PRODUCTION OF RECOMBINANT PROTEIN USING *E. coli*

Layla C. McIntosh, Chelsea Blackstock & Dr. Adele Williamson — Te Aka Mātuatua School of Science - University of Waikato

BACKGROUND

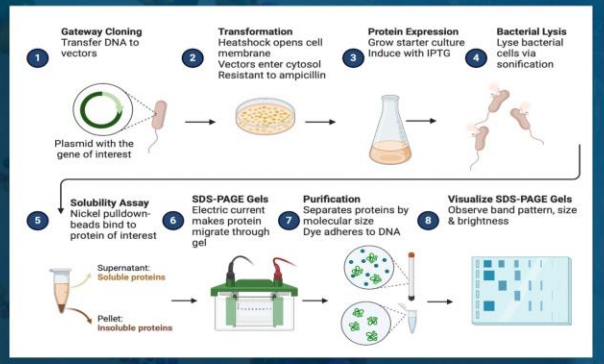
Producing protein in *E. coli* is rapid, inexpensive and straightforward in comparison to more complex eukaryotic expression systems (Bird, 2011).

Small-scale expressions are used to determine the achievable quantity and quality of production before scaling up (Dannemeyer et al., 2024), and they can identify the optimal expression conditions for the specific protein.

PROJECT AIM

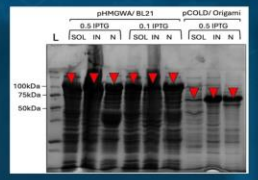
The aim of this research project was to conduct a small-scale expression test to determine the most effective expression vector, and to compare the two strains of *E. coli*.

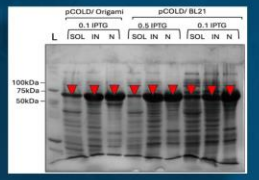
METHODS

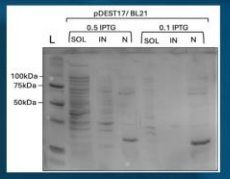


- **Expression Strains:** BL21 & Origami
- **Expression Plasmids:** pCOLD, pHMGWA & pDEST17
- **Constant Conditions:** Temperature- 15℃, Media- TB & Glucose- 1%
- **IPTG Concentrations:** 0.1mM & 0.5mM

RESULTS







Expression Treatments:	Protein→ Plasmid→ *E.coli*	IPTG Concentration:	Approx. size of protein incl. tags	Was this treatment effective?
1	LB3 in pDEST17-> BL21	0.1mM	63kDa	✗
2	LB3 in pHMGWA-> BL21	0.1mM	105kDa	✓
3	LB3 in pCOLD -> BL21	0.1mM	63kDa	✓
4	LB3 in pCOLD -> Origami	0.1mM	63kDa	✓
5	LB3 in pDEST17-> BL21	0.5mM	63kDa	✗
6	LB3 in pHMGWA-> BL21	0.5mM	105kDa	✓
7	LB3 in pCOLD -> BL21	0.5mM	63kDa	✓
8	LB3 in pCOLD -> Origami	0.5mM	63kDa	✓

DISCUSSION

- The most effective expression vector- pCOLD & the most effective expression strain- BL21.
- There was no significant difference in IPTG concentrations.
- The pDEST17 vector was the least effective- it did not express the protein at all.

NEXT STEP: conduct large-scale expression using pCOLD/ BL21, using the same conditions & 0.1mM IPTG.

REFERENCES

- Bird, L. E. (2011). High throughput construction and small scale expression screening of multi-tag vectors in Escherichia coli. *Methods in Structural Proteomics, 55*(1), 29–37. https://doi.org/10.1016/j.ymeth.2011.08.002
- Dannemeyer, M., Berling, A., Kanje, S., Enstedt, H., Xu, L., Afshari, D., Westin, M., Hober, G., Uhlén, M., Hober, S., & Tegel, H. (2024). Fast and robust recombinant protein production using episomal stable pools in WAVE bioreactors. *Protein Expression and Purification, 221*, 106505. https://doi.org/10.1016/j.pep.2024.106505
- *Download Colorful Colors Molecule Artistic DNA Structure 4K Ultra HD Wallpaper.* (n.d.). Wallpaper Abyss. Retrieved January 23, 2025, from https://wallpapercave.com/big.php?i=735243

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TE NEHENEHENUI

HONEY! I FOUND THE GENES

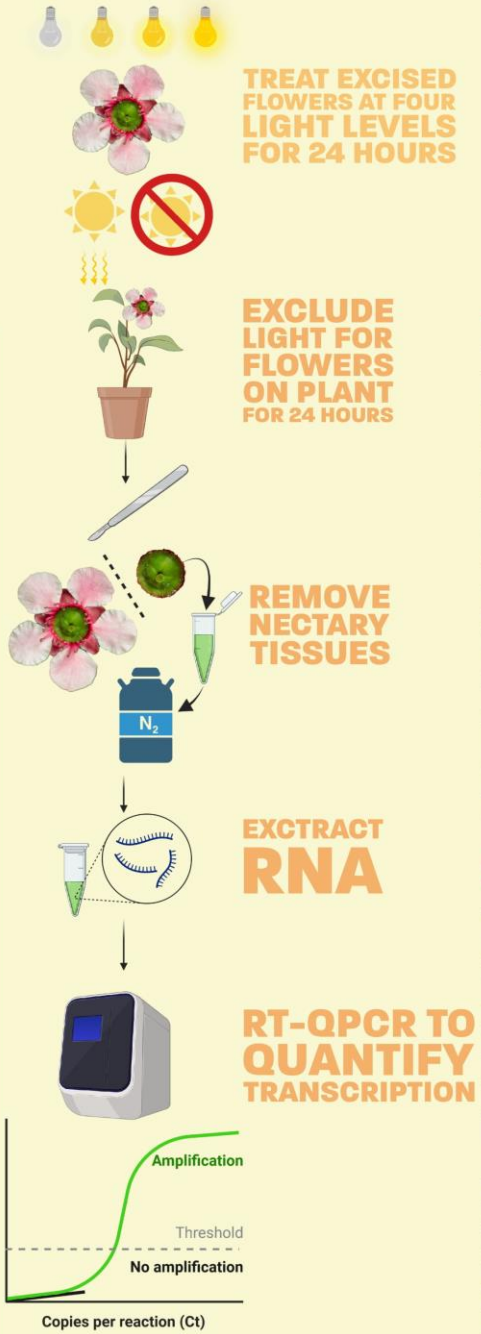
AIM

To investigate how light influences the regulation of the Lspgg2 gene in Leptospermum scoparium (Manuka), which plays a key role in the production of methylglyoxal (MGO) found in Manuka honey.

INTRODUCTION

Methylglyoxal (MGO), is a molecule found in Manuka honey, that is responsible for its remarkable antibacterial properties. In 2024, Ella Grierson and her colleagues identified a gene in Manuka, Lspgg2, which encodes a phosphatase. This enzyme dephosphorylates dihydroxyacetone phosphate (DHAP), a central metabolic intermediate, converting it into dihydroxyacetone (DHA). DHA subsequently transforms into MGO in the derived honey. Building on this discovery, our research explores the role of light in regulating Lspgg2. This study aims to enhance our understanding of how environmental factors influence this gene and, in turn its physiological role.

METHOD



MY EXPERIENCE

The Waikato University Summer Research Scholarship has provided me with invaluable opportunities, including working in a university lab with extremely knowledgeable and inspring mentors such as Associate Professor Mike Clearwater. This experience both expanded my knowledge and offered insight into postgraduate life. Additionally, I gained hands-on experience with industry lab techniques, such as RT-qPCR by woking in a PC2 laboratory, at Plant and Food Research in Palmerston North guided by highly regarded plant molecular biologists, including Ella Grierson & Dr Kevin Davies, giving me a glimpse into research beyond the university setting.

OUTCOMES

We anticipate that the results of this experiment will demonstrate a positive correlation between higher DHA levels and greater irradiance. This relationship could be explained by an increased demand for phosphate cycling or higher DHAP availability, driven by elevated photosynthetic activity under intense light conditions.

By Lennox Reynolds.
Supervised by Associate Proffesor Mike Clearwater, Ella Grierson, Dr Kevin Davies & Dr Kathy Schwinn
Refrences: doi: 10.1111/nph.19714.

Plant & Food™ Research
Rangahau Ahumāra Kai

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Down the drain

What is the real hydrological role of farm drains in PEATLAND agriculture?

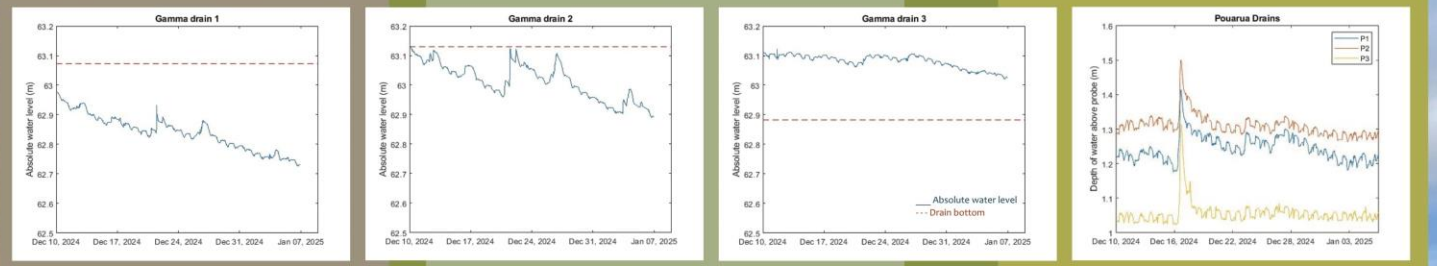
INTRODUCTION

Peatlands in Aotearoa and around the world are commonly drained for agriculture/pasture. Peatlands are also carbon rich organic wetlands and draining them introduces oxygen into these anoxic soils making them hotspots for emissions of greenhouse gases such as CO_2, CH_4, No_2.

Maintaining a shallow water table depth can help reduce greenhouse gas emissions from drained peatlands; and a better understanding of the hydrological function of farm drains will allow for more informed peatland management opportunities.

The aim of this project was to install and monitor water table measuring equipment in 1st, 2nd, 3rd order drains at two farms with contrasting water tables (deep and shallow) that have been drained for agricultural purposes for a few decades.

Data from the drain monitoring network will continue to be collected for several years and contribute to GHG measurement and mitigation research.



L to R – Fig. 1-3 show drain water levels with respect to the drain bottom at Gamma. Fig. 4 – shows relatively steady water levels at Pouarua during the study period.

RESULTS

The water levels in different drains (fig. 1-3) are plotted assuming benchmarks are all at 64 m asl.

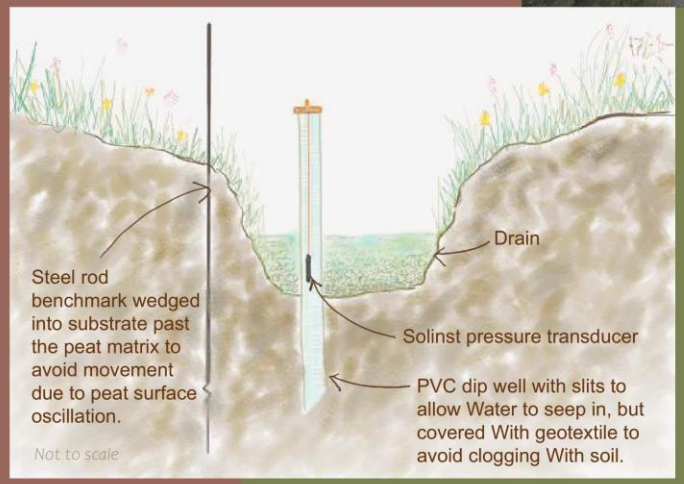
Individual graphs for Gamma farm shows changes in water level in each drain over the study period with respect to the drain bottom.

The water levels in 1st and 2nd order drains at Gamma were below the drain bottom to begin with (refer fig. 1 and 2; meaning deeper water tables).

The water table dropped much more rapidly than the gentle slope seen in the 3rd order drain where the water table was above the drain bottom (fig.3).

A prominent rain event can be seen in the spike at both sites, especially at Pouarua. Flashy flow from the rain elevated the water levels before they started to lower again.

At Pouarua Farm, all drains had some amount of water at the beginning of the study period (meaning shallower water table). As seen in figure 4, the water levels did not change as much in any of them through the season, reflecting similarity with the 3rd order drain at Gamma.



METHOD

We installed PVC dip wells (with slits, covered with geotextile, in 1st, 2nd, and 3rd order drains alongside steel rods (9 m) that served as a benchmarks.

A Solinst pressure transducer was placed within each dip well to measure water level in the drains, at half hourly intervals. This was corrected to exclude barometric pressure with data from existing barologgers on nearby sites.

4-5 standalone dip wells were installed along a transect across the paddock;
water table measurements from these were taken manually.

Ongoing work includes surveying to establish relative height of the benchmarks and profiles across each of the monitored drains.

DISCUSSION

Analysing the trends of change in water level at both sites gave insight on the possible relationship between the antecedent water table depth and the rate at which it lowers as the season progresses.

Having shallower water tables may mean less fluctuation of the water table especially during summer when there's moisture deficit.

And thus, oxidation of saturated and anoxic soil in peatlands can potentially be reduced by maintaining the water tables closer to the surface.

