make the home page return search results. Search results should not be placed on a separate page. In addition, ensure that the search is maintained in the search bar for reference.

You can find their website at https://obliquepro.com/

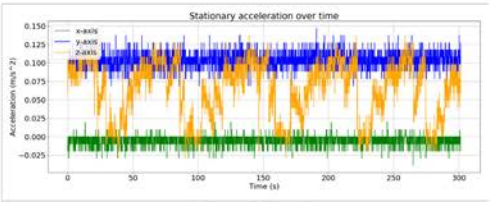
Student projects: Software Engineering

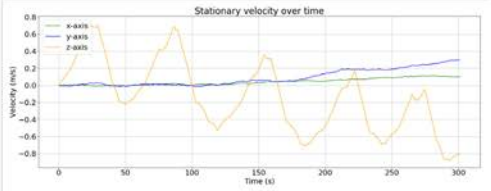
Scooter Movement Detection using IMU and GNSS data

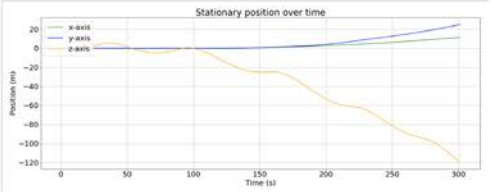
Author: Matthew King Supervisor: Andreas Willig
Industry client: Oblique Pro Industry product owner: Paul Hill

What is the project about?

Oblique Pro is a startup that is aiming to achieve the gamification of freestyle scooter riding. The hope is to build a platform that allows freestyle scooter riders to record their runs and process the data to identify tricks and other metrics. The recorded runs and accompanying metrics will be able to be shared with friend and other users of the platform to build a social experience. The run will be recorded by observing the scooters state using sensors and pulling metrics such as acceleration, velocity, position and orientation from this state.







What is the problem to be solved?

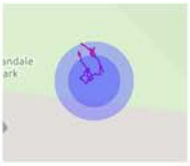
This project aims to solve the issue of accurately recording the scooters position. Two Bosch BN055 IMUs (inertial navigation units) were supplied to record the orientation and acceleration of the scooter. One was attached to the bars and the other to the base, this is to allow recording the different acceleration and orientation values that these free moving components could have. The first step to accurately record the scooters position is to focus on absolute position, and worry about the position of the IMUs relative to each other later, so only the data from the base IMU will be used.

IMUs have a high sensitivity so are good for recording small changes in movement at a high frequency. The problem with trying to identify changes in the scooters position using an IMU occur because the readings have error in them due to noise and drift. Over time these errors in the reading build up and accelerate in growth, this leads the results to quickly become inaccurate and unusable. This error can be somewhat corrected by incorporating position data from another source.

Two obvious solutions were discussed that could be used as the second data source. The first was using reference points that could be used to measure change if position using timestamps and video capture. This however was quickly dismissed as reference points would need to be established at all locations that someone wanted to record a run at, and its complexity requiring video capture. The second option was using location data provided by a mobile phones GNSS (Global navigation satellite system) receiver, otherwise know as GPS. This is a much more accessible solution from a users point of view a mobile device is needed to record IMU data to begin with.

The plots to the right show how noise can affect accelerometer readings over time. A completely stationary IMU had its accelerometer reading recorded for five minutes. These reading were integrated to obtain velocity over time, and integrated once more to obtain position over time. Each integration adds further error to the results. In the velocity plots it is possible to see the affects of noise and error accelerating as time progresses. After five minutes the data shows that the IMU has moved 10-20 meters in the x and y directions and -120 meters in the z direction which was experiencing lots of noise. There is also error in the GNSS readings. Typical mobile phone GNSS receivers are only accurate to within +-5 to +-3 meters in good conditions. The image below shows the drift experienced over five minutes while staying stationary. The outer blue circle shows the +- 5 meter range and the inder circle shows the +-3 meter range. The following image shows a mobile GNSS recording trace compared to the actual path moved. The mobile GNSS trace is approximately five meters off to the left the whole way. From these results it is clear to see why only using one sensor would lead to inaccurate results.

Mobile GNSS recording examples showing inaccuracies

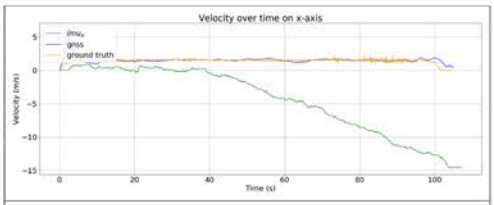


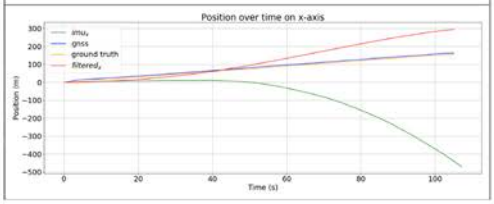
Solution: Kalman filter

In order to fuse the IMU and GNSS data signal together a sensor fusion algorithm was needed. The Kalman filter is a commonly used algorithm to reduce noise, estimate values and perform sensor fusion. All of which are useful for the application of this project. It works by estimating a systems current state by using its previous estimated state and combining this with a measured value, typically from a sensor, to output a predicted current state. This output is then used to estimate the next system state in the following algorithm loop. This allows the results to converge towards the real system state, provided the algorithms variables are tuned correctly and the system model to estimate the state is accurate. Unfortunately it can be difficult to achieve the above requirements.

Due to the complexity of implementing a Kalman filter to fuse all three axis with GNSS data simultaneously we are just focusing on sensor fusion of the x-axis of IMU accelermoter data with GNSS data in a straight line. The plots to the right show recorded velocity and position data over time from pushing the scooter in a straight line. The yellow plots label ground truth represent the real state of the scooter at a given time. We can see that the GNSS data closely resembles the ground truth already, while the IMU data is affected by noise and accumulating error as time goes on. The red plot labeled filtered_x is the result of sensor fusion using a Kalman filter. Ideally this plot will converge closer to the ground truth plot than the GNSS, this would show that accuracy is improved over using only one sensor and we could move onto developing more complex models.

It can be seen that the filtered results do converge towards the ground truth values much better than IMU reading alone, however the GNSS reading alone are more accurate than the filtered results. This means that in this case it would be better off just using mobile GNSS reading to track position over time. There are a number of possible reasons for this result, including poor/incorrect system model to predict state, Kalman filter noise co-variance matrices are ill tuned or the noise reading in the IMU reading are so great they are affecting the data to the point where it is unrealiable to use.





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Computer Science & Software Engineering

OBLIQUE PRO

Student projects: Software Engineering

AUTOMATED MEASUREMENT OF BLOODSTAINS

ALEX TOMPKINS | SUPERVISOR: RICHARD GREEN

OpenCV

Flask

WHY MEASURE BLOODSTAINS?

Bloodstain pattern analysis is a forensics technique often used when investigating a bloody crime scene. By measuring properties of bloodstains within the scene, experts can estimate the trajectories of spattered blood droplets and determine their potential area of origin. This method can provide crucial evidence about what took place, and where, at a crime scene.

Investigators often carry out their analysis by laying physical strings to represent droplet trajectories, visually reconstructing the spatter event within the scene to find an area of origin. Although reliable, this method is cumbersome and time-consuming.

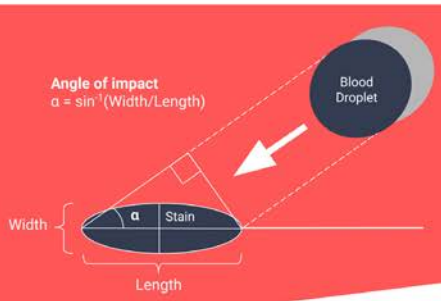
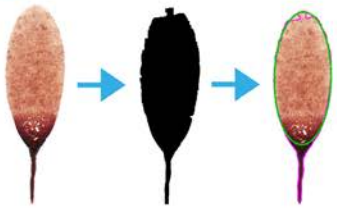


IMAGE PROCESSING PIPELINE

To solve this problem, I developed an application that automatically processes images containing bloodstains. Using computer vision techniques including Otsu thresholding and morphology, the program finds edges of likely bloodstains within an image. Since images often contain other objects such as markers or text, the shape, colour and size of potential stains is evaluated to discard unlikely candidates. Ellipses are then fitted to the remainder, allowing their width, height and angle to be measured, mimicking the manual process carried out by forensics experts.