CONCLUSION AND FURTHER

More readings of in field water table are needed to detect a conclusive pattern in the change in WT due to drains. For a complete and just representation of drains in this project, more data on relative heights of the drain monitors, and volume of drains is needed.

More critical monitoring of rate of discharge from drains in comparison to loss of moisture due to evaporation will provide a better understanding on the real impact of drains on the hydrological regime of the peatland.

Each peatland has unique soil characteristics (hydraulic conductivity, land use, and management practices) and so a larger network of research sites and more long term studies are needed in order to be able to suggest effective alternate management practices for agricultural peatlands.

raah
Supervised by ***A Prof. David Campbell*** *Special thanks to* ***Ben Roche***

REFERENCES

Fritz, C., Campbell, D. I., & Schipper, L. A. (2008). Oscillating peat surface levels in a restiad peatland, New Zealand—magnitude and spatiotemporal variability.*Hydrological Processes: An International Journal*,*22*(17), 3264-3274.
Evans, C. D., Peacock, M., Baird, A. J., Artz, R. R. E., Burden, A., Callaghan, N., ... & Morrison, R. (2021). Overriding water table control on managed peatland greenhouse gas emissions.*Nature*,*593*(7860), 548-552.
Tiemeyer, B., Heller, S., Oehmke, W., Gatersleben, P., Bräuer, M., & Dettmann, U. (2024). Effects of water management and grassland renewal on the greenhouse gas emissions from intensively used grassland on bog peat.*Agricultural and Forest Meteorology*,*345*, 109858.

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BREAST CANCER'S PLOT TWIST: ESR1 MUTATIONS

MUSKAN SHEBA
SCHOOL OF SCIENCE, UNIVERSITY OF WAIKATO
SUPERVISOR DR.LINDA PETERS

Introduction

Breast cancer is often driven by oestrogen receptor-positive (ER+) tumours [1]. DNA mutations in the *ESR1* gene (Fig 1) lead to endocrine therapy resistance by activating ERα independently of oestrogen [2]. This pilot project aims to create and validate a mutation test using DNA from 80 biopsy samples of Waikato breast cancer patients, assess their ESR1 mutation status, and determine these mutations' incidence and clinical implications for treatment.

ESR1 Gene

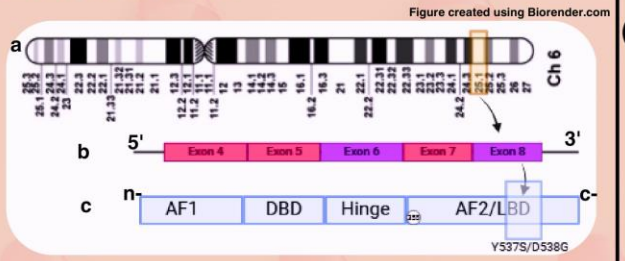


Figure 1: Location and structure of *ESR1* gene. (a). ESR1, located on chromosome 6 (6q25.1), encodes ERα protein. (b) Exons 4–8 and key protein domains are shown. (c). Mutations Y537S and D538G in the ligand-binding domain (LBD) of exon 8 lead to constitutive ERα activation, driving cancer growth without estrogen.

Methodology

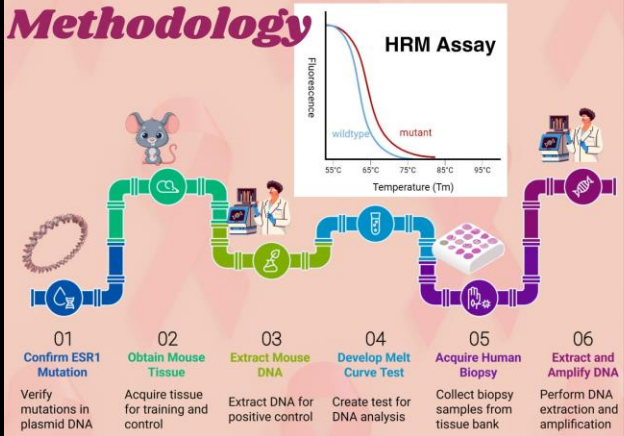
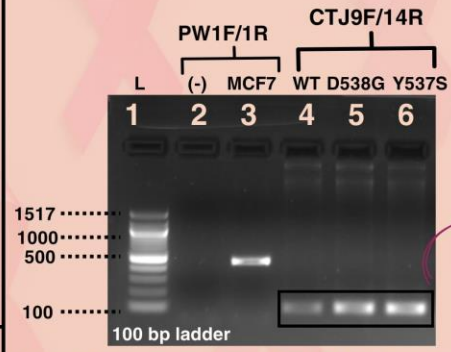


Figure 2: Outline of ESR1 mutation test

Results

1 Amplification of the ESR1 Gene



87bp bands, matching the ESR1 fragment reported [2]

Figure 3: 2% agarose gel showing WT, D538G, and Y537S variants. Lane 1: 100 bp ladder; Lanes 2 and 3: negative and human cell line MCF7 (positive control) amplified with PW1F/1R primers; Lanes 4–6: plasmid samples amplified with CTJ9F/14R primers that covers ESR1 exon 8.

2 Plasmid DNA Extraction for Melt curve test

Sample	Concentration (ng/ul)	A260	A260/280	260/280
wildtype	52.648	1.053	2.001	3.989
D538G	67.861	1.357	2.039	2.778
Y537S	58.396	1.168	2.025	3.707

Good Quality A260/280 > 1.8

Figure 4: DNA concentration and quality of the plasmid DNA extracted from *E. coli*

3 Restriction Enzyme Digest Analysis

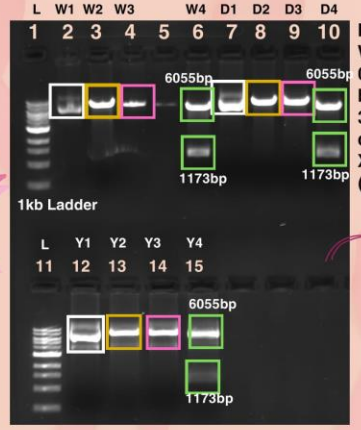


Figure 5: Restriction digest analysis of WT, D538G, and Y537S variants on 0.8% agarose gel. Lanes 2 & 7 (white box): undigested circular DNA; Lanes 3, 8, & 13 (Yellow box): BamHI digestion; Lanes 4, 9, & 14 (Pink box): XbaI digestion; Lanes 6, 10, & 15 (Green Box): BamHI + XbaI digestion.

Matching the expected plasmid size (7228 bp) with the mutation insert.

4 Confirmation of Mutation in Plasmid DNA

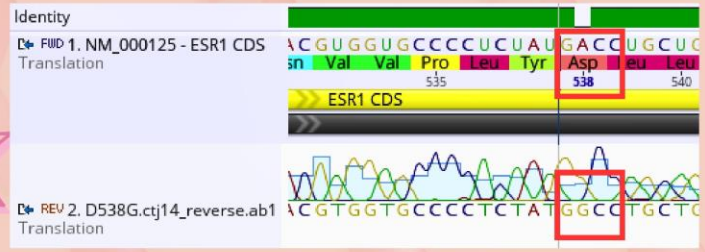


Figure 6: Nucleotide alignment of the *ESR1* coding sequence (CDS) (yellow bar) to plasmid D538G shows a SNP (A > G), resulting in a missense mutation at amino acid position 538.

Conclusions

- The 3 plasmids contain the *ESR1* gene (Fig 3 & 5).
- Extracted high-quality plasmid DNA can be used for DNA sequencing and HRM assay(Fig 4).
- Plasmid D538G contains the correct mutation (Fig 6).

Future Directions

- HRM assay optimisation (Figure 2, steps 4 - 6)

Acknowledgements

- Supported by a grant from Gallagher Research Trust for research funding.
- University of Waikato Summer Scholarship Programme

References

1. Dustin et al. (2019). Cancer, 125(21), 3714–3728.
2. Wang et al. (2015). Experimental and Molecular Pathology, 98(2), 152–157.

EXPLORING
Ecological Corridors

Shakaya Templeton.

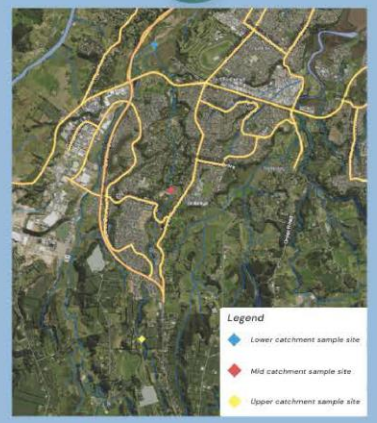
Supervised by
Ang McGaughran,
Michael Barton,
Paul Greenshields.

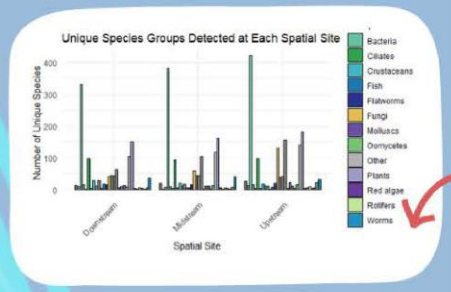
01. Background

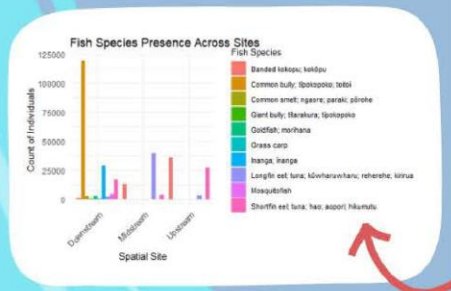
The Kopurererua catchment is a vital ecological link from the Kaimai Ranges to the Tauranga Harbour. In recent years the catchment has experienced significant land modification. Tauranga City Council (TCC) in partnership with the University of Waikato has initiated a monitoring program to assess and restore the ecological health of the Kopurererua and Nanakau streams.

02. Objective

To identify and map potential ecological corridors within Tauranga City to enhance biodiversity and natural connectivity and build understanding of how to connect fragmented areas of high-quality vegetation.







03. Methods

- Conducted riparian and in-stream habitat field surveys along the Nanakau.
- Collected environmental DNA (eDNA) samples for laboratory analysis.
- Conducted a literature review to understand the state of the area.
- Created detailed maps of potential ecological corridors.

04. Results

Results were plotted into graphs and tables via R studios to showcase important data.

The unique species detected at each site were plotted to show how biodiversity varied across space.

DNA sequence reads for detected fish species was plotted at each site to determine how the sites differed in their fish diversity.

05. Discussion

Field surveys identified poorer quality habitat at midstream and downstream regions, improving moving upstream.
However, eDNA sampling found a large proportion of invasive species and lower number of fish in upstream sites. This information and a literature review revealed that many perched culverts along reaches can hinder fish passage.
Recommendations include adding fish ramps to perched culverts, riparian planting in fragmented areas, and the removal of weeds from degraded reaches.

06. Conclusion

This study revealed overall poor habitat quality in the Nanakau stream, especially with a lack of biodiversity of fish across the entire stream reach.
Among the first steps for creating connectivity within the Nanakau include the remediation of perched culverts that are barricading native biodiversity.

Tauranga City

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07. References

Dare, J., & Sanchez-Medina, R. (2022). Kopurererua Focus Catchment Report 2022. Bay Of Plenty Regional Council.
M. Beadel , S. (2006). Otanewainuku Ecological District . MORPHUM Environmental LTD. (2021). Kopurererua Watercourse Assessment.
Tauranga City Council. (2024). Vision for Tauranga - Tauranga City Council. Retrieved December 5, 2024, from tauranga.govt.nz website: https://www.tauranga.govt.nz/our-future/our-direction/vision-for-tauranga
Thomas, C. D. (1991). ECOLOGICAL CORRIDORS: AN ASSESSMENT . Department of Conservation.

Where Heavy Metals Accumulate in Honey Bees

Tasha Terelmes, Amber Bell, and Dr Megan Grainger

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Background

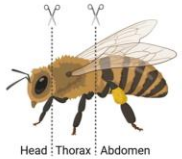
- Honey bees are important for pollinating about 80% of major crops and they produce many useful products[1]
- Heavy metals are released into the atmosphere and they do not break down[2]
- Exposure of metals to bees occurs through contaminated water and food sources, or airborne particles that settle on the bee's bodies[2]
- Heavy metals can bioaccumulate in bees, brood, and in hive products[3,4]
- Heavy metals could threaten the health of bees and the quality of their products, therefore also affecting the health of humans[5]

Aim

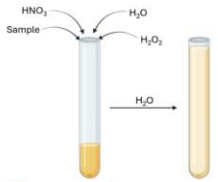
Determine whether heavy metals accumulate in the abdomen, thorax, or head of honey bees fed with environmentally relevant concentrations of copper, cadmium and lead.