Input Stage | Binary Stage | Ellipse fitting Stage

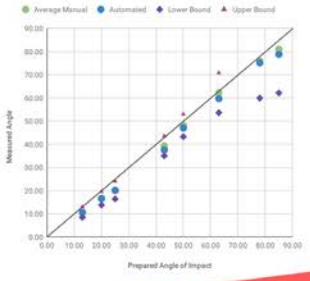
WEB SERVER

A simple web server, written in Python, allows immediate processing and long-term storage of images, results and associated documentation. This server works in tandem with the AR app (see below) to process a pattern containing several bloodstains and display the results.

RESULTS

Accuracy of results is crucial in forensics, as bloodstain pattern analysis is often used as evidence in court cases.

The automated method described was compared with manual measurements taken by experienced forensic scientists on several training datasets. The results (shown right) placed the accuracy of the automated approach well within the bounds of the manual measurements.



AUGMENTED REALITY APP

An iOS app (developed by Evans Taylor Digital) displays the bloodstain analysis in real-time, allowing the user to capture an image of a bloodstain and immediately send it to the server for processing. The app makes use of augmented reality technology to visualise the resulting 3D droplet trajectories placed within the scene in much the same manner as the string method. The tool also allows a 3D reconstruction of the scene to be viewed at a later date.

Analysing an entire bloodstain pattern and manually determining trajectories usually takes a forensic scientist over an hour. The automated method allows a stain to be measured and displayed in a matter of seconds.

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Student projects: Software Engineering

ML CLASSIFICATION OF ELECTRICAL ENCLOSURES

By Andrew Spearman, supervised by Dr. James Atlas and in partnership with Damien Tiede

A subset of all the enclosure locations in Christchurch

Is this a Model X enclosure?

Objectives

Orion has thousands of electrical enclosures around Christchurch—you likely have one at the end of your driveway. Understanding the type of enclosure is important when managing these assets. Instead of using a time-consuming paper form to determine the type, Orion would like to apply machine learning (ML) to automatically identify the enclosure model.

How can Orion use machine learning to identify the enclosure model from an image?

ML Features

Convolutional Neural Network
CNNs have been recognized as the best way to classify images since a CNN won the ImageNet classification competition in 2012.

Supervised Learning
We show the model images, and then using how correct or incorrect the prediction was the model re-configures itself using back-propagation and gradient descent.

Transfer Learning
We started from scratch to achieve 60% accuracy. To improve, we built upon InceptionV3, a model pre-trained on billions of images, and re-trained it on our enclosure dataset. This surprisingly resulted in an accuracy of 36%, likely due to our poor dataset.

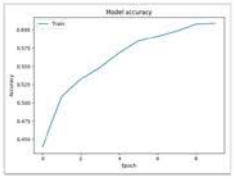
Data Augmentation
Augmentation helps oversample dataset to create more training images.

Augmented images

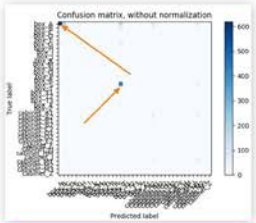
Training Results

With roughly 10,000 images of 38 enclosure types provided by Orion, our model did not have sufficient data per class. Further inspection shows nearly 60% of the images were of enclosure type BOX_A, with the second most frequent type being BOX_S.

The model simply learned the difference between the two types and disregarded learning all other enclosure types. This resulted in 60% accuracy after 10 epochs. Testing was performed using a 20% reserved test set.



60% Accuracy
...is Misleading



The model is simply guessing the two most common classes

Key Lesson Learned: ML Is No Better Than Its Dataset

Vegetation occlusion

Too close, uncovered

Too far away

Missing

Missing

Occluded by other box-shaped objects

Poor images

Ideal Image

Despite obtaining a high of ~60% accuracy, we found **the model was simply guessing the enclosure type which occurred in the dataset ~60% of the time.** Upon closer inspection of the dataset we discovered more issues with how the data was collected. Despite these issues, **we nonetheless delivered a working ML 'pipeline'** which Orion can train using new data obtained following our recommendations. In addition to far more data, and more balanced data cross types, we recommend enclosures be:

- Fully inside the image
- The majority of the image
- Free of most occlusions such as fencing
- Covered in its casing

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Orion

Student projects: Software Engineering

USING SONARQUBE TO IDENTIFY BADLY DESIGNED CODE

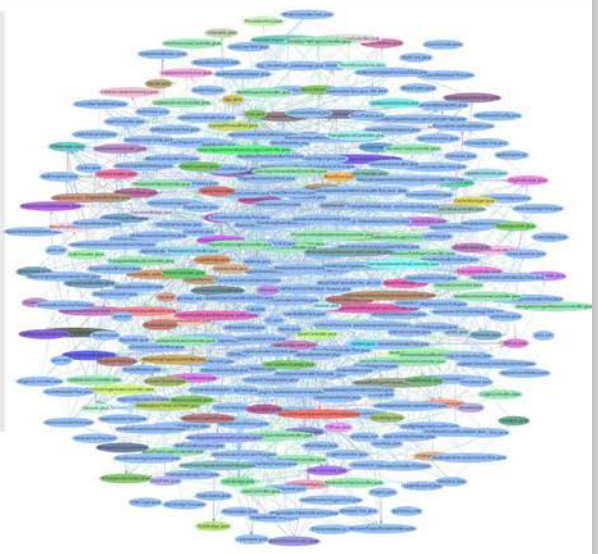
By Eiran Ling supervised by Fabian Gilson

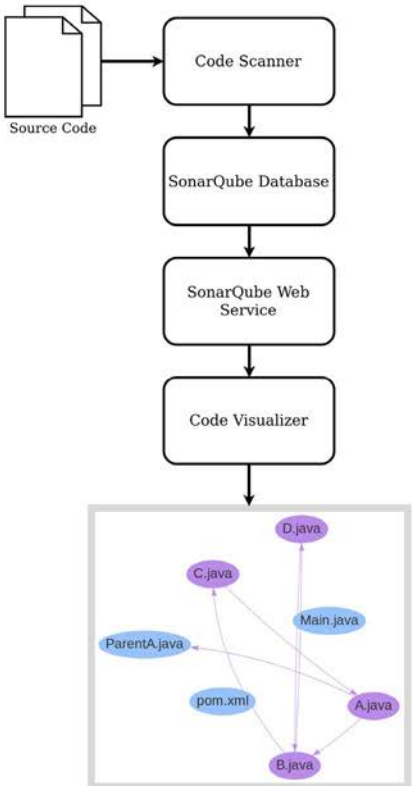
WHAT DOES CODE LOOK LIKE?

When we think of code, we think of huge amounts of text all working harmoniously to create software with nice shiny interfaces. In reality, software is made up of many small bits of text, interacting with other small bits of text.

However, when we have thousands of small bits of text interacting with each other, we often end up with something on the right, where each coloured circle is one bit of text. This is what we call **badly designed** code.

This problem exists with a lot of the systems that exist today, and is very difficult to detect with the tools that exist today.





WHAT IS SONARQUBE?

SonarQube is a popular tool that tries to find issues in code that might lead to errors in the software being made. While this is useful, it also fails to identify bigger issues in the code like how well it is designed.

THE SOLUTION

The solution to this problem is surprisingly simple. By making a **visual aid** to show developers the state of their code, it becomes a lot easier to tell when an entire code base is badly designed.

The solution does two things:

1. Shows what each bit of code depends on
2. Shows which bits of code are 'stuck' together

It does this by building on top of **SonarQube** to scan for **dependencies** between code, and to display the graph shown above in the **SonarQube** application. More details can be seen in the diagram on the left

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TECHNOLOGIES

Java JP sonarqube npm

Student projects: Software Engineering

Segmenting CT Scans of Bone

STUDENT - EOGHAN ROBERTS

SUPERVISOR - JAMES ATLAS

Background

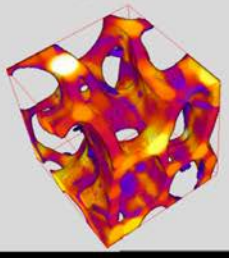
Radiologist look at hundreds of x-rays in a day, there are some small details that are incredibly important, but also have similar numerical definitions, an example being the density of the bone. This number can be calculated by processing the image using the number and brightness of the pixels to determine the this density. The question is then ask, can deep learning be used to improve and speed up this process.

Objectives

-Create a system to successfully segment bone from a CT scan using a deep learning algorithm

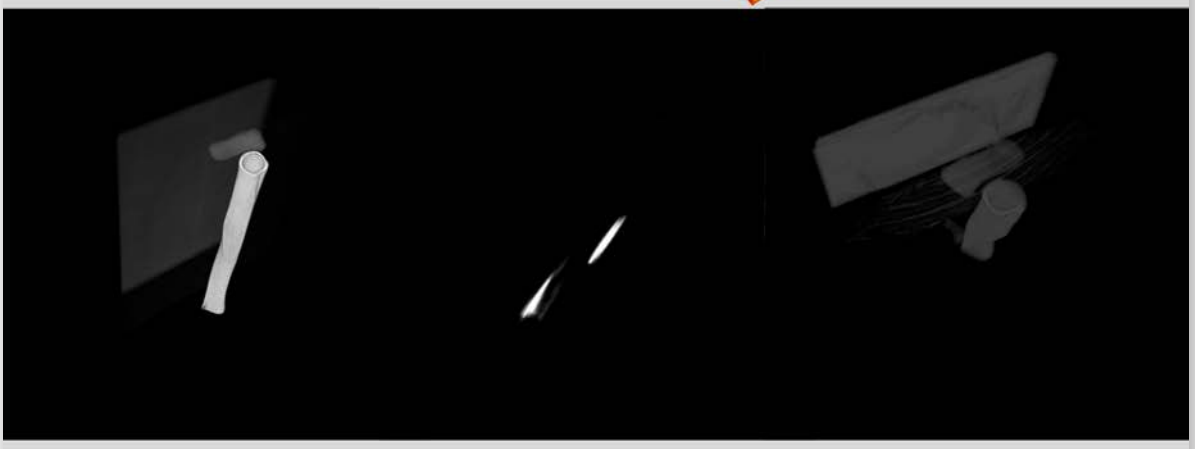
-Create a baseline segmentation to test the segmentation against

-Create a system to compare results of segmentation



Tools

A number of different tools were used throughout this process to help with the development of this project, this includes but is not limited to Tensor Flow, Nifty-Net, ImageJ and BoneJ. Nifty-Net and Tensor Flow are both deep learning tools that were used to create the segmentation algorithm . ImageJ and BoneJ were both used for image analysis



Results

The results of the final segmentation system created were poor, this can be seen in the second image, with only a small percentage of the the bone being picked up by the segmentation AI. However, other parts of this project went well, mainly the system and pipeline created to run and compare these results. There is now a complete system that can be run from segmenting the image with both a manual and deep learning algorithm to then comparing the results

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Computer Science & Software Engineering

Student projects: Software Engineering

WHITE CROW PM

UC University of Canterbury — Computer Science & Software Engineering

HAYDEN TAYLOR

supervised by

MIGUEL MORALES

What is WHITECROW?

White Crow PM is an educational board game that was adapted from a Russian game called "Belaya Vorona". The game simulates the economic life of a software project with the goal of maintaining wealth to deliver a product at the end of the month, all while making important decisions regarding risk management.

This project was aimed at digitising the existing physical board game in order to reach a larger audience through the convenience of technology and to investigate, through a case study, the effectiveness of using this game as a supplement to students learning.

Method

In order to analyse the effect the game had on players knowledge surrounding risk management in software projects, students studying courses such as Software Engineering, Computer Science and Project Management from universities in Mexico and New Zealand were invited to participate in the study.

After development of the game was complete, students were asked to complete a **pre-test**, play a few rounds of White Crow and complete a **post-test**. These tests consisted of questions based on scenarios with real risks, where students needed to classify, rank and suggest mitigations. As a last step, students were asked to complete a **survey** in order to gather feedback on the game, the level of engagement with the games content and also the their preception of games effect on their learning.

Results

Analysing the differences in the scores between the pre-test and post-test of each student indicated a shift of **approximately 10%** in the normal distribution of the grades. In order to assess the true nature of this relationship, the number of participants would need to increase. Majority of the students enjoyed playing the game and thought the cards were a rich source of content regarding risks. In future, the level of interactivity and the players impact towards winning will be improved.

TECHNOLOGIES

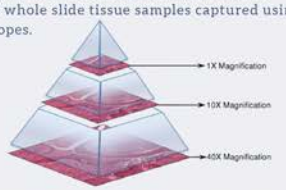
Student projects: Software Engineering

Whole Slide Image Pre-Processing Algorithms for Applications in Digital Pathology

Imas Neupane
Ramakrishnan Mukundan (Supervisor)

INTRODUCTION

In the field of Digital Pathology, whole slide image analysis refers to analysing digitised versions of whole slide tissue samples captured using high power electronic microscopes. These slides are composed by taking numerous images at varying zoom levels, and stitching them together to produce a single highly detailed image.



Since these images are often Gigabytes large, fully analysing them is infeasible; as such, my application set out to pre-process this large image and break it down into several smaller tiles.

OBJECTIVES

The main objective of my project were as follows

1. Produce a program capable of accurately identifying key regions within a large whole slide image. These Regions of Interest (ROIs) would have to be scored and compared with all other ROIs; allowing us to produce multiple output tiles based on a calculated score.

2. Optimize this process and make use of graphics programmable pipelines to greatly speed up the processing by simply offloading it onto a GPU. Given certain technical difficulties that arose during development, I had to resort to simply performing these operations in parallel on the CPU.

METHOD

1. Scale the image to a lower resolution (1024 x 1024) for further breakdown as attempting to analyse the original image (46000 x 23000) is too ineffecient. This effectively blurs the image and also helps reduce random noise in it, which could interfere with the tile scoring later.
2. Divide the image into multiple subsections (based on the number of CPU cores) and repeat the remaining steps for each subsection on a seperate thread.
3. Use colour detection to remove certain pen/highlighter colours used for marking the slides. We use this operation to also remove certain colours in the background(red, green and blue) below a certain threshold.
4. Threshold the background colour away using Otsu's threshold[1,2]. We combine this with another technique to remove small objects that are leftover after these filters have been applied to obtain just the tissue sections.
5. Subdivide the remaining image into tiles (100 x 100 each) and score each tile from 0 to 1 based on the overall quality of the tile. This method factors in the staining method used to highlight the tissue, the quantity of tissue present in the tile, and the proximity to nearby nuclei which is calculated using simple contour detection of nearby tiles.
6. Collate together tiles from each subsection (From step 2) and output tiles that scored above a certain threshold (0.8).

1.

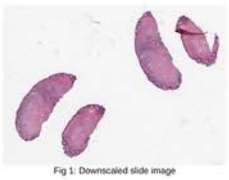


Fig 1: Downscaled slide image

2.

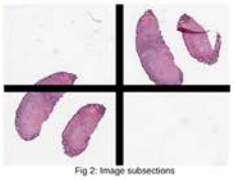


Fig 2: Image subsections

3.

Fig 3: Slightly modified image after pen removal

4.

Fig 4: Image after background removal

5.

Fig 5: Image with tile overlay

6.

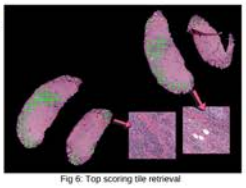


Fig 6: Top scoring tile retrieval

RESULTS & CONCLUSION

In conclusion, my program successfully breaks down an entire Whole Slide Image (WSI) and produces multiple high-scoring tiles whilst being highly configurable and incredibly efficient. **Is is capable of filtering, subdividing, scoring and outputting 10 tiles for a 1GB image in under 4 seconds.** Due to technical difficulties, I was unable to measure the performance gain when using GPU optimization, however based on similar projects, I would expect a **performance gain of up to 300%.** [3, 4]

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Computer Science & Software Engineering

Student projects: Software Engineering

Student projects: Software Engineering

THE FASTEST AND MOST ACCURATE SQL GUN IN THE WEST

JENNIFER HALVORSEN SUPERVISED BY MIGUEL MORALES

PROJECT MOTIVATION

Maintaining motivation and consistently practicing can be difficult for students learning SQL for the first time. This lack of motivation can be detrimental to how well a student will perform in future tests and assignments that require knowledge of the given language.

CONTEXT

QueryCompetition is a website that has been used in the university of Mexico to assess students that are learning SQL in database courses. The website encourages students to practice SQL by participating in query-based competitions. However, one issue the universities encountered was a lack of engagement with the website which led to infrequent use by students.

PROJECT GOAL AND SOLUTION

- Increase student engagement with QueryCompetition by using gamification

To achieve this, this project included the development of an improved version of QueryCompetition with the addition of two very common gamification elements - a leaderboard and badges.

LEADERBOARD

Leaderboard

Rank	User ID	Total Points
1	user1	20
2	user2	17
3	user3	15
4	user4	13
5	user5	8
6	user6	3
7	user7	0

- Creates a sense of competition between students
- Encourages students to practice SQL more in order to climb higher on the leaderboard

WHAT IS GAMIFICATION?

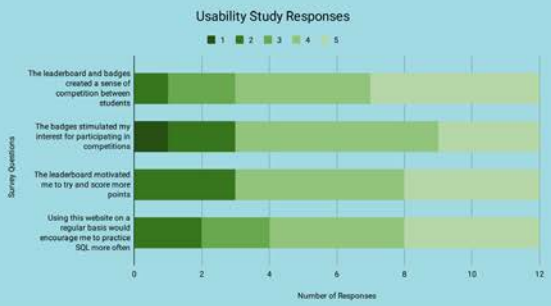
Gamification is the application of game mechanics or design to non-game environments in order to engage and motivate users to achieve their goals.