Methods

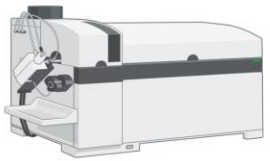
1. Young bees collected then fed for 21 days with diets dosed with Cu, Cd, or Pb



2. Separated the head, thorax and abdomen



3. Prepared bee segment samples using acid digestion



4. Analysed elemental concentration using ICP-MS

Results

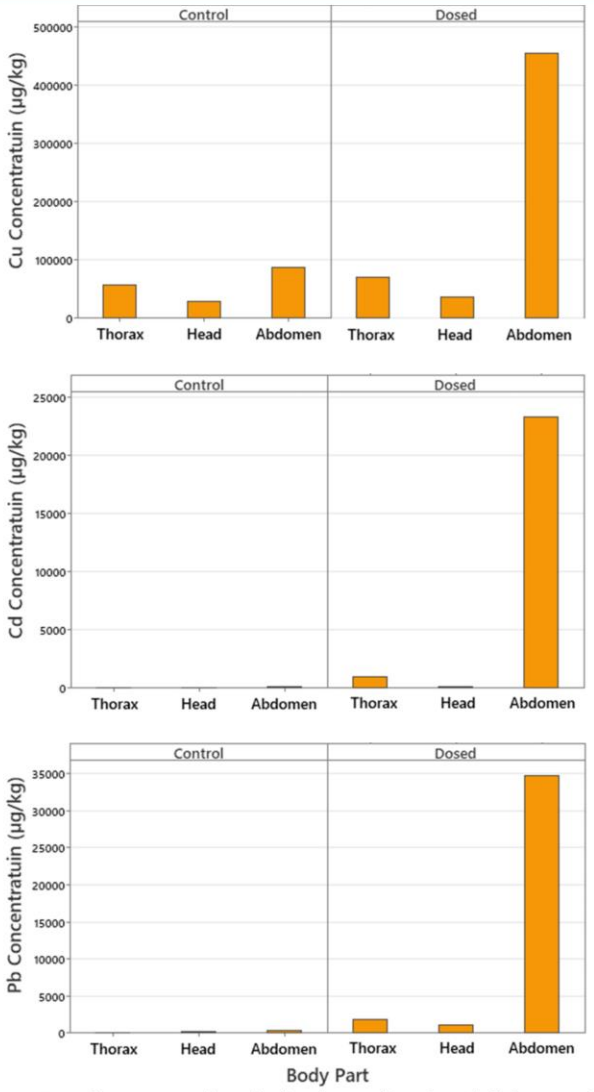


Figure 1: Metal concentrations in the thorax, head, and abdomen of control (non-dosed) and dosed bees. Top to bottom: copper (Cu), cadmium (Cd), and lead (Pb).

Discussion

- The concentration of the metals in each body segment are greater in the dosed bees compared to the control (non-dosed) bees
- Some of the metals have moved into the head and thorax while majority has remained in the abdomen, where the digestive system is located
- It is likely that the metals have accumulated in digestive waste in the rectum, rather than being absorbed into the rest of the body
- Dissecting the abdomen into its components and further testing would be needed to confirm whether the metals are being absorbed or not
- The increase in lead concentration in the brain was larger compared to cadmium, this aligns with previous work that showed an increase of lead in the brain

References

1. Dai, P.; Wang, M.; Geng, L.; Yan, Z.; Yang, Y.; Guo, L.; Ma, S.; Diao, Q. The effect of Bt Cry9Ee toxin on honey bee brood and adults reared in vitro, Apis mellifera (Hymenoptera: Apidae). Ecotoxicology and Environmental Safety 2019, 181, 381-387. DOI: https://doi.org/10.1016/j.ecoenv.2019.06.031.
2. Perugini, M.; Manera, M.; Grotta, L.; Abete, M. C.; Tarasco, R.; Amorena, M. Heavy Metal (Hg, Cr, Cd, and Pb) Contamination in Urban Areas and Wildlife Reserves: Honeybees as Bioindicators. Biological Trace Element Research 2011, 140 (2), 170-176. DOI: 10.1007/s12011-010-8688-z.
3. Monchanin, C.; Drujont, E.; Devaud, J.-M.; Lihoreau, M.; Barron, A. B. Metal pollutants have additive negative effects on honey bee cognition. Journal of Experimental Biology 2021, 224 (12), jeb241869. DOI: 10.1242/jeb.241869.
4. Monchanin, C.; Gabriela de Brito Sanchez, M.; Lecouvreur, L.; Boidard, O.; Méry, G.; Silvestre, J.; Le Roux, G.; Baqué, D.; Elger, A.; Barron, A. B.; et al. Honey bees cannot sense harmful concentrations of metal pollutants in food. Chemosphere 2022, 297, 134089. DOI: https://doi.org/10.1016/j.chemosphere.2022.134089.
5. Astolfi, M. L.; Conti, M. E.; Messi, M.; Marconi, E. Probiotics as a promising prophylactic tool to reduce levels of toxic or potentially toxic elements in bees. Chemosphere 2022, 308, 136261. DOI: https://doi.org/10.1016/j.chemosphere.2022.136261.

Carbon processing over a land use gradient

Using cotton strip assays to determine stream decomposition across varying land uses

Alexandria White, Supervisor: Dr Frank Burdon - Acknowledgments: Jasmine Brown, Mael Marguet, Martin Sarkezi

References

Introduction

Streams and rivers process carbon through the breakdown of terrestrial plant matter. Decomposition of these inputs is an important functional indicator of stream health.[1] Decomposition rates vary due to factors including nutrient concentrations, temperature, and microbial activity.[2] Our aim was to investigate stream organic matter processing over a land-use intensity gradient using the cotton strip assay (CSA). We hypothesized that decomposition rates and their variability would increase with land use intensity.

Methods

We deployed the CSA in 10 Waikato streams across differing land use types (indigenous forest, exotic forest, pasture, urban). The CSA uses tensile strength loss to measure decomposition.[2] Stream temperatures and specific conductivity were also measured as key drivers of decomposition.

Conclusion

Cotton strip assays can be used to determine differences in decomposition rates across a land use gradient. I found that decomposition increased as human land uses put more pressure on the stream ecosystem, with urban streams being the most impacted. Temperature was found to increase decomposition rates, showing the importance of this physical driver on biological activity rates.[1] This research is important to show differences in stream ecosystems and how human impacts like land use and climate change might affect them.

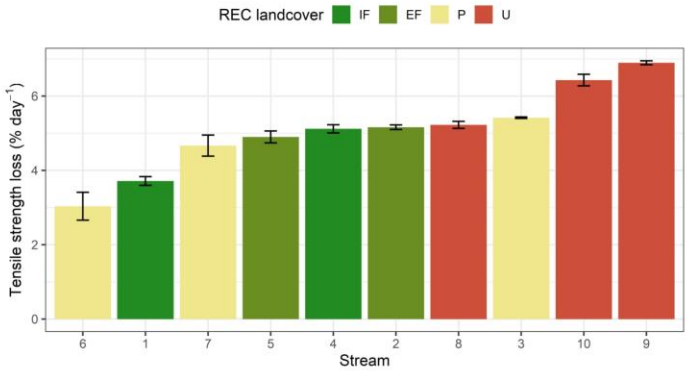


Figure 1. Mean stream decomposition rates (±SE) in different River Environment Classification[3] (REC) land use types (IF, indigenous forest; EF, exotic forest; P, pasture; U, urban).

Results

Decomposition rates increased with changing land uses (Fig.1). Temperature and conductivity were weakly associated with decomposition (Fig.2). Stream 6 was an outlier confounded by flow conditions. Removing it meant the correlation between decomposition and temperature was statistically significant ($p<0.05$).

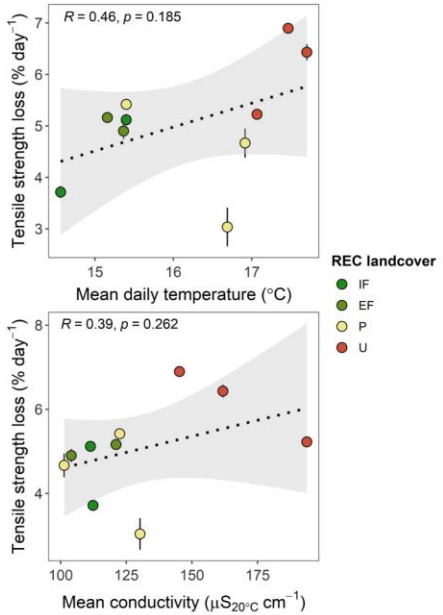


Figure 2. Correlations of decomposition rates (±SE) with mean daily temperature and specific conductivity in streams influenced by different land-use type.

Native

Pine

Pasture

Urban

Land use gradient

Breaking Barriers in Nanopore Sequencing

Introduction

Figure 1. A single MinION flow cell generates data at a rate of 10 to 20 Gb every 48 hrs. Running multiple flow cells in parallel allows for human genome sequencing (30x coverage) in about a day.

ONS, or Oxford Nanopore Sequencing, is a third generation technology that sequences both DNA and RNA at high speed and lower cost than other genomic methods. It uses a protein pore called CsgG, which defects changes in electric resistance as nucleic acids pass through it. These changes are recorded as raw signal data files.

Bioinformatic post-processing is needed to convert raw signal data into high-quality sequence reads, requiring knowledge of Unix commands and bioinformatic tools.

Aim

The goal of this project is to create an accessible and easy-to-use pipeline that streamlines the tedious post-processing steps while maintaining functionality and usability

A graphical user interface - (GUI) is the optimal solution for simplifying and enhancing the existing workflow, allowing more users to access ONS with minimal training.

A typical ONS workflow can be summarised into four major stages, as illustrated on the right side.

Sequencing
↓
Quality Control
↓
Alignment
↓
Polishing

Method

Jupyter Notebook was selected as the framework for designing the GUI, utilising Python for the front end and Bash for the back end. Python facilitates easier maintenance of the UI, as it enables rapid coding and is understand by a wider range of users. Using Bash for the back end allows the pipeline to leverage existing, well-developed bioinformatic tools and enables data processing at native speed.

Th enhance the usability of the pipeline, a script was created to simplify the installation process. This script can automatically determine the operating system (OS) and central processing unit (CPU) architecture. This information is then used to guide the installation of the appropriate dependencies and tools.

Below is one of the six interface designed specifically for base calling.

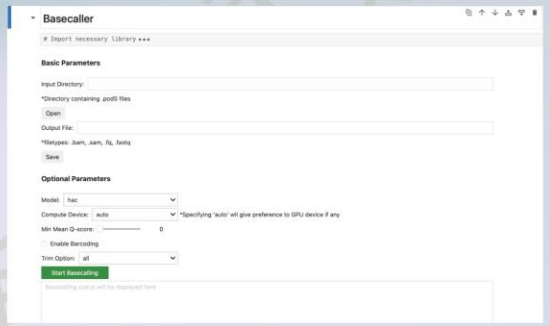


Figure 2: Base calling interface. Base calling refer to the process of converting raw data (time-series signal graph) to nucleic acid sequence using a neural network model.

Conclusion

The development of the pipeline was completed in January, and it received positive feedback from stakeholders, including my supervisor and lab staff. The default parameter values are optimal in most cases, but not always. As a result, a user training document and a development document will be created to assist future user and developers. The software is expected to be deployed in early 2025!

Despite the success of this project, there are areas for improvment that can be addressed in the future:
- An interface for custom model training
- An interface for task pre-scheduling
- An interface for assembly polishing
- An interface for data visualization
- Smart/Automatic parameter selection

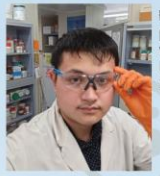
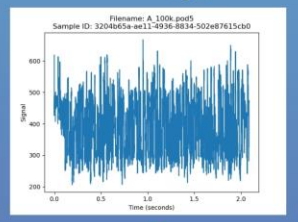


Figure 4. A picture of me working in the lab - Summer 2024

Result



Post-Processing

The developed pipeline consists of six interfaces for different bioinformatic post-processing tasks:
- Base calling
- Report
- Format Conversion
- Filtering
- Indexing
- Alignment

Each post-processing step is crucial for producing high-quality data for analysis. Base calling especially requires high-end GPU - (Graphical Processing Unit) and often take hours to produce high-quality nucleic acid sequences with the best AI model available.

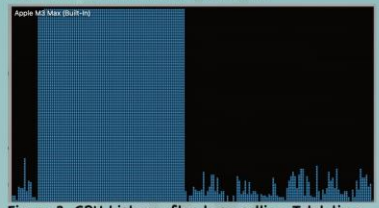
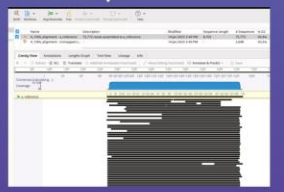


Figure 3. GPU history after base calling. Total time taken is 1 hr and 22 min with a sample data set of (100,000 reads). A standard dataset with multi-million reads will take days to processing. (Exponential Scale)

To ensure that users can utilise other interfaces while waiting for base calling, parallelism or multi-threading is integrated into the UI controls. This allows previously spawned processes to run in the background, freeing up the main thread for UI interaction.

Data Analysis



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Poster Designer: by Kang Zhou
Project Supervisor: Dr. William Kelton
Acknowledgement: Kevin Beijerling, Kyrin Hanning, and Patrick Wightman

References

1. Oxford Nanopore Technologies. (n.d.). Nanoporetech. GitHub. Retrieved December 5, 2024, from https://github.com/nanoporetech
2. Jupyter Development Team. (n.d.). *ipywidgets: Interactive HTML widgets*. Read the Docs. Retrieved December 5, 2024, from https://ipywidgets.readthedocs.io/en/stable/
3. Oxford Nanopore Technologies. (n.d.). *Nanopore sequencing technology*. Retrieved December 5, 2024 from https://nanoporetech.com/platform/technology

THE UNIVERSITY OF WAIKATO
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Te Kura Pūkaha – School of Engineering

Testing Kava 'Washdown' Hepatotoxicity using 'Organ on a Chip' Technology - Pilot Trials

Sosaia Afungia, Joanna Hicks, Martin Atkins & Apo Aporosa

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Introduction

Kava, a traditional Pacific plant and beverage known for its relaxing effects, has been consumed for decades. While traditionally consumed on its own, modern practices often mix kava with alcohol to mask its bitterness. This trend has raised concerns about potential liver damage and hepatotoxicity. This project then aims to determine the effects of kava and alcohol on liver cells butHEK293 kidney cells were used instead of HepG2 liver cells for toxicity testing due to their rapid and robust growth. The findings will support further research using organ-on-chip technology to assess their combined impact more precisely.