BADGES

- Shows recognition for students skills and efforts
- Sense of achievement motivates student to keep learning

USABILITY STUDY

In order to validate that the new version of QueryCompetition would be useful, a usability study was conducted through a survey on students who had previously taken a database course learning SQL. The responses included mostly positive feedback for the addition of gamification elements, as well as a discussion of some improvement opportunities to make the website more intuitive.



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Computer Science & Software Engineering

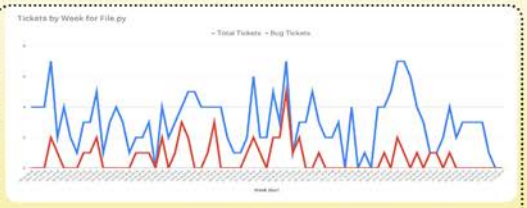
STATIC ANALYSIS OF CODE HOTSPOTS

AUTHOR
Jono Hills

SUPERVISOR
Kourosh Neshatian

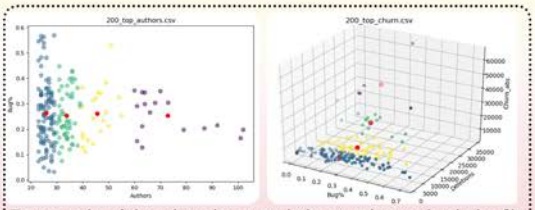
INDUSTRY PARTNER
Caterpillar Trimble Control Technolgies

When developing any kind of code, encountering bugs or defects is unavoidable. For developers this means code that must be reworked or adjusted in order to fix these issues. More often than not these defects are found by failing tests, a testing team, or end users. But what if there was a way to predict and prevent these defects earlier in the development period? This would ultimately result in less failing code, and a productive development team. The aim of this project is to **analyse source code for an organisation in such a way that a file can be classified to demonstrate how at risk it is of containing a bug or defect.**



A graph depicting the development history for a file on a week by week basis. The line in blue depicts the total number of tickets worked on for a week. The red line is how many of those were classified as a bug. This was used to identify any development patterns over time for a file.

The focus the data analysis was to **examine the values of these features for each file, and identify any kind of patterns or trends that may occur,** linking files with a large number of defects to any other combination of inputs. An attempt to group these values using a clustering algorithm was attempted, however no valid clusters or correlations were identified from the inputs used.



Two examples of clustering using a sample dataset, where each point is a file, and the red points represent the centroid of each cluster. Clustering was used to find if any groups of files shared similiar values for certain features and if those similarities had an effect on a files bug ratio. In both examples it can be seen that bug ratio is not affected by any of the other features.

If a clustering or trend was found across multiple files, these patterns could then be used to **identify similar files** across the entire codebase. Developers can then evaluate for further action. Potential uses include fixing undiscovered bugs, or code instability that may have been unintentionally caused by developmental patterns at the organisation.

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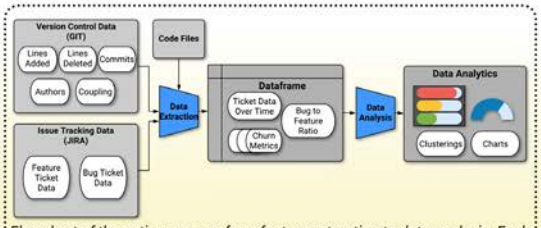
Computer Science & Software Engineering

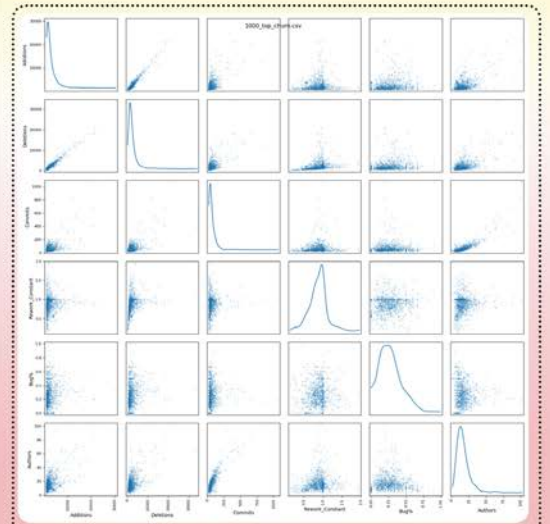


Flowchart of the entire process, from feature extraction to data analysis. Each stage built and added to data collected in previous stages.

This was done by examing **code hotspots** - files which had a large amount of development activity, or many authors. For each hotspot, various features and attributes of the file were obtained to create an overall **dataframe**, containing metadata about a particular file. This metadata was largely sourced from the codebases version control and issue tracking systems. This provided data such as:

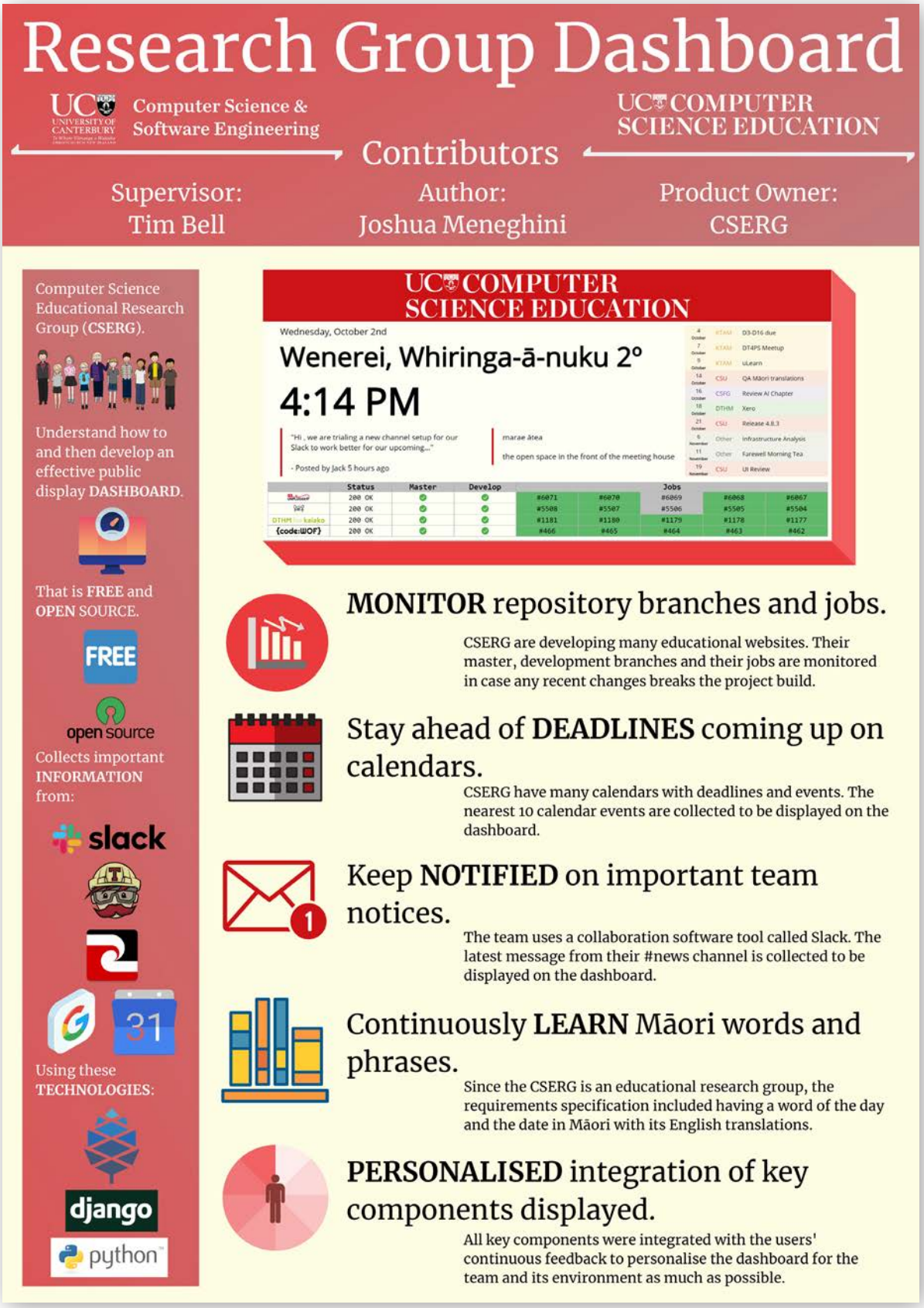
- Lines of code added
- Lines of code deleted
- Number of Authors
- Bug/Feature Ratios

These act as fundamental inputs to more complex metrics such as churn (additions + deletions) and bugs to tickets over time. This added extra layers of information to the analysis.



A matrix of scatter plots for one of the 1000 file datasets, mapping each combination of file deatures against ech ther. Examining these graphs for potential correlations was one example of the analysis conducted.

Student projects: Software Engineering



HiVo

Recording past and future audio on your phone

1. Problem

When you hear something that you want to save, for example, an interesting segment on the radio, a baby's first word, or a rare bird call, it is often too late to record it. Unless someone was recording, that audio is lost forever.

The aim of this project is to create a mobile solution that provides DVR-like functionality for audio on a mobile device.

2. Existing solutions

There are several varied existing solutions to different use cases of this app, but none provide all the functionality of this project: keeping the last few hours recorded, and allowing the user to save a segment of it, along with scheduling recordings for the future.

There are several apps that constantly record audio, then allow the user to save some part of it. I analysed three.

Past Recorder allows the user to save one of six set amounts (such as the last 30 seconds, or the last 15 minutes), up to 30 minutes, then crop and play back the result.

Snipback allows the user to save either one of three predefined amounts (which they can choose from eleven set amounts, up to 30 minutes, before they start recording), or the whole recording.

Rewind allows the user to save one of six set amounts, up to three hours, which they choose before they start recording.

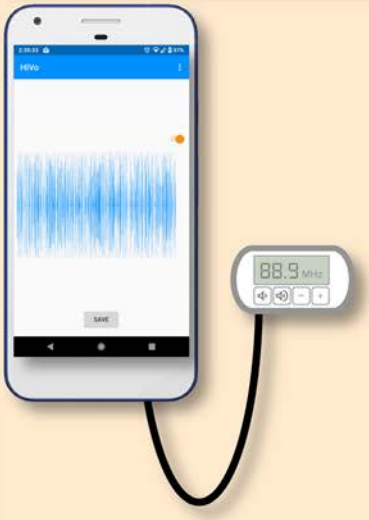
CinixSoft's *Schedule Voice Recorder* app allows the user to schedule audio recordings.

3. Solution

This project addresses the project's aim using an Android phone's ability to record audio. After installing the HiVo app on their phone and turning it on (to "listen"), the app will store the last user-specified duration of audio. The user can then select segments of audio the device has listened to, saving them for future use. The user can also schedule recordings to start and end at a set time.

The HiVo app is compatible with the vast majority of Android devices, so it can be installed on an old phone rather than consuming the processing power and battery of the user's main device.

By default, it uses the phone's internal microphone. However, if there is an audio input device plugged into the phone, such as an FM radio or an external microphone, it uses that instead.



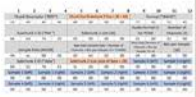
Download it now!
olliechick.co.nz/hivo

4. Design

The app has four screens. The main screen shows the audio-stream visualisation, and from here users can save chunks of audio. **Past Recordings** has a list of past recordings. **Scheduled Recordings** has a list of scheduled recordings, and gives users the ability to add more. **Settings** allows the user to set how far into the past the app keeps audio that was "listened to" before discarding it, and the filename format.

5. Implementation

When recording is started, an empty WAV file is created in internal storage with the WAV headers, then the audio data is added onto it. Amplitude data is sent to the main activity using intents, which renders it on the canvas by moving all existing lines left and adding the new amplitude to the very right. When recording is stopped, the two size headers are updated. To save all the audio, this file is copied into external storage. To save a section of audio, a new WAV file is created with the headers, and the relevant samples are copied over from the original file, then the size headers updated. This file is then moved into external storage.



6. Future work

There are several more features that could be implemented. The biggest is the ability for users to play back the audio as the app is listening to it, scrubbing through it to find the segment they want to save. This would greatly improve the app's usability.

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Computer Science & Software Engineering

Ollie Chick
Supervised by Andy Cockburn

Student projects: Software Engineering

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Computer Science & Software Engineering

Machine Learning Classification of Breast Cancer Hormone Status

Andrew Davidson
Supervised by Ramakrishnan Mukundan

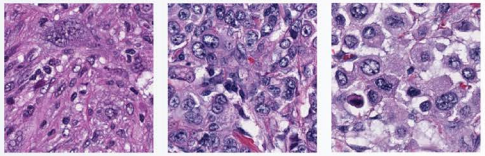
Background

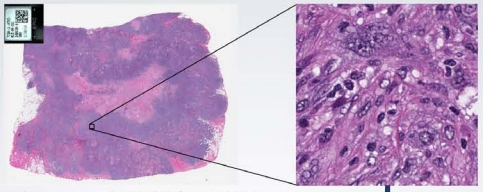
Machine learning classification could be used as a faster and less biased replacement of the current, manual hormone status classification method employed by pathologists. Knowing the hormone status of a breast cancer patient is vital, because it determines whether hormone therapy is able to slow or stop the growth of the cancer. [1]

The estrogen receptor status (ER status) is one of the most important hormone statuses in determining the treatment of breast cancer patients. A breast cancer tumour with a higher ER status grows more in response to estrogen. It can be 1+, 2+, or 3+ (using the immunohistochemistry 3-point scale). Currently, classification of ER status is done manually by pathologists, with the consensus rate between pathologists deliberating on the same sample being only around 70%. [2]

Within the last decade, the availability of digital pathology scanning technology and data has increased. Now, large repositories of high-quality breast cancer tissue slide images are available online and can be used to build a machine learning classifier that will increase speed of ER status tests, and decrease the bias involved.

ER status 1+ | ER status 2+ | ER status 3+

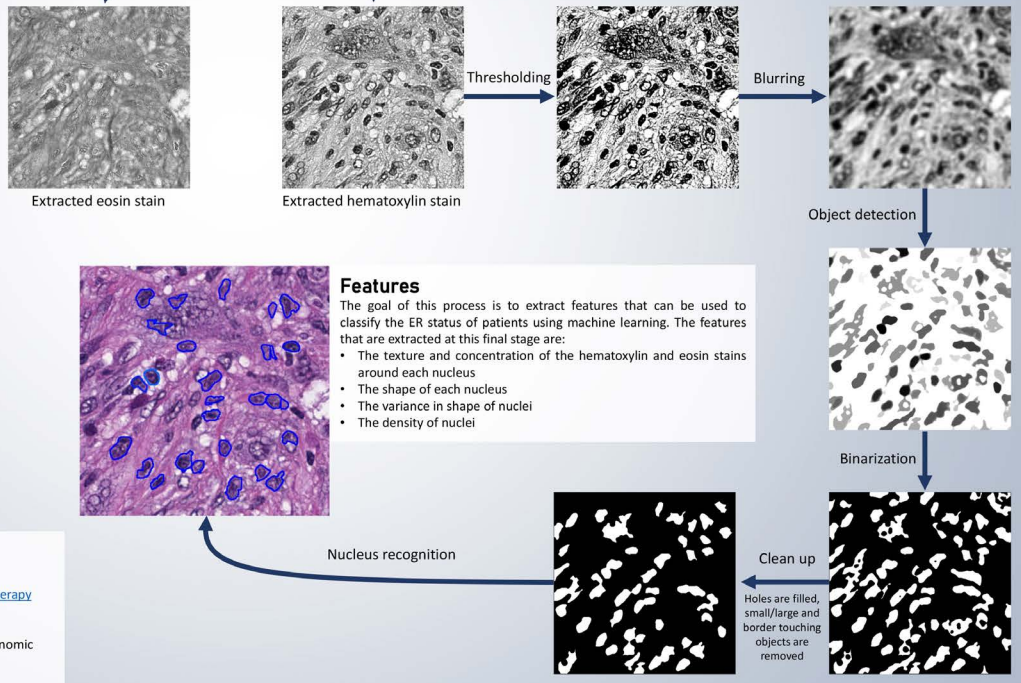




A digital breast cancer tissue slide (97608x69881 pixels), stained with hematoxylin (indigo) & eosin (pink) to make cell nuclei more distinct. [3]

Process

For machine learning to work effectively, information about the features effecting ER status must first be extracted from the breast cancer tissue slides. Extracting hand-picked features allows the machine learning classifier to learn much faster, as it is only given the relevant information instead of the entire raw image. The flow chart below shows the process that I designed to extract relevant features from tissue slide images.