Methods

A: Treating Cells with Kava and Ethanol

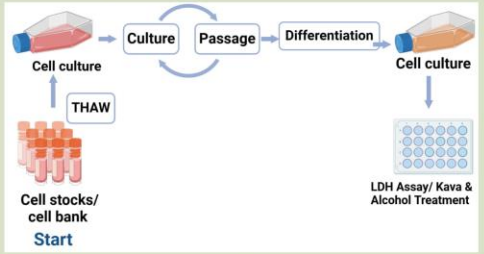

Figure 2: Cell Culture Workflow

B: Lactate Dehydrogenase(LDH) Activity Assay

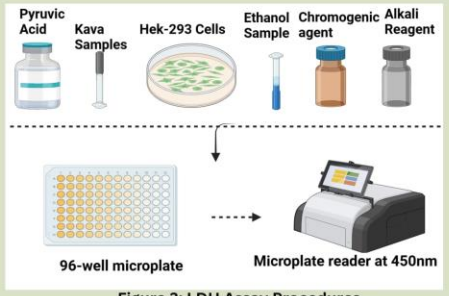

Figure 3: LDH Assay Procedures

Results

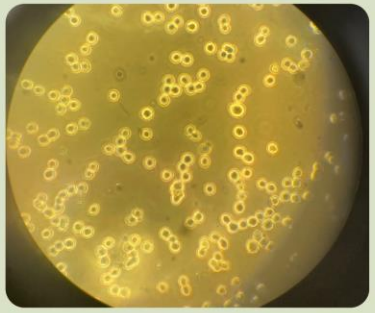

Figure 4: Hek-293 cells under microscope

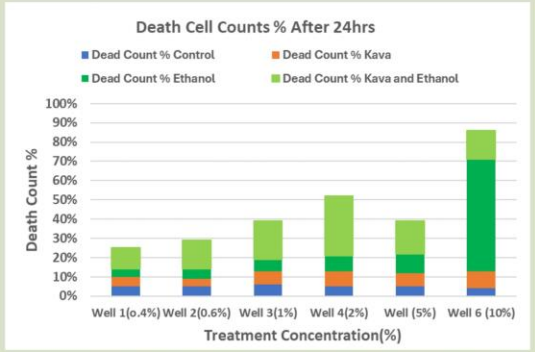

Figure 5: Stacked Column graph for dead cells count % for each treatment after 24hrs

Cell Concetration : 4.80 x 10^6 cells /mL

A: Treating Cells with Kava and Ethanol

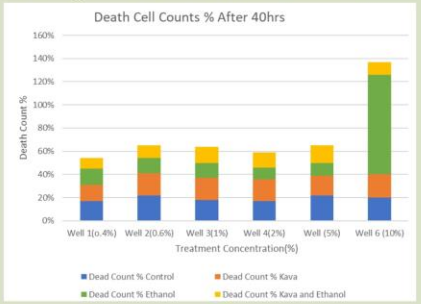

Figure 6: Stacked Column graph for dead cell counts % for each treatment

B: Lactate Dehydrogenase Activity Assay

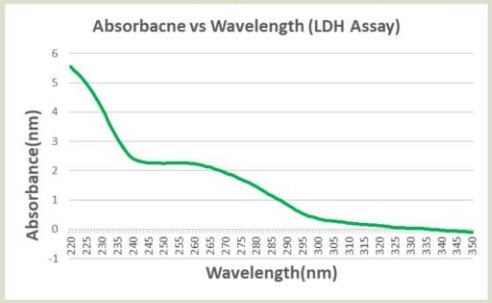

Figure 7: Curve showing the amount of absorbances done by tested samples at different wavelength for LDH assay.

Discussion

- Figure 5& 6: concentration of Kava, specifically ethanol, may have an effect on cell death; mortality increases with concentration. Alcohol, ethanol appears to cause more cell damage than the other treatments that do not have ethanol.
- Figure 7: Protein concentration increases, demonstrated by the peak at 220nm, are associated with increased cell damage due to lysis. The absorbance ratio at 260/280 (~1.53) indicates nucleic acid contamination and requires further refining.

Conclusion

To summarize, it has been generally discovered that alcohol, whether coupled with kava or not, mostly damages Hek293 cells.

- Provides directions
- Future research should focus on the responses between alcohol and kava
- LDH assays should be more accurate by avoid contamination, as well as optimizing methods.

Acknowledgments

My thanks go to the University of Waikato and the Summer Scholarship Program for this opportunity. Thanks to my supervisors, Joanna Hicks, Martin Atkins, and Apo Aporosa, for their help and invaluable advice. Special thanks to the C2 lab's team for their knowledge and pleasant assistance.

THE TREE-D SCANNER

3D RECONSTRUCTION AND MEASUREMENT OF WOODY PLANT FEATURES

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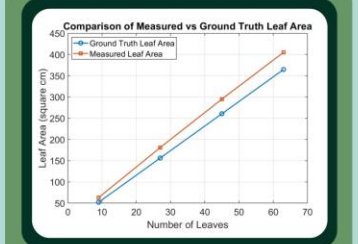
Te Whare Wānanga o Waikato

INTRODUCTION

3D scanning of plants is a growing field that enables researchers to quantify important features of key plant structures like leaves, stems, and branches. The data gained from this has applications in horticulture, where automating what is usually a labour-intensive and destructive task would be very beneficial to the industry. This project takes the novel approach of using Bonsai trees to develop and validate 3D scanning techniques.

AIM

The aim of this project is to develop and test an automated and low cost but high-detail 3D scanner, capable of reproducing plant features with millimetre accuracy. The scanner is used to create accurate 3D models of Bonsai trees. The 3D model is segmented into two categories (stem and leaf) in order to measure physical attributes like leaf area and stem volume.



From the graph above it can be seen that as the number of leaves increases the measured leaf area error also increases. Further investigation into a better meshing algorithm would reduce this error.


Scanning Setup


Captured Image


Mask Preview


Segmented Image


Segmented Model


Combined Model

METHODS

Various methods of scanning plants were compared, including LIDAR and laser scanning. Photogrammetry was selected as the most suitable method for this project. Most low-cost scanners rotate the plant in front of a stationary camera, but this project instead moves a camera around the plant. This has the benefit of eliminating small leaf movements which are common when rotating the plant, and negatively affect capture quality. An aluminium frame with a camera on a motorized arm was designed from scratch and built to capture the images. The images are segmented using a neural network to mask and isolate the desired features. These are processed in Reality Capture to reconstruct the 3D model. Cloud Compare is used to get the various measurements.

RESULTS

The scanner reproduces 3D models accurately. The process is almost fully automated, with minimal user input. The 3D models have densities of more than 600 points per square centimetre of plant surface area. The measured leaf area increases with the number of leaves, but further work on this project should reduce this significantly. The project successfully demonstrates how a low-cost high-detail 3D scanner can be made. The project also shows that using 2D segmentation of images before processing into a 3D model is successful in reproducing 3D models as if they had been segmented directly.

FUTURE WORK

Future work could include looking into segmenting the dense 3D point clouds directly by using a neural network designed for such an application. Improvements could also be made to the camera mounting system such as adding motorized z-axis movement to the camera to fully automate the capture process. Stabilizing the camera may also be of benefit to increase the sharpness of the images.

THE PROCESS

SCAN
↓
SEGMENT
↓
RECONSTRUCT
↓
MEASURE

SCAN ME
VIEW IN 3D!

Design:
Tim Aiken

Supervisors:
Ben McGuinness,
Margaret Barbour

Acknowledgements:
William T. Salter,
Arjina Shrestha,
Colby Butler,
the D.G.12 Team

PneuGrip Fatigue Testing System

Developing a novel fatigue testing system for compliant kiwifruit grippers.

Design
Paulo Baldo

Supervisors
Dr. Ben McGuinness
Dr. Ajit Pal Singh

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Te Whare Wānanga o Waikato

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

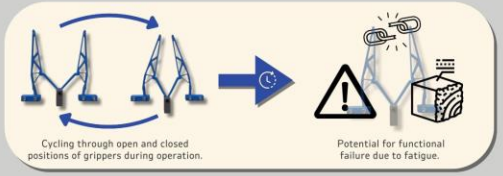
Acknowledgements
University of Waikato Summer Research Scholarship Programme, MBIE, D.G.12 Team

WaiRAS
WAIKATO ROBOTICS, AUTOMATION & SENSING

Introduction

Kiwifruit grippers, based on compliant mechanisms, are being developed to alleviate the manual labour shortages in the New Zealand kiwifruit industry.

Given their cyclic operation, these grippers are subject to fatigue. After cycling so many times, the grippers may reach a point of functional failure where they can no longer grip kiwifruit effectively.



Cycling through open and closed positions of grippers during operation.

Potential for functional failure due to fatigue.

Aim

A testing system that can analyze the fatigue characteristics of this style of gripper does not yet exist. Thus, the aim of this project is to engineer a fatigue testing system that:

- Can test the grippers to determine their functional failure.
- Read and record the force outputs of each gripper finger while a test trial occurs.
- Is capable of testing multiple, and different, kiwifruit gripper prototypes.

Solution

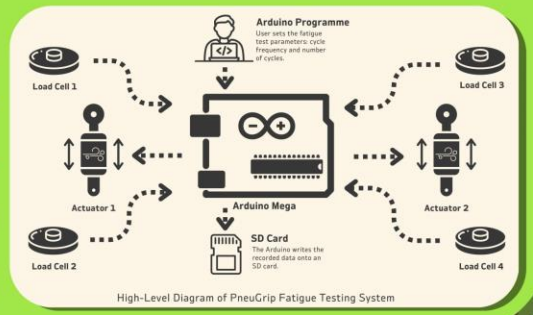
The PneuGrip Fatigue Testing System can meet the aforementioned functional requirements.

Pneumatic piston rod actuators drive the cycling of the compliant grippers.

Each gripper finger is allocated a load cell, enabling independent analysis of the force outputs of each finger.

Aluminium extrusion, a prominent design component, allows for extensive adjustability and modularity of the system.

The PnueGrip system is electronically controlled by an Arduino Mega. Users can programme the Arduino to change the test cycle frequency and number of cycles.



High-Level Diagram of PneuGrip Fatigue Testing System

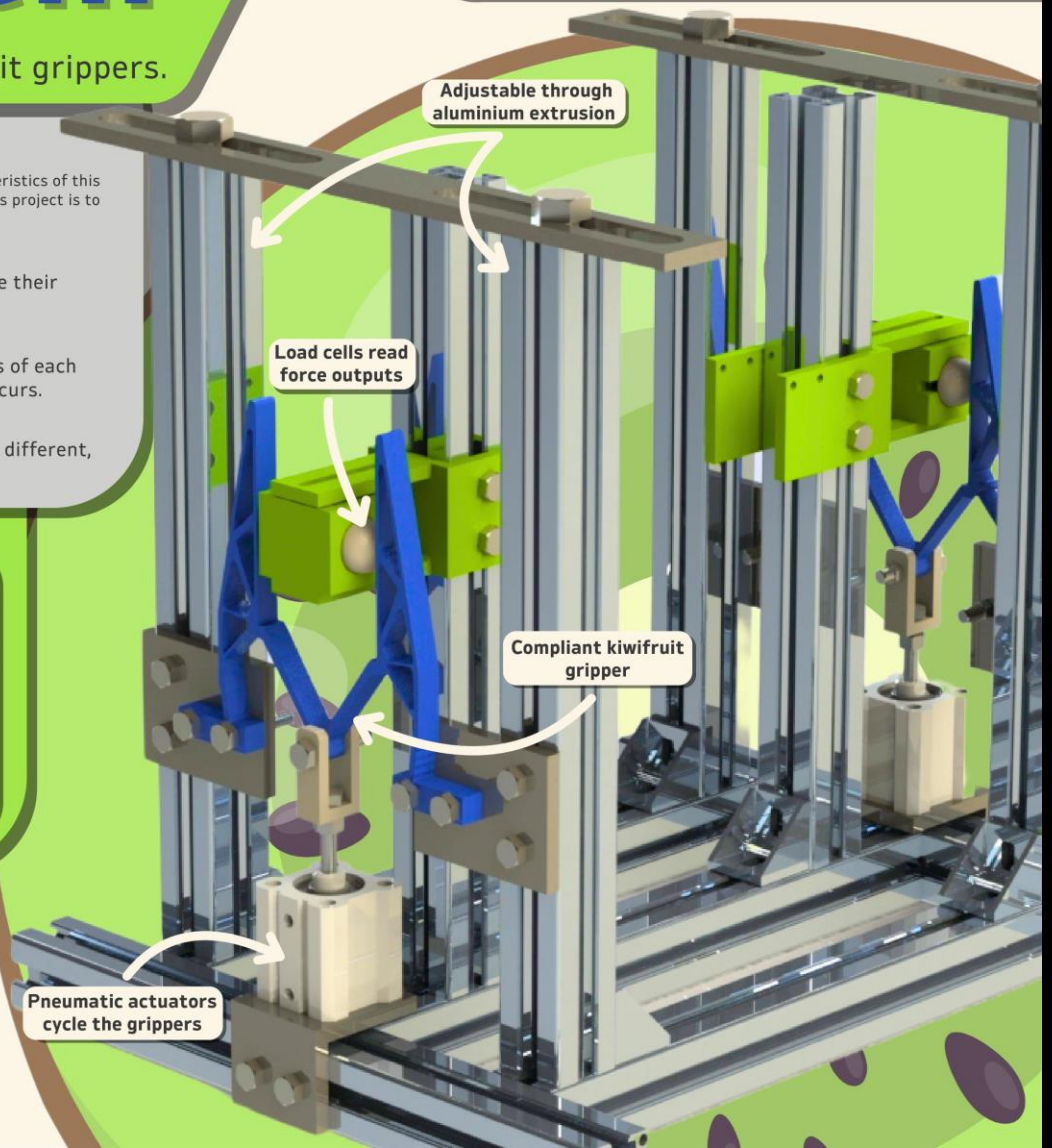
Conclusion

The PneuGrip fatigue testing system is at its final development phase.