Outcomes

- 4109 nuclei and their features were extracted from 180 512x512 pixel image patches
- A machine learning classifier was trained using these features
  - 93.78% accuracy when classifying the ER status of a nucleus
  - 100% accuracy when classifying the overall ER status of a whole 512x512 patch
  - Single source of truth that can be tweaked and refined, eliminating pathologist bias as a factor in ER status classification
- Entire process is automated apart from selection of region of interest to extract patches from

Features

The goal of this process is to extract features that can be used to classify the ER status of patients using machine learning. The features that are extracted at this final stage are:

- The texture and concentration of the hematoxylin and eosin stains around each nucleus
- The shape of each nucleus
- The variance in shape of nuclei
- The density of nuclei

Further Reading

More about breast cancer hormone therapy can be read at:
[1] https://www.breastcancerfoundation.org.nz/breast-cancer/treatment-options/hormonal-therapy
Source for 70% agreement between pathologists on ER status:
[2] https://www.ncbi.nlm.nih.gov/pubmed/19661080
Breast cancer slide images were obtained from the Cancer Genome Atlas Program using the Genomic Data Commons Data Portal:
[3] https://portal.gdc.cancer.gov/repository

{code:WOF} Exercises

Project by: Maree Palmer
Supervisor: Tim Bell

The Problem

A new initiative from The Ministry of Education mandates that New Zealand schools provide Digital Technologies education in primary and secondary school. It follows that, in order to teach the new curriculum, teachers should possess basic programming skills. As these teachers may not specialise in programming, they would benefit from maintaining their programming skills over the course of the school year in order to teach the required modules to their students.

The Solution

A solution to this problem is the CodeWOF website which encourages teachers to maintain their programming skills by solving daily problems in Python. In this project, we improve the CodeWOF website by adding elements of gamification. Gamification is where elements of gameplay are applied in an effort to increase user interactions. Two elements of gamification, a point system and badges, were added to CodeWOF to motivate teachers to practice their Python programming skills. These elements encourage regular use of the CodeWOF website.

Points

Users can earn points by solving Python problems. For every question answered correctly, users gain 10 points. Additionally, if the user gets the question right on the first try, they can earn an extra two points.

Users can also earn points by earning badges, with the number of points added dependent on the badge's "tier". Points, along with badges, can be viewed on a user's dashboard, as shown below.

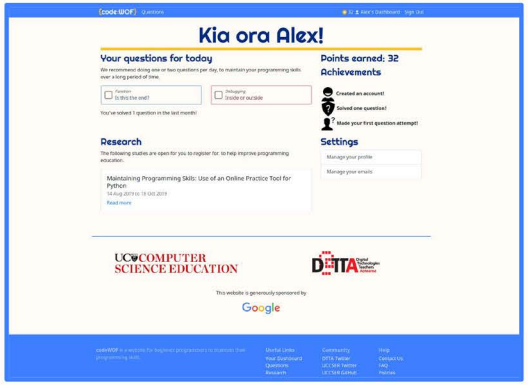
Questions

Users solve Python problems on the CodeWOF website to maintain their skills. These questions come in four main categories:

- Function: Writing a Python function
- Program: Writing a Python program (no function definition)
- Debugging: Finding the error in a given Python function or program
- Parsons: Dragging and dropping pre-generated lines of Python code to build a function or program

```
def fizz_buzz(num):
    if (num % 3 == 0) and (num % 5 == 0):
        print("FizzBuzz")
    elif num % 3 == 0:
        print("Fizz")
    elif num / 5 == 0:
        print("Buzz")
    else:
        print(num)
```

Parsons problems involve users dragging and dropping lines of code to build a specified function.



A user can view their current points and badges earned on their dashboard.

Achievements

Users can earn badges for their dashboards in CodeWOF. Some of these badges come in multiple "tiers" depending on how difficult they are to obtain. There are four types of badge available to users:

- **Account Creation Badge:** A badge awarded when a user creates a CodeWOF account.
- **Attempts Made Badge:** Badges awarded on the number of attempts the user has made to solve questions. Thresholds for these are 1, 5, 10, and 100 attempts for each badge tier.
- **Questions Answered Badge:** Badges awarded on the number of attempts the user has made to solve questions. Thresholds for these are 1, 5, 10, and 100 attempts for each badge tier.
- **Consecutive Days Badge:** Badges awarded for the number of consecutive days the user has answered questions on. These badges are awarded after 2, 7, 14, 21, and 28 days.




Badge tiers can be identified by the colour of the icon, or the number displayed for the consecutive day badges. Tiers are coloured monochrome, bronze, silver, and gold in ascending order, as shown below.

Student projects: Software Engineering

EER-Tutor Gamification

University of Canterbury
Te Whare Wānanga o Waitaha
Christchurch New Zealand

Computer Science & Software Engineering

Courtney Hoskin
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Context

EER-Tutor is developed by the University of Canterbury and used in COSC265.

Objective

Make EER-Tutor more effective for student learning.

Outcome

The study results were inconclusive, however, research and qualitative data indicate potential for future work.

Gamification

Inclusion of game elements in a non-game context.

Intelligent Tutoring System

Software that uses artificial intelligence to mimic human-tutors.

Research

Objective

Determine the feasibility of gamifying EER-Tutor, and how best to do so.

75% of students use EER-Tutor

37% activity increase for students with gamification

Outcome

Gamification increases motivation, enjoyment and satisfaction. The design needs to be user-centered. The preferred game elements are badges, points and leaderboards, which should encourage problem completion, time in the system and self-testing.

Implementation

Objective

Have a gamified version of EER-Tutor.

Outcome

EER-Tutor now has badges! Earned for logins, completing problems and learning. The main page summarizes the earned badges. There is also a more detailed view with all badges and descriptions.

Evaluation Study

Objective

Determine if EER-Tutor gamification is worthwhile for COSC265 students.

	U - value	P - value
Control Improvements	137	0.42
Experimental Improvements	218	0.57

INSIGNIFICANT

68% of students were positive about the gamification features

Outcome

The study gave no conclusions. Comparisons between the two groups showed no significant difference in learning, knowledge or motivation. Yet, positive comments reiterate the potential benefits of gamification.

Supporting Categorical Data in Scikit-learn Decision Trees

James MacKay Kourosh Neshatian - *supervisor*

Introduction

Scikit-learn is a machine learning library for Python. While it provides a comprehensive set of tools for developers, its decision tree module only supports numerical data, a shortcoming which can cause a variety of issues in terms of the complexity and understandability of the generated models, especially when these effects are not fully understood by the developer.

Decision Trees

Decision trees are fitted to training data and can be used to make predictions about unseen samples of the same type of data. Figure 1 shows a decision tree generated by Scikit-learn trained on a dataset of flower petals.

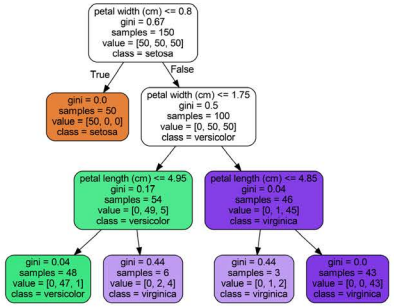


Figure 1. A decision tree generated by Scikit-learn trained on the built-in iris dataset.

Decision trees consist of split nodes and leaf nodes. Split nodes perform a test on a single sample of data in order to decide which child to send the sample to (in Scikit-learn, left is True, right is False). For example using the tree in Figure 1 a petal with width <= 0.8 cm is classified as being of the species setosa. Larger petals go to the right branch and classification continues.

Numerical vs Categorical Data

Scikit-learn only supports tests on numerical features. Categorical features, like colour for example, must be encoded numerically. The table below shows example encoding schemes.

Categorical (as is)	Ordinal	Onehot		
Colour	Colour	c1	c2	c3
red	0	1	0	0
green	1	0	1	0
blue	2	0	0	1

All three columns represent the same data. Ordinal encoding however introduces ordering into the feature which doesn't make logical sense (the test colour > blue is nonsense), while onehot encoding introduces new columns, making the data more complex and harder to understand.

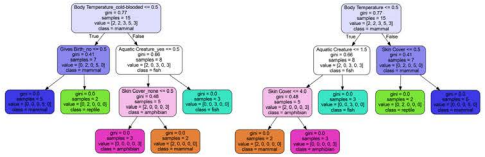


Figure 2. Decision trees generate with a small dataset encoded with ordinal (left) and onehot (right).

Figure 2 shows decision trees generated from data with *only* numerically encoded categorical variables which could be improved with native support for categorical data and non-binary splits.

Cython

For efficiency, Scikit-learn's tree module is developed in Cython[1], a 'superset' of Python which allows developers to write programs using C types.

[1] https://cython.org/

[2] https://en.wikipedia.org/wiki/Decision_tree_learning#Metrics

Impurity

Tree learning algorithms make splits which minimise impurity[2]. Impurity metrics include entropy (number of bits required to identify a sample) and Gini impurity (the probability of misclassifying a random sample based on the class distribution).