The first test trials of kiwifruit grippers are scheduled to take place by the end of the Summer Research Scholarship Programme.

The student's fourth year capstone project will be a continuation of this work, which will see the incorportaion of "smart" elements into the system.

- **Cycle Frequency Range: 0.5 to 1.5Hz**
- **Adjustable and Modular**
- **Arduino Control**



Grasping Greatness: The Future of Kiwifruit Harvesting

Author: Colby Butler

Designing an Autonomous Picking Algorithm to Account for Kiwifruit Clustering

Background

New kiwifruit grippers, designed with compliant mechanisms, require thorough real-world testing to identify any issues or faults not detected during laboratory experiments.

The Project

Given a Universal Robots UR5 robotic arm and an Intel RealSense D435i camera, design and implement an automated kiwifruit picking algorithm.

Requirements

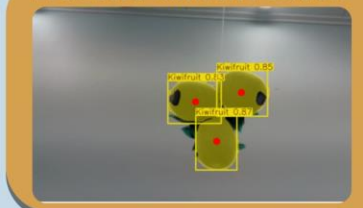
- Avoid colliding with adjacent kiwifruit
- If growing in a closely packed cluster, the algorithm must include smart scheduling to pick the kiwifruit in a favourable order.
- Must be able to work in variable light conditions

1 - Detection

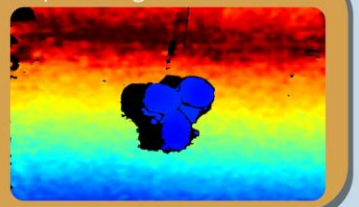
The Intel RealSense D435i camera outputs both colour and depth images, which are synchronised and processed by the algorithm. The color image is analysed using a YOLOv11 CNN trained on ~4,000 kiwifruit, achieving 92% precision and 88.7% recall. The CNN detects the kiwifruit and provides pixel coordinates for depth analysis.

After the YOLO network identifies a fruit, the program retrieves the depth measurement at the corresponding coordinate on the depth image. Using camera intrinsics, such as focal lengths and principal point, it converts the fruit's coordinate into a 3D point relative to the camera.

Predicted Kiwfruit Position



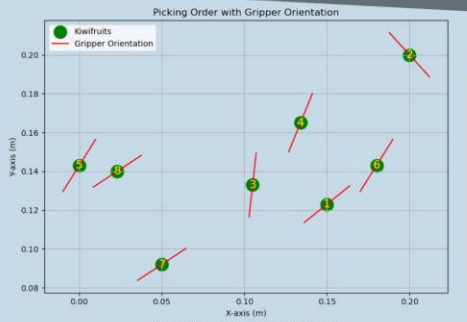
Depth Image

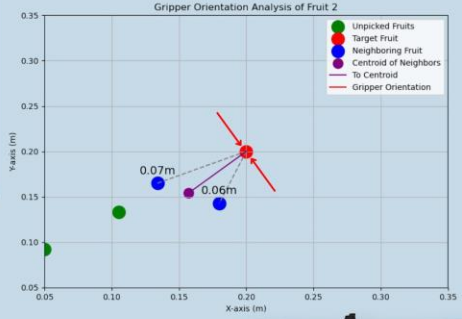


2 - Routing

After detection, the program generates an unsorted list of kiwifruit positions. The fruit are then grouped into clusters based on their proximity to each other, using a distance threshold of 110mm—twice the average kiwifruit diameter, as determined by prior research. This value may be adjusted with further testing.

The algorithm processes kiwifruit clusters sorted from lowest to highest position. For each fruit, it identifies neighbours using the 110mm radius threshold, calculates their centroid, and determines the vector pointing from the kiwifruit to the centroid. The gripper's desired orientation is set perpendicular to this vector around the vertical axis. Once a fruit is picked, it is removed from the list to prevent future operations from considering it as a neighbour.





Future Work

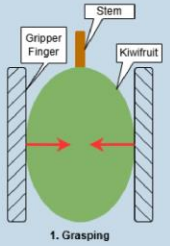
Further testing is needed to refine strategies for handling fruit clusters, such as prioritising fruit farthest from the cluster centroid. Field testing is essential to identify bugs and assess how external factors, like low light affecting the camera or wind impacting reliability, influence the system's performance.

3 - Picking

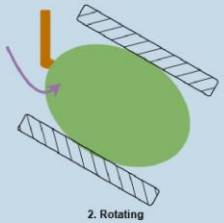
After the algorithm generates a picking order, another program controls the robotic arm to follow a consistent process for each fruit. The arm approaches from below at the desired orientation to avoid damaging nearby fruit. It then grasps the fruit, adjusts the gripper to an optimal angle, rotates around the fruit's centroid, and picks it by pulling downward. The fruit is then deposited into a storage crate.

Picking Process

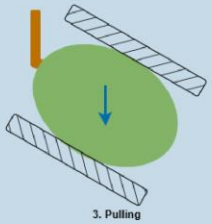
Approach kiwifruit from below and grasp it



Rotate gripper to specified angle



Pull downwards on kiwifruit and pluck from vine



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WaiRAS
WAIKATO ROBOTICS, AUTOMATION & SENSING

Acknowledgements

Research Supervisors - Dr Ben McGuinness, Dr Ajit Pal Singh

Special Thanks to Christoff Venter, Tim Aiken, Hung Le Phan, Paulo Baldo, Eva Prinz and the D.G.12 Team

Engineering solutions for community-centric heritage building preservation

Researcher: Rhyan Dass
Supervisor: Dr. Megan Boston

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Introduction

After the Christchurch earthquake hit in 2011, it significantly impacted New Zealand's cultural and architectural heritage. A large amount of heritage buildings in Christchurch, known for their historical and cultural value, suffered severe damages.

Figure 1 - Christchurch Earthquake damages (Reeves, 2015).

The earthquake revealed vulnerabilities in these heritage buildings which were not designed to withstand seismic forces as structures built using modern engineering techniques.

Methodology

Twenty heritage building cases were selected to be investigated ensuring that there was a diversity of damage and restoration outcomes. With each building case, there was information gathered regarding:

- Timeline data
- Damage information
- Financial considerations
- Information on community influence

Results

After investigating the twenty heritage cases, information was collected and grouped accordingly. An example of the Christchurch Town Hall restoration timeline and restoration outcomes is shown below.

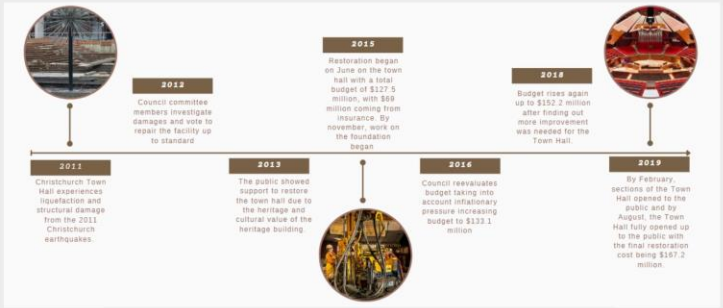


Figure 2 – Christchurch Town Hall restoration timeline

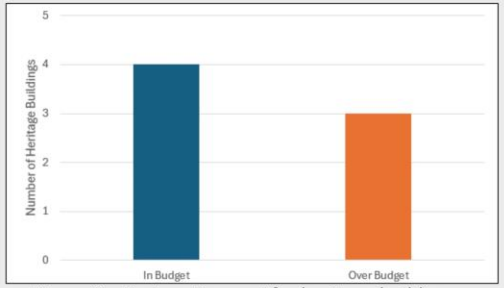


Figure 3 – Restoration cost for heritage buildings

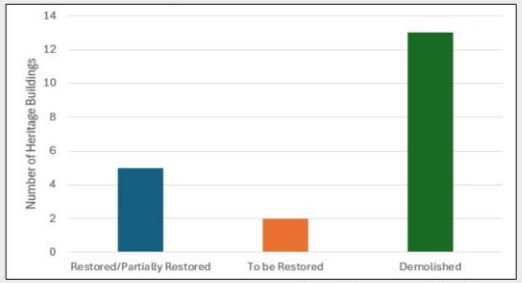


Figure 4 – Restoration outcomes for all heritage buildings

Structural and liquefaction damages were the most common result of damage to the heritage buildings after the earthquake hit. Community involvement played a major role in the consideration of the restoration outcome due to the heritage and cultural value of the buildings.. The Canterbury Earthquake Recovery Authority (CERA) and Christchurch City Council engaged with the public through consultations to gauge community decisions.

Objective

The aim of this research is to investigate several heritage buildings which suffered from the 2011 Christchurch earthquakes by looking into the restoration efforts and decisions which were made for them.

Conclusion

Investigating the heritage buildings provided insight into how the community involvement plays a vital role in the restoration of heritage buildings. Public consultation shaped the restoration timeline and approach, emphasizing the importance of preserving Christchurch's identity.

Acknowledgement

I would like to thank my supervisor, Dr. Megan Boston, for guiding me in this research project

Reference

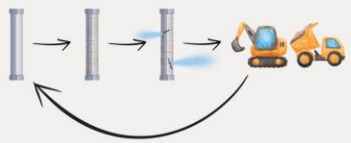
Reeves, P. (2015, April 5) *Will New Zealand Rebuild The Cathedral My Forefather Erected?* NPR. https://www.npr.org/sections/parallels/2015/04/05/397093510/will-new-zealand-rebuild-the-cathedral-my-forefather-erected

QUANTIFYING PIPELINE DEGRADATION

Tauranga City
THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

1 INTRODUCTION

The three waters pipeline network, embedded underground, significantly enhances our daily lives by transporting drinking water, stormwater, and wastewater across Tauranga. These pipes operate unseen but are critical to the city's infrastructure.



Over time, they degrade and will eventually fail without renewal. The rate of degradation depends on the environmental conditions they are exposed to. To manage this, Tauranga City Council (TCC) employs 'Adjustment Factors' to quantify how conditions affect pipe longevity, which aids in renewal scheduling.

2 AIM

The Adjustment Factors currently used by TCC were developed based on rough estimates.

This research aims to investigate how different environmental conditions affect pipeline lifespan, with the goal of creating scientifically supported Adjustment Factors to improve accuracy and reliability.

3 METHODS

- **Literature Review:** Synthesise existing research on factors influencing pipeline degradation across common materials.
- **Failure Data Analysis:** Examine TCC's pipe failure records and CCTV footage to identify trends and patterns.
- **Simulation Testing:** Set up controlled experiments using unused pipes to replicate specific environmental conditions for future validation.

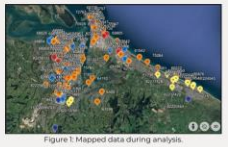


Figure 1: Mapped data during analysis.

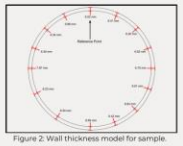


Figure 2: Wall thickness model for sample.

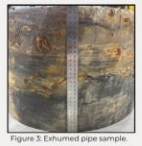


Figure 3: Exhumed pipe sample.

4 RESULTS & DISCUSSION

Key Factors

A review of **52 research articles** identified key factors influencing pipe degradation rates, such as:

- *Elevated pressure*
- *Chemical attacks*
- *Groundwater*
- *Manufacturing defects*

Failure Data

Failure data from TCC was **limited**, restricting data analysis. Data showed that life predictions for pipes unaffected by groundwater were **inaccurate** (Figure 5), while predictions for groundwater-affected pipes were **accurate** (Figure 4).

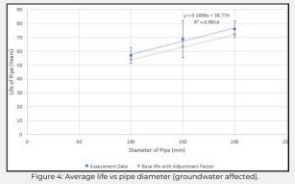


Figure 4: Average life vs pipe diameter (groundwater affected).

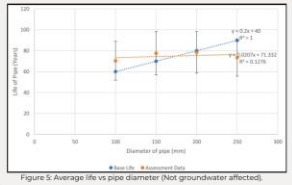


Figure 5: Average life vs pipe diameter (Not groundwater affected).

Discussions with TCC focused on strategies to enhance data collection for more robust data analysis in future projects so more factors can be validated.

Testing setups were established to simulate Tauranga conditions, facilitating future investigations into pipe degradation. A testing methodology was developed to ensure consistency, enabling the use of these tests to create accurate adjustment factors for TCC.

5 FUTURE RESEARCH

- Data analysis should be carried out once additional failure data is collected by TCC.
- Test the pipes involved in the simulation setups after allowing it to degrade for a significant amount of time.
- Set up more complex tests to investigate additional factors e.g. pressure.

Read More

Research By: Darryl De Jong

Supervisors: Dr. Kim de Graaf & Dr. Chanelle Gavin

Acknowledgements: Willem van Blerk, Stephen Wright, University of Waikato Summer Research Scholarship, Tauranga City Council

INTRA-CDI-CELL PH ANALYSIS

RESEARCHER: DAVID DICKSON
SUPERVISOR: PETER KOVALSKY
ACKNOWLEDGEMENTS:
MATHAVAN THARMAN
MARKO ALEKSIC

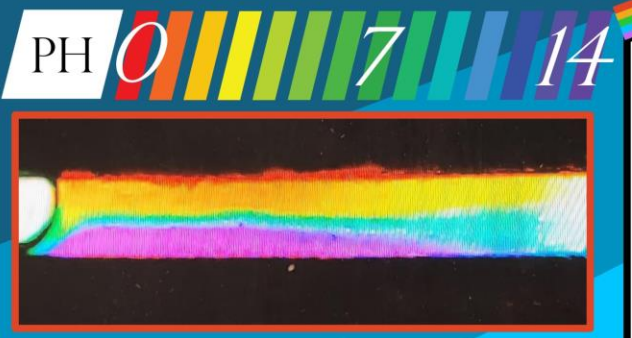
THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

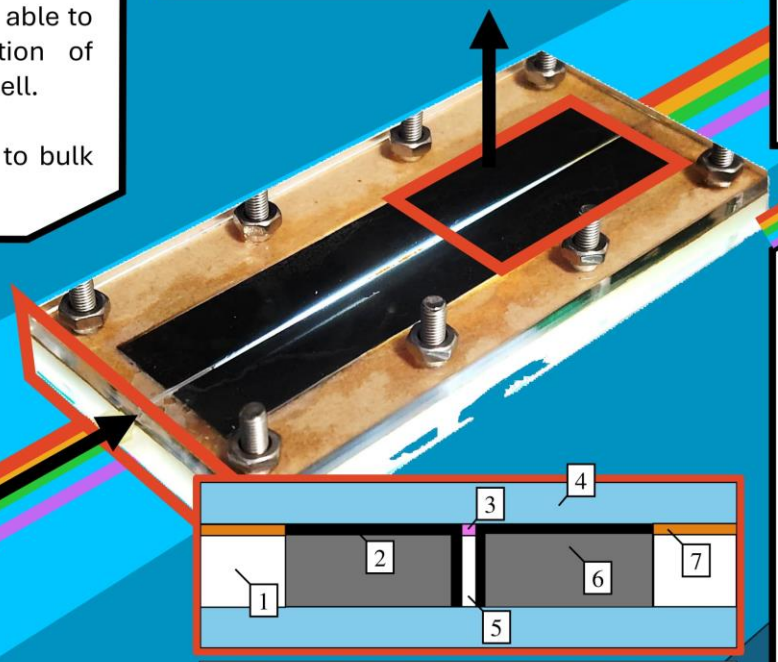
Motivation For Research

Capacitive De-Ionisation (CDI) technology is promising for water desalination as it is cheaper and more energy efficient than current alternatives such as reverse osmosis.

To better understand the chemical mechanisms such as ion-transport and faradaic reactions, it is desirable to be able to analyse the precise in situ evolution of properties like pH across a single CDI cell.

Existing analysis methods are limited to bulk inlet and outlet measurements.





Legend
1.Filament Printed Bracket 2.Activated Carbon Membrane 3.Electrolyte Flow Channel 4.Transparent Acrylic 5.PET Plastic Spacer 6.Graphite Electrode 7.Gasket Card

Analysis

Image and video captured by a microscope camera is colour analysed. The extracted Hue from the HSV colour space lets us correlate the UI dye colour to the corresponding pH. This measures a distinct pH gradient across the CDI cell.

The details of the gradient like the width and shape of each band can be compared to a COMSOL model which aims to simulate and characterise the same chemical mechanisms physically observed within the CDI cell.

Construction And Design

The construction of a normal CDI stack disallows observation between cells. The construction of the new experimental cell (left) allows illumination and observation of pH Universal Indicator (UI) dye.

Diffused LED light shines up through the acrylic and PET spacer to illuminate the UI dye. And a microscope camera observes from above

The electrolyte and dye solution is injected by syringe and needle. This gives control for stationary, steady flow, or flushing regimes.

The precise 0.5mm width of the flow channel required precision manufacturing equipment such as a CNC and filament 3D printer.

Towards Sustainable 3D-Printed Building Structures

Introduction

Designing structural building walls for disassembly, made from recyclable plastics, supports a circular economy model (reuse, repair, recycle). Manufacturing the wall modules through 3D printing enables design flexibility, additive manufacturing and minimising waste.

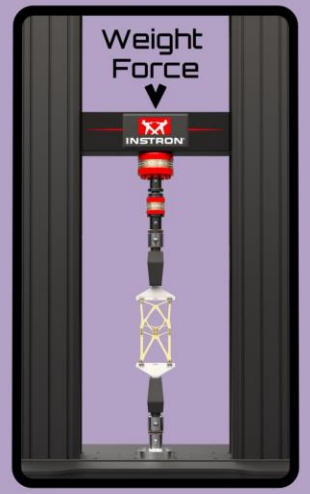
Finite element analysis (FEA) is used to optimise the shape and mass of the modules for load cases based on the building code, and to analyse their performance (centre of poster). However, physical testing is required to verify these findings.

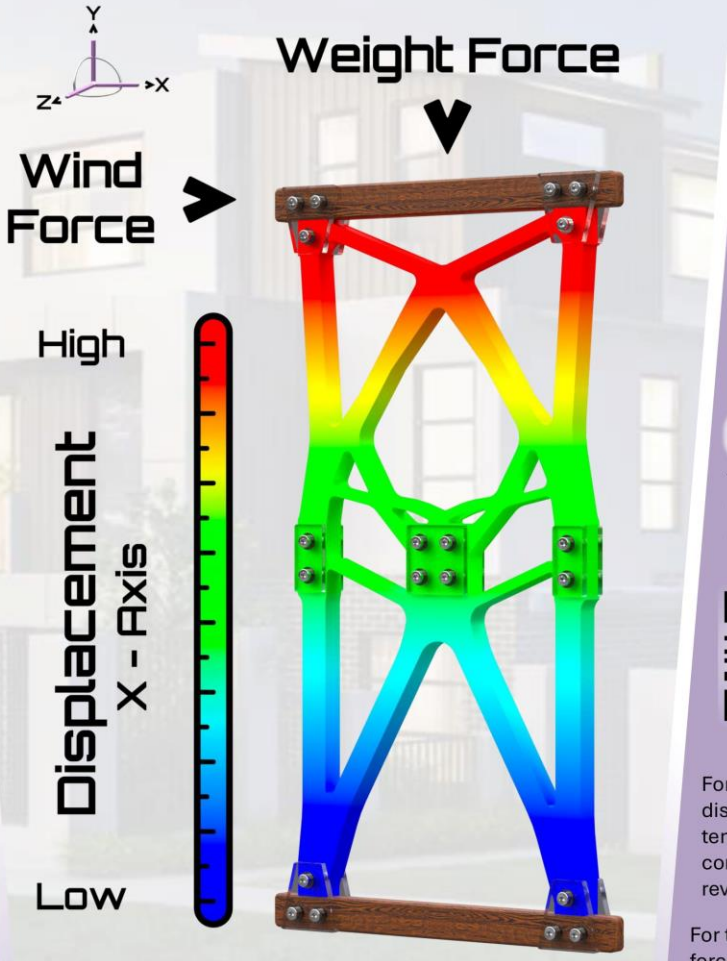
Aim

The aim of the project is to prototype test benches that simulate the wind and weight force load cases of buildings separately and measuring the displacement and force of the modules to inform the FEA models.

Test Design

The test benches, made from mild steel (highlighted in white) are designed around the Instron mechanical testing machine, with negligible deflection under load, utilising the existing tools and mounting points, and providing a way to bolt to the modules.





Āmiomio Aotearoa

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Researched by: Nathan Dinan
Supervised by: Christian Gauss and William Allouche
Acknowledgements to: Ethan O'Donnell and The University of Waikato Summer Research Programme

Test Method

Three sets of 3D-printed PLA modules (top and bottom) are tested for each experiment. These modules are assembled and bolted to the test bench, with all bolts tightened to 2 Nm. A load is applied at a constant crosshead speed until failure, with displacement and force being measured throughout the tests.

Results

The results of the tests are summarised in the table below. Curious about the results? Scan the QR code to watch the tests in action!

Load Case	Displacement (mm)	Force (kN)
Wind Force Load Case (Yield Point)	6 (Load Direction)	1.1
Weight Force Load Case (Failure)	9 (Buckling Direction)	4.2

For the wind force load case, the structure yielded at **1.1 kN**, displacing **6 mm** in the direction of the load before fracturing in tension at the bottom left bolt connection. The failure at this connection indicates that the bottom connections should be revised to strengthen the structure.

For the weight force load case, the structure buckled at a peak force of **4.2 kN**, displacing **9 mm** in the direction of buckling where it fractured and delaminated at the bottom module indents. This suggests the indents allowed for controlled failure.

Conclusion

In conclusion, the prototypes effectively transferred the load to the modules, where the test results revealed weak points in the module design and performance, providing valuable insights to help improve both the design and the accuracy of the FEA models, aligning them more closely with the physical results.

CHANGING LANDSCAPES, CHANGING WATERS?

THE UNIVERSITY OF WAIKATO

INTRODUCTION

*Land development transforms landscapes, but what happens beneath the surface? As **Tauranga** expands, once-porous volcanic soils are compacted, altering natural water movement. This research investigates how **urbanization** affects the hydrological cycle—particularly **infiltration** and **runoff**—helping to shape smarter stormwater management strategies for the region.*

AIM

*This project seeks to quantify the **hydrological impact** of land development by tracking changes in groundwater levels and surface runoff as farmland transitions to urban areas. By installing **Levellogger** sensors and a custom-designed **weir**, the project aims to observe how Tauranga's volcanic soils respond to increasing impermeable surfaces over time.*

METHOD

To capture the evolving water cycle, the project uses the following:

- ***Rain gauges** to determine the amount of minor losses due to interception from plant and tree leaves.*
- *A **Levellogger** sensor to track underground water table fluctuations on a daily basis to create a large dataset.*
- *A **sharp-crested weir** to measure runoff that collects in a local catchment.*
- ***Chicago Design Storm** methodology to design for extreme rainfall scenarios.*
- ***HEC-HMS modelling** to simulate water flow patterns and create theoretical estimates.*

(The weir's optimal dimensions were determined using peak discharge calculations from HEC-HMS, ensuring accurate runoff measurement throughout the study)

Fig. 1: Rain Gauge

Fig. 2: Parau Rd. Research Site

RESULTS

These findings set the foundation for long-term monitoring and future stormwater policy updates.

- *The **5-year storm** event model of the site predicts a peak discharge of 0.857 m^3/s.*
- ***Site contour mapping** identified three sub-basins contributing runoff to the monitored gully.*
- *A **weir** with a **1.8m x 0.2m** opening and a **120° V-notch** was designed out of timber and street signs, ensuring precise low-flow measurement while having capacity for storm events.*
- *A **hand auger** method was chosen over CPT drilling for cost-effective groundwater monitoring sensor placement.*

Fig 3: Chicago Design Storm Hyetograph (Tauranga)

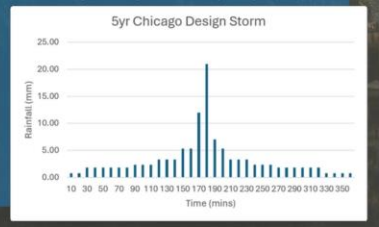


Fig 4: Parau Rd. Site Discharge from Design Storm

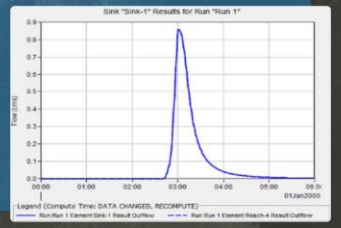
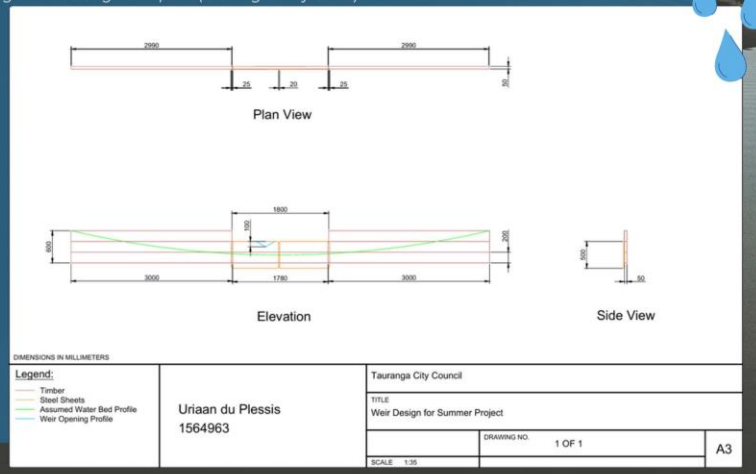


Fig 5: Weir Design Blueprint (3rd Angle Projection)