Solution

The solution proposed extends the Scikit-learn tree module to support both categorical and numerical data types natively and in addition, allows non-binary splits to be made on such data. Using the same data used to train the trees shown in Figure 2 a new tree was generated:

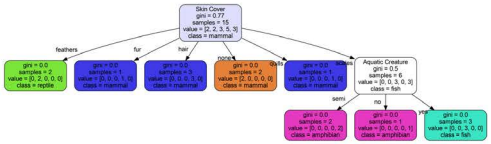


Figure 3. The new system generates trees with fewer splits when trained on the same data as in Figure 2.

Notice the new tree contains only two split nodes where the previous ones have four each.

[1] Stefan Behnel, Robert Bradshaw, Dag Sverre Seljebotn, Greg Ewing, et al. Cython: C-extensions for python. *Cython*, 2008.

[2] F. Pedregosa et al. Scikit-learn: Machine learning in Python. *Journal of Machine Learning Research*, 12:2825–2830, 2011.

[3] J. R. Quinlan. *C4.5: programs for machine learning*. Morgan Kaufmann Publishers, San Mateo, Calif, 1993.

UC UNIVERSITY OF CANTERBURY Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND
Computer Science & Software Engineering

Creating a Browser Testing Suite

Using BrowserStack and Selenium

Written by Oscar Stockill, Supervised by Tim Bell

Motivation

Two websites hosted here at the University of Canterbury by the Computer Science Education Research Group provide learning material to school students and above that wish to learn about computer science. The two sites, "CS-Unplugged" and "Computer Science Field Guide", have good test coverage for much of their back-end operations, but the web pages themselves do not. This has resulted in regular bug reports and lower user satisfaction.

To remedy the situation, a way of simulating user interactions with the websites was required. The answer is an automated browser testing suite.

CS UNPLUGGED

Check out both of these websites at **csunplugged.org** and **csfieldguide.org.nz**

What Makes a Testing Suite Effective?

Automated testing has the core purpose of ensuring that existing and future behaviour demonstrated by the product is acceptable. By focusing on these following principles the groundwork provided by this browser testing solution will allow for the developers within the Computer Science Education group to achieve this goal for their user-facing components.

The browser testing suite must be **flexible**, **easy to learn**, and **easier to extend**. These three principles will allow for an easy transition for the developers while also encouraging it to be further developed.

Proposed Solution

Selenium provides the foundation for performing the browser tests.

Selenium is a portable framework for testing web applications that provides web interactions that simulate how a user would interact.
This includes mouse movement, clicks, and more complex actions like dragging elements.

This is then linked to the BrowserStack testing platform.

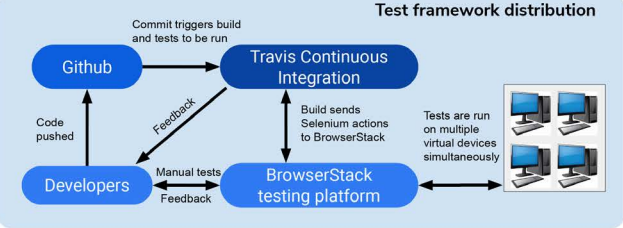
BrowserStack

BrowserStack has been specifically designed to function well with Selenium commands and allows for the tests to be run remotely, removing the need for a local device to be put out of action. The golden feature of BrowserStack is it allows for any configuration of operating system, browser type, and browser version to be tested despite the settings available to the developers locally. It also allows for up to five devices to be run concurrently, effectively reducing the testing time by 80%.

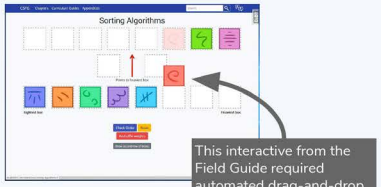
This solution can be integrated in to the existing Travis CI build cycle and project structure to run alongside the existing test suites. It also assists the developers by allowing them to shortcut the build process when quick feedback is required on test behaviour. This means more time can be spent writing tests to improve the end-user experience.

See the '**Test framework distribution**' diagram below for an idea of how these different systems interact.

Test framework distribution

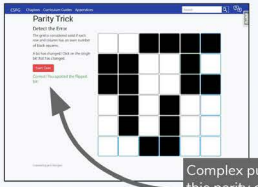


Selenium Testing Examples



This interactive from the Field Guide required automated drag-and-drop Mechanics.

Web elements such as these binary cards can be identified and clicked with selenium. The effect this has can then be checked.



Complex puzzles such as this parity grid can also be tested using the framework!

Student projects: Software Engineering

Computer Science & Software Engineering

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Investigating the Effect of Adding a Chatbot to EER-Tutor

Robert Bruce, Tanja Mitrovic

AutoTutor

A dialogue-based ITS developed at the University of Memphis. The system holds a conversation with its users during the problem solving process.

SQL-Tutor

A constraint based intelligent tutoring system developed by the Intelligent Computer Tutoring Group. It teaches students about Structured Query Language.

Intelligent Tutoring Systems

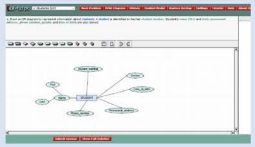
Smart e-learning software that allows students to solve problems. Each interaction is recorded and shapes the next.

Constraint Based Tutors

Intelligent tutoring systems built around constraints, special rules which model student knowledge and determine whether a solution is marked right or wrong.

EER-Tutor

An intelligent tutoring system developed by the Intelligent Computer Tutoring Group which teaches enhanced entity-relationship modelling. This system served as the starting point of the project.



GnuTutor

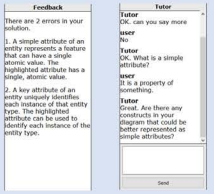
A simplified version of AutoTutor developed as an open-source alternative. It shares the same dialogue-based feedback system as AutoTutor.

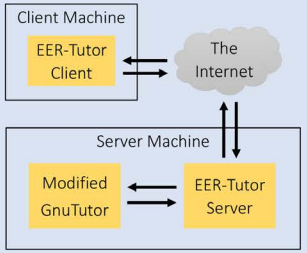
CAPIT

A capitalisation and punctuation ITS developed by the Intelligent Tutoring Computer Group for children.

Project Goals

The project aimed to evaluate the impact of adding a chatbot to EER-Tutor. By default, EER-Tutor provides feedback in the form of a static message when a student violates a constraint. We hoped that the chatbot would be capable of holding a conversation with a student, as a human tutor might. The original feedback system was compared to the chatbot system in a study conducted at the University of Canterbury.





System Design

The chatbot is activated whenever a student violates a constraint. When communicating with the chatbot, a student's message is sent from a client on their web browser to the EER-Tutor server via the internet. It is then passed to the chatbot - a modified version of GnuTutor. The chatbot's response is sent back to the student through the EER-Tutor server.

Findings

No statistically significant difference was encountered between the control (standard feedback) and experimental (chatbot) groups on the first day of the study. A technical issue prevented the collection of relevant data on other days and restricted group size.

If significance is ignored, the experimental group demonstrated a greater normalized learning gain. This was calculated from test scores before and after EER-Tutor use. The group also attempted and solved more problems in a shorter period.

Both groups saw a similar number of feedback messages. This indicates that the chatbot group did not converse with the chatbot on many occasions.

	Control Mean (Standard Deviation)	Experimental Mean (Standard Deviation)
Participants	17	14
Learning Gain	-0.43 (0.60)	-0.07 (0.16)
Problems Attempted	8.00 (4.37)	9.50 (4.38)
Problems Solved	7.53 (4.52)	9.21 (4.05)
Solved Per Minute	0.08 (0.05)	0.10 (0.04)
Messages Seen	29.12 (38.83)	33.29 (27.46)

DEEP LEARNING TEXT COMPRESSION

By Tim Hamblin under the supervision of Dr. James Atlas

University of Canterbury
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Computer Science & Software Engineering

OVERVIEW

Open AI released a powerful natural language processor called GPT2. This model had very impressive predictive capabilities that made it appealing to use for text compression. An input prompt could be provided to the model and it would produce coherent sentences as a response.

GPT2 PREDICTION EXAMPLE

Prompt: How good is Tim's honours project?
GPT2: It's definitely high on the list, but we'll have to wait for the official announcement about it.

FINDINGS

The best predictive accuracy that was achieved by the model was 60% (on a Wikipedia article), this translated to a compression rate of 58.7%. These rates were achieved by tuning the amount of input words given to the model, the amount of outputs the model produced as a prediction, the type of article being compressed and the size of the article

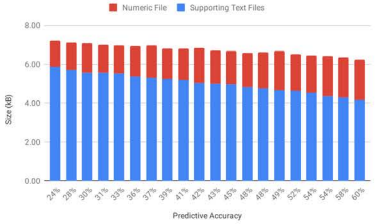
ARTICLE TYPE

Some articles were inherently easier to predict than others. "April 19th" contains a lot of lists with no shared context. "Agent Orange" contains lots of contextually connected flowing text.