DISCUSSION

*Previous studies suggest Tauranga's soils have higher sensitivity to compaction. The compaction process reduces **infiltration** and increases **surface runoff**. As land development on the site progresses, a shift in the infiltration-runoff balance is anticipated, influencing **flood risk** and **groundwater recharge**. Long-term monitoring will reveal whether current mitigation strategies—such as retention ponds and permeable surfaces—are effective in maintaining pre-development hydrological conditions.*

CONCLUSION

*Urban expansion is inevitable, but its hydrological impact doesn't have to be. This research will provide **critical data** to guide Tauranga City Council in developing tailored stormwater management strategies that reflect the **unique permeability** of the local soils. By bridging science and policy, a resilient, flood-resistant future for the region can be ensured.*

NEXT STEPS

*Over the next **five years**, this study will track how land development impacts Tauranga's hydrology.*

- ***Data Collection:** Once installed, the Levellogger will begin monitoring groundwater, while the weir records runoff flow during rainfall. Periodic field surveys will document soil changes.*
- ***Analysis & Trends:** Comparing pre- and post-development data will reveal shifts in infiltration and runoff. HEC-HMS models will be refined to improve stormwater predictions.*
- ***Final Comparison:** Observed data will be tested against theoretical predictions—was peak discharge accurate? How much permeability was lost? Were stormwater controls effective?*
- ***Policy Impact:** Findings will guide Tauranga City Council in updating stormwater strategies, ensuring sustainable urban development.*

ACKNOWLEDGEMENTS

***Design:** Uriaan du Plessis*
***Supervisors:** Bodo Hellberg & Mark Lay*
***Acknowledgements:** Tauranga City Council, Niel Blazey, Marlene Herewini*

Tauranga City

Decoding Minds

Using Deep Learning to Classify Brain Signals from EEG Data

Student: Simeon Ensing

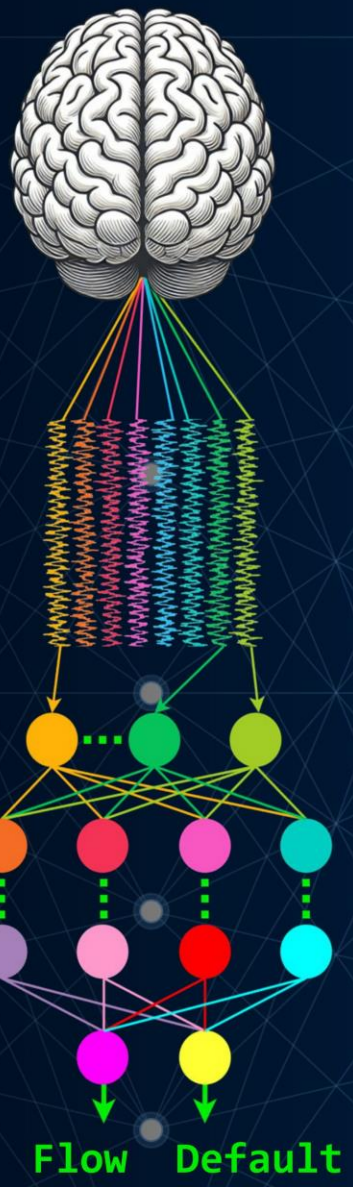
Supervisors: Dr. Mitchell Head, Dr. Anany Dwivedi

Background:

Brains produce electrical signals. We think it is possible to use deep learning to distinguish between different cognitive states by analysing this electrical activity.

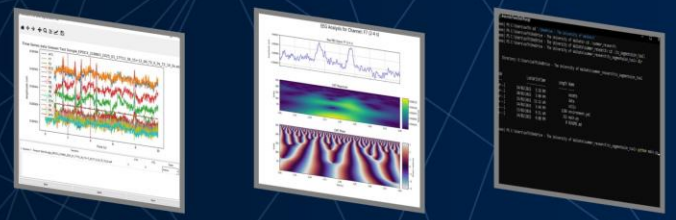
Methods:

EEG data from a driving simulator task are preprocessed by bandpass filtering, ICA artifact removal, segmentation, and wavelet transformation to extract features. These features train a deep learning classifier to differentiate between various cognitive states, while explainable AI highlights the most influential features.



Results:

We have developed two software tools for the project pipeline: a data labelling and segmentation tool and a feature extraction tool. The output from the first tool serves as the input for the second whose output will be used for machine learning.



Labelling --> Extraction --> ML

Conclusion:

The software tools created in this project streamline the data pipeline, enabling efficient processing and feature extraction for future machine learning applications. We hope that using artificial intelligence to differentiate between cognitive states will be useful for both medical and sport applications.

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ROYAL SOCIETY TE APĀRANGI
Au Reikura | School of Computing & Mathematical Sciences
MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Characterisation of New Biometallic Materials

By Brooklyn Gilbert
Supervised by Dr. Leandro Bolzoni

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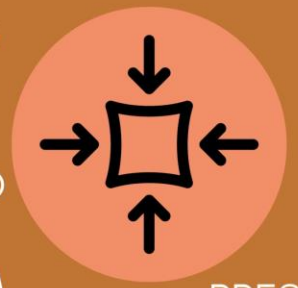
STEPS TO MAKE AN ALLOY

MIX



PRESS

SINTER

CHARACTERIZE

INTRODUCTION

While medical technology has made significant strides, the chase for ideal implant material that combines strength, affordability, and infection resistance continues. This project focuses on developing novel titanium-based biomaterials to address biological incompatibility.

By advancing techniques to stabilize critical phases and optimize mechanical properties, this research has the potential to enhance the quality of implants like hip and knee replacements and make a difference in the material engineering and biomedical field.

METHOD

The alloy titanium alloy is created by mixing powders, compacting them under heat, and sintering in a vacuum furnace. The finished material is studied to assess its structure, strength, and suitability for medical use. This includes analyzing its microstructure, testing its hardness and strength, analysing its corrosive and biological behaviour and interpreting the results to understand how it performs.

PROJECT EXPERIENCE TO DATE

The focus of the project started with designing the new alloy composition, mixing the elemental powders, and pressing them using a warm compaction technique. However, due to the sintering furnace being out of order, the focus shifted. I then assisted with experiments on other samples in my department, contributing to completion of their projects while continuing to gather data. Tasks included performing electrochemical testing, preparing materials for mechanical and biological testing, and reviewing literature from the materials space. Although my project has not yet produced its own results, I've been able to work through all the procedures I would have used if the sintering furnace had been operational, expanding my understanding of the research process, enhancing technical skills, and reinforcing the importance of flexibility and collaboration in research.

CONCLUSIONS

The expected outcome was the development of an alloy with enhanced properties, which remains to be fully researched. Thus, these outcomes have not yet been realized. However, ongoing tasks have demonstrated continued progress, and the research remains active, with a clear path forward for completion.

Processing recycled cardboard fibre into sustainable cellulose foams

Scholar: Jordan Hazlehurst
Supervisors: Dr. Mohammad Dalour Beg & Dr. Christian Gauss

Introduction

Protecting fragile items during transport is a key part of packaging design. Packaging materials need to be lightweight, cushion well, and ideally resist moisture for extra protection.

Most packaging today is made from extruded polystyrene (EPS) *(1)*, a plastic derived from petroleum. Unfortunately, millions of tons of EPS end up in landfills every year, taking decades to break down. It's also a common water pollutant, harming both people and wildlife. This shows how important it is to find packaging materials that are both sustainable and biodegradable.

Cellulose, a natural material found in plants, is a promising solution. In plants, it forms tiny fibres (called microfibrils) supported by other components like lignin. By carefully treating cellulose, these fibrils can be separated via fibrillation and interlocked through hydrogen bonding, creating a strong, durable material perfect for packaging.

Aim

This project aims to create sustainable packaging foam from recycled paper, reinforced with Harakeke fibres, using eco-friendly methods. Additives like surfactants, binders, and crosslinkers will enhance the material's water resistance. The research focuses on optimizing fibrillation techniques to get the most fibrillation without compromising the strength of the fibres which will lead on to a stronger foam in the next stages.

Method

15 combinations of number of passes through a Supermasscolloider (1-5) and plate gap (200, 100, 50 µm) were tested on recycled paper pulp, kraft pulp and bleached paper.

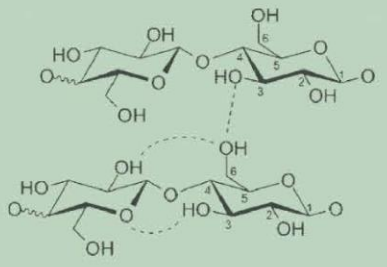
Using microscopy, SEM, a fibre quality analyzer, dynamic sheet forming and Canadian standard freeness test, those with the highest degree of fibrillation were selected for the foaming stage.

Scan here for more details!

Discussion/Results

After the pulp refinement, it appears that at 100 µm, passes 3-5 display similar amounts of high fibrillation. At 50 µm, a similar effect was seen, as passes 3-5 show similar fibrillation degrees to both each other and the 100 µm passes. This suggests that for the next stage of experiment, we are able to use 100 µm to get the desired effect, saving both time and energy.

Cellulose



Pictured above is a cellulose chain, depicting hydrogen bonding between them- this is the type of bonding which occurs between microfibrils during the foaming step.

Future plans

The next steps of this experiment are:

- Using the optimal refinement conditions on both Kraft virgin pulp,and bleached pulp.
- With the fibrillated fibres, a **cellulose foam** *(2)* will be synthesized, using a mix of surfactants, cellulose fibres and harakeke fibres.
- These foams will also use cellulose nanofibre/alkyl ketene dimer (CNF/AKD) Pickering emulsions to coat pulp microfibres to create a reinforced, low-energy interface *(3)*.

This will hopefully enable scalable production of lightweight, water-resistant, and biodegradable cellulose foams through simple oven drying, without requiring harmful cross-linking chemicals.

Acknowledgements

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GRANT_NUMBER: UOW2432

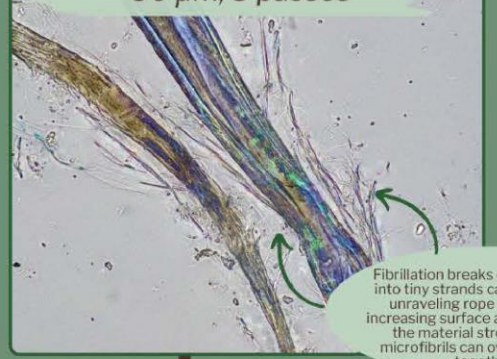
Thank you to Jing Xu, Katty De Visser and Dr Kelly Wade for their help with this project.

References

(1) Jahirul, M.I.; Rasul, M. G.; Schaller, D.; Khan, M.M.K.; Hasan, M.M.; Hazrat, M.A. Transport fuel from waste plastics pyrolysis – A review on technologies, challenges and opportunities. Energy Convers. Manage. **2022**, 258. DOI: 10.1016/j.enconman.2022.115451.
(2) Ferreira, E. S.; Dobrzanski, E.; Tiwary, P.; Agrawal, P.; Chen, R.; Cranston, E.D. Insulative wood materials templated by wet foams. Mater. Adv., 2023, 4, 641-650. DOI: 10.1039/D2MA00852A
(3) Sun, L.; Lu, J.; Chen, X.; Zhao, H.; Liu, L.; Yao, J. Cellulose nanofibre powered interface engineering strategy to manufacture mechanically stable, moldable, recyclable, and biodegradable cellulose foam. J. Chem. Eng. **2024**, 498. DOI: 10.1016/j.cej.2024.155155

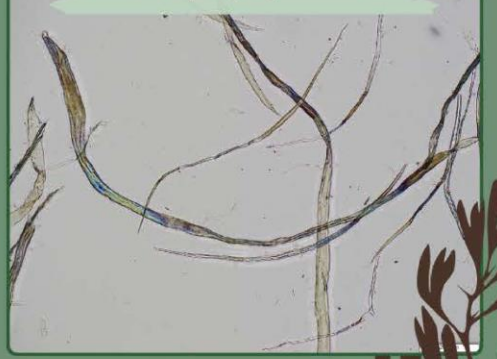
Control Sample

50 µm, 3 passes



100 µm, 4 passes

200 µm, 4 passes



Fibrillation breaks cellulose fibres into tiny strands called fibrils, like unraveling rope into threads, increasing surface area and making the material stronger as the microfibrils can overlap and net together!

Use of forestry waste biochar as an additive in New Zealand concrete mixes

Poster by Hyun-Min Kim. Supervised by Dr. Ray Hudd. Partnership with SCION Research.

Introduction & Objective

During Cyclone Gabrielle, undisposed slash, or forestry waste from harvesting, exacerbated infrastructure damage in the Tairāwhiti and Hawke's Bay regions when it washed downhill, and then downstream in flooded rivers. A potential solution for slash management is making biochar from slash via pyrolysis, and using it in concrete mixes; with previous studies **[2] [3]** showing an increased compressive strength performance of mixes with biochar than without. Considering the construction industry contributes 9.4% of CO_2 emissions in New Zealand **[4]**, and concrete production contributing 9% globally **[5]**, biochar could be a partial replacement of cement in concrete mixes, for reducing cement usage and emissions in construction.

The objective of this study is to determine the optimum % of biochar replacing cement powder in a mortar mix, and the optimum grind time biochar must be ground for.