FROM PREDICTION TO COMPRESSION

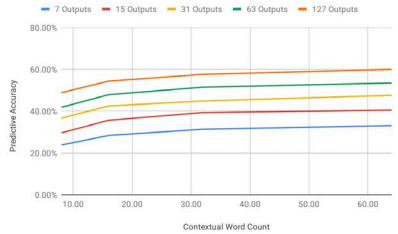
For each word in an article, a set number of previous words are given to the GPT2 as an input context. The GPT2 will then output a given amount of predictions for this word. If one of these predictions is correct then the index within the prediction list is recorded, if not the word itself is recorded. Storing an index is much smaller than storing a word so compression has been achieved.

INDICES VS TEXT



Indices can be stored in less space than words. So the more predictions the model can make, the better the compression rate.

INPUTS AND OUTPUTS

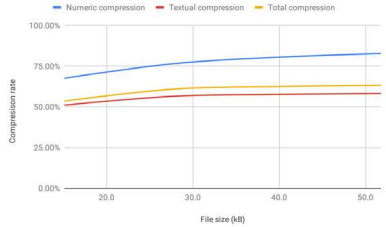


Increasing the amount of outputs that the model predicted caused the largest increase in the accuracy of the model.

DECOMPRESSION

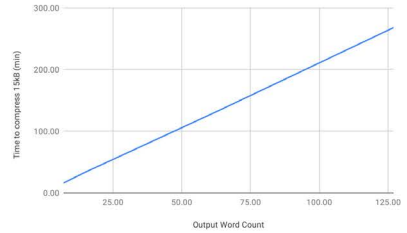
To decompress, the model is given a small amount of starting text from the article. If an index exists for the next word, the model is prompted for a prediction and uses this corresponding index to select the correct word. If the model has no index the correct word is taken from a list of missed words. This is repeated to rebuild the article.

ARTICLE SIZE



The larger the file, the better compression that could be achieved. This was due to the final compression of the encoded data being more efficient on larger data sets.

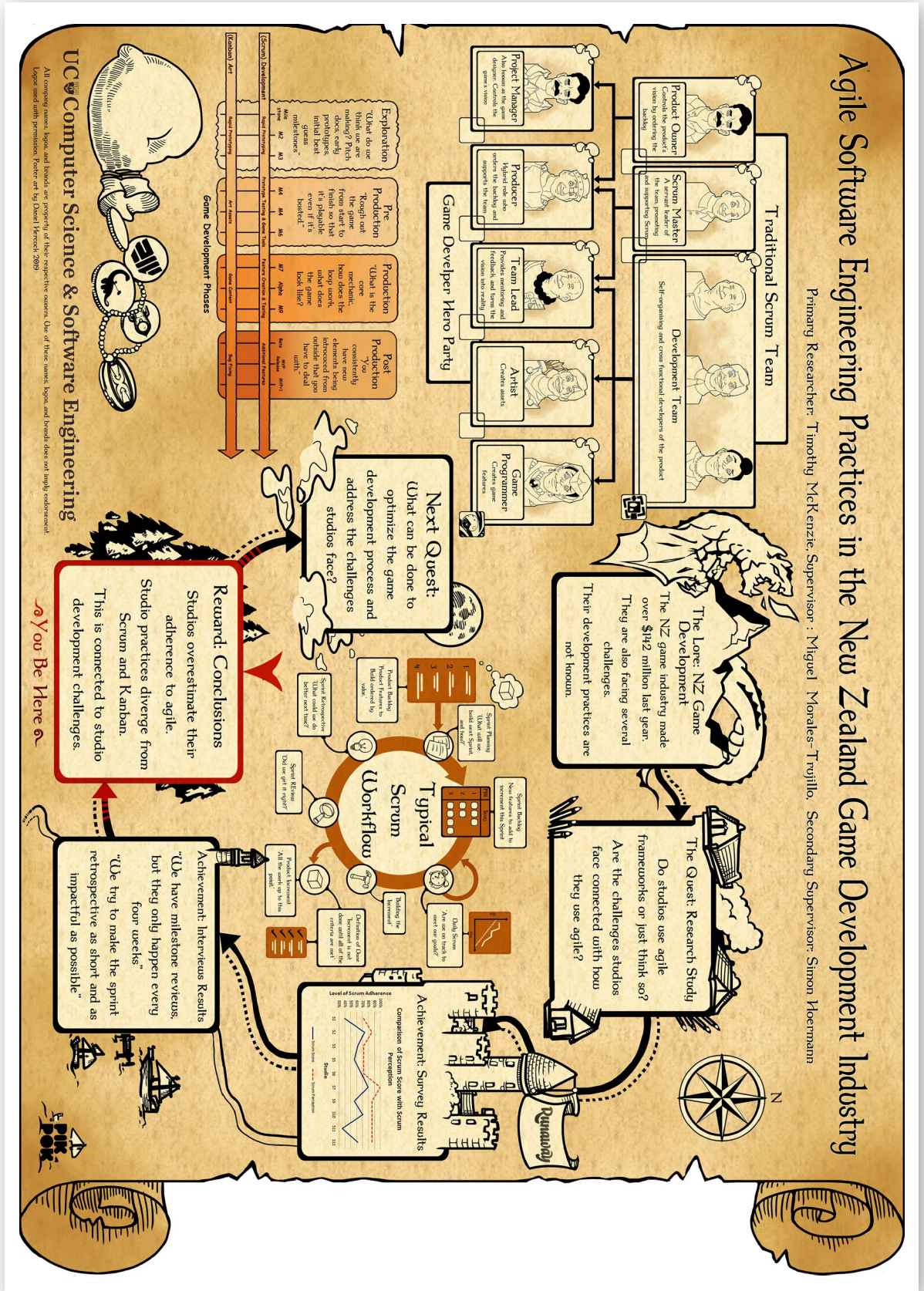
TIME



As the output word count increased, the time to compress drastically grew. This limited the feasibility of increasing the predction rate fruther.

Student projects: Software Engineering

Student projects: Software Engineering



Sponsor a project in 2020

If you have a project you would like our final year engineering students to work on, we would like to hear from you. Submit a summary of your idea by email to engindustry@canterbury.ac.nz including the following information:

- 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.
- Support (time, resource & equipment) your business/organisation will provide (in addition to sponsorship).
- Any other information you consider relevant.

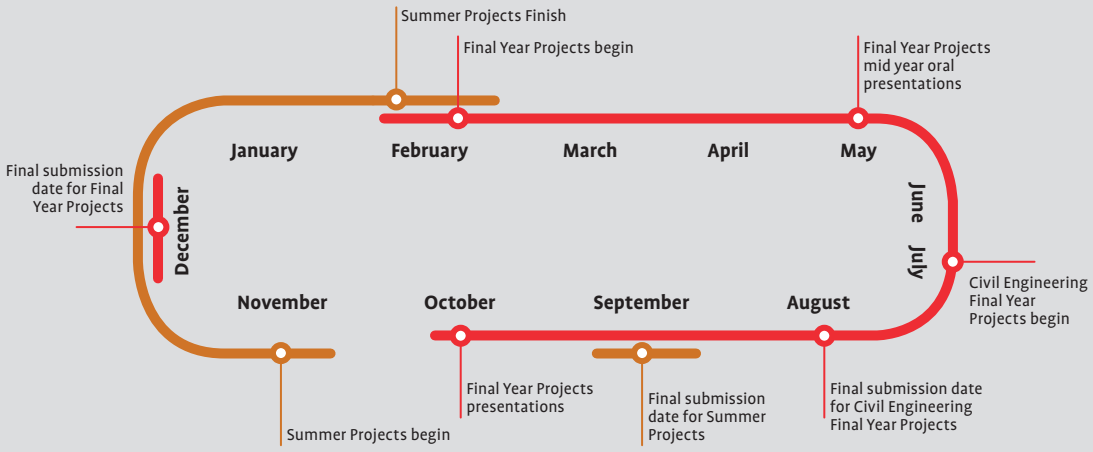
Or complete the online form: **www.canterbury.ac.nz/engineering/industry/project-sponsorship**

PROJECT TIMELINE:

Final Year Project final submission date for an idea or project is: Friday, 20 December 2019, for projects to be started in February 2020.

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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College of Engineering, University of Canterbury
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Email: engindustry@canterbury.ac.nz
Web: www.canterbury.ac.nz/engineering/industry