Methodology

- Preparation: Oven dry sand and grind 5 biochar samples with a range of 1-5 minutes to determine if finer biochar influences compressive strength (refer to QR Code graph)
- Mix Design: Use a 1:2.75 sand:cement ratio, and 1:0.6 water:cement ratio. Refer to the table on the right.
- Weigh and mix dry ingredients (sand, cement powder, biochar) until there are no unmixed spots. Then weigh and mix water until the mortar turns cohesive and viscous.
- Compact 6 cubes into moulds & dry for 1 day. Then remove, label, and place into water to moist cure with 2 cubes per curing time (7 days, 7 days moist & 21 days air cure, 28 days). Repeat the 3rd and 4th steps for each mix with a different grind time and %.
- Test for compressive strength using a compression machine, and take the average of the two cubes. Repeat.

Biochar %	0%	1%	2%	3%	4%
Cement (g)	400	396	392	388	384
Biochar (g)	0	4	8	12	16
Sand (g)	1100				
Water (mL)	240				

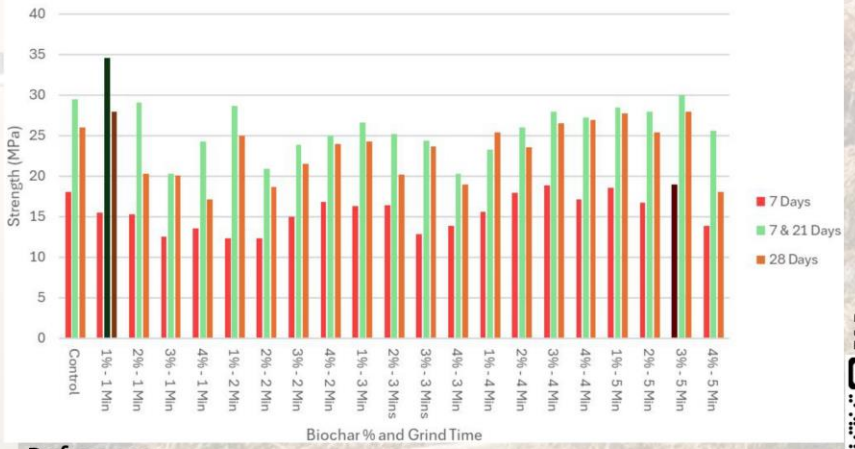
Results

Using the graph shown (right), compared to the control (18.037MPa), biochar grinded for 5 minutes replacing 3% of cement resulted in a 5% increase in compressive strength (18.933MPa) for 7-day, while for 7-21 and 28 days, biochar grinded for 1 minute replacing 1% of cement resulted in a 7% (27.94MPa) and 17.6% (34.624) increase compared to control (26.03 and 29.434MPa respectively).

Air curing resulted in the highest compressive strength than moist curing, because biochar reduces concrete porosity, increasing its density. Results also showed no determinable relationship between biochar % and compressive strength due to the lack of any repeating pattern throughout the different mixes. Similarly, there is a very small correlation between grind time and compressive strength, as compressive strength continues decreasing as grind time increases from the 1 minute grind mixes to 3 minute mixes, but increases from 4 minutes onwards.

Because two grind times and %'s were considered optimum, because of variability in cube making, such as errors e.g. instrumental error with scales, variable cube density based on compaction, and the change in compaction method from vibration to manual midway. Also some mixes had strengths outside an acceptable range, with a large difference between the two cubes. Because of this, the optimum grind time and % for the best performing mix can't be determined, which is why a repeat of this experiment with a 1:2.25 sand:cement ratio, a 1:0.55 water:cement ratio, and manual compaction throughout, is currently ongoing.

Graph showing Average Compressive Strength for Mortar Cubes with different Biochar %, Grind Times, and Curing Times



Conclusion

Replacing a % of cement with grinded biochar resulted in a 5%, 7%, and 17.6% increase of compressive strength for cubes with their respective curing times compared to without biochar added, potentially being feasible for concrete mixes. However, because of factors causing a difference in strength values outside of an acceptable range, and because the optimum % and grind time cannot be confidently determined, a repeat of methodology is currently ongoing with different adjustments to the mix design and methods to produce the cubes for testing.

References

1. Buckland, W. (2023). *The Redclyffe bridge, destroyed in Cyclone Gabrielle, pictured in February with wood debris piled against it*. Hawkes Bay Today.
2. Wazir, P. (2024). *The effect of biochar as a partial replacement of cement in cement mortar mixture and its mechanical properties.* University of Waikato.
3. Wynne-Jones, D. (2024). *Use of Forestry Waste Biochar in Concrete.* University of Waikato.
4. Construction Accord. (2022, August 11). *Construction Sector Transformation Plan 2022-2025.* Ministry of Business, Innovation, and Employment, New Zealand Government.
5. Scientific American. (2023, February 1). *Solving Cement's Massive Carbon Problem*. Written by Fischetti, M., Bockelman, N. & Srubar, W.V.

Link to QR Code to see all values recorded during testing, and biochar particle size distributions.

THE UNIVERSITY OF WAIKATO Te Whare Wānanga o Waikato

SCION FORESTS + PRODUCTS + INNOVATION

Flexibility: the Future of the Electricity Market.

AHUORA
CENTRE FOR SMART ENERGY SYSTEMS

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Background

New Zealand's electricity market faces increasingly volatile spot prices[1] and uncertain supply[2] as measures are taken to reduce emissions;

- **Electrification** of process heat decarbonises industry but **increases demand**[3].
- Expansion of **solar and wind**, both intermittent generators, is increasing **uncertainty in supply.**

Demand response (DR) is one way of achieving the **flexibility** needed to bring balance to the changing market.

Demand Response is a reduction or shift in electricity demand, in reaction to changing price or supply.

Industry has significant potential to provide this flexibility, with process heat using ⅓ of New Zealand's total energy[4]. As of January 2025 only two companies had DR arrangements[5].

The **aim** of this research is to understand the factors influencing industry participation in demand response.

Methods

Assessed the current framework and Transpower's guidelines for DR in New Zealand.

Investigated past and current industrial DR arrangements in New Zealand.

Developed a model to calculate potential savings from DR.

References:

1. Electricity Authority. (2024, September 16). *What was behind high wholesale electricity prices.* https://www.ea.govt.nz/news/eye-on-electricity/what-was-behind-high-wholesale-electricity-prices/

2. Williams, B., & Bishop, D. (2024). Flexible futures: The potential for electrical energy demand response in New Zealand. *Energy Policy*. Volume 195. https://doi.org/10.1016/j.enpol.2024.114387.

3. Electricity Authority. (2025, January 16). *Powering the Future.* https://www.ea.govt.nz/about-us/what-we-do/powering-the-future/

4. Ministry of Business, Innovation and Employment. (2025, January 16). *Decarbonising process heat.* https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/low-emissions-economy/decarbonising-process-heat

5. Major Electricity Users' Group. (2023, November 2). *Advancing New Zealand's Energy Transition.*

Results

Transpower's guidelines cover what is required for participation in DR to be practically feasible; a compatible dispatch capable load station, and that loads larger than 10MW must have real-time indications and communications.

What has worked so far?

Sites currently participating in DR share key attributes:

- **Predictability** in demand patterns for real-time operation and response.
- **Controllability** allowing demand to flexibly adapt to changing prices.

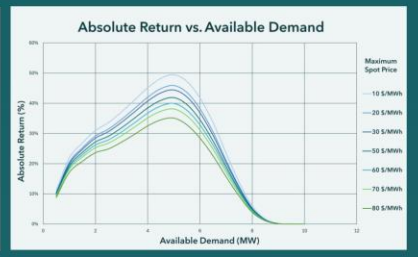
What has limited participation?

Many industries find that the costs of participating outweigh the benefit of avoiding high prices. These costs include:

- The initial capital investment to connect.
- Long shut-down and start-up periods preventing a timely response to price.
- Reliance on electricity for essential operations and safety.

Modelling Absolute Return

The model calculates savings as absolute return, for a range of demand response scenarios. Each scenario has a quantity of available demand (to be reduced by) and maximum spot price (above which demand is reduced). The model uses site demand data and the spot prices from corresponding trading periods.



These charts show the absolute return calculated using demand data from real sites. These results can be used to determine:

- If a site is capable of a demand reduction that would yield a significant return.
- The optimal spot price at which demand should be reduced.

Conclusions

- Industry's low level of participation cannot be attributed to the unobstructive regulations. Instead, the **main factor dissuading participation** is the **cost and disruption** involved.

The **next step** is to incentivise industry participation by:

- Building on tools, like the model developed in this research, which help demonstrate the benefits of participation to industry.
- Prioritising outreach to industrial sites with operations that already accommodate DR.

Poster by Jordyn Marriott, Supervised by Martin Atkins

Phase Transformation of Titanium Alloys

Presenter: Alex Sorensen
Supervisors: Dr Ajit Pal Singh, Rajkumar Das

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

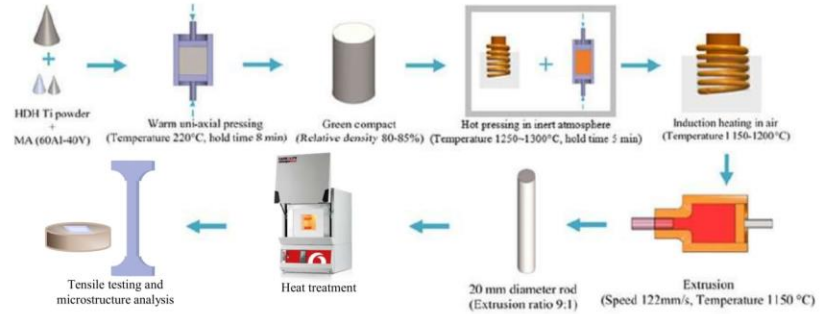
Introduction

Titanium's unique combination of strength, low density, and corrosion resistance makes it a critical material across a range of different industries, including aerospace, biomedical and automotive sectors.

Aim

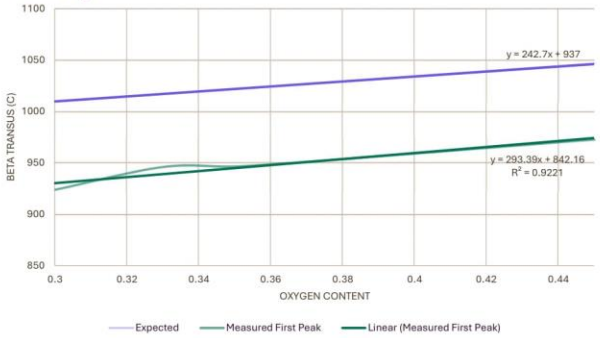
Investigate the relationship between oxygen content and the solid-state transition temperature in powder-produced Ti-6Al-4V alloy and develop heat treatments to optimise microstructure for improved ductility.

Method

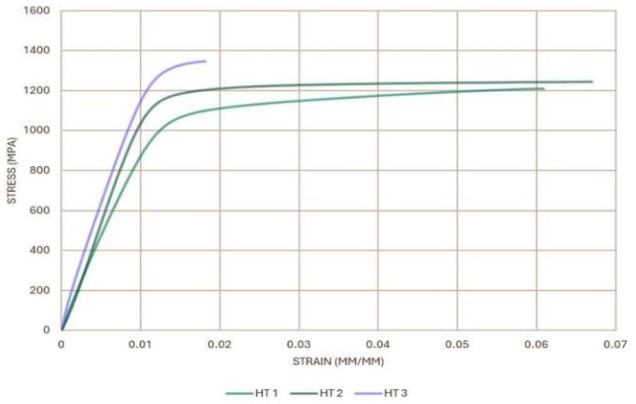


Effect of Oxygen

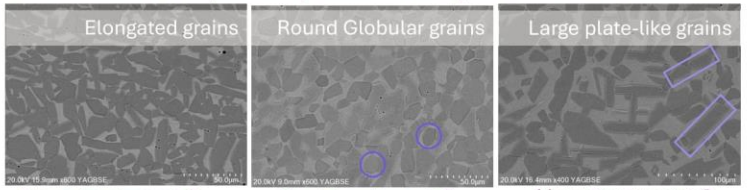
Oxygen is known to linearly increase the temperature at which titanium undergoes a solid-state phase transformation (Beta Transus Temperature). Differential scanning calorimetry (DSC) investigation proved that this holds true for the samples made from powder in this study.



Effect of Heat Treatments



Microstructure of powder produced samples after heat treatment



Heat treatment 1 | Heat treatment 2 | Heat treatment 3

Discussion

To increase ductility, an equiaxed grain structure is ideal, as it promotes uniform plastic deformation. This is exemplified by Heat Treatment 2, which exhibits the most equiaxed microstructure and achieves the highest elongation (6.7%). In contrast, Heat Treatment 3 exhibits elongated grains, resulting in the highest ultimate tensile strength (1346 MPa) but at the expense of ductility, achieving only 1.8% elongation. Heat Treatment 1, however, exhibited inferior properties compared to Treatment 2 and 3, with lower strength and elongation.

T-Lab: Virtual Platform for NZ Engineering Training and Education

Kimi Wang | Supervisors: Arthur Fang, James Lim

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

1 Background and Challenges

The Importance of Engineering to New Zealand's Economy:

Engineering contributes **6.3%** to New Zealand's **GDP** in 2023;
Employs over **250,000** people.
Faces a **shortage of 4,000** engineers annually.

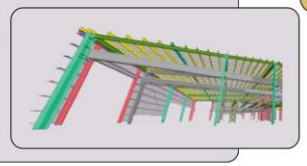
6.3% **250,000** **4,000**

Limitations of Traditional Education:

1. Despite a NZD 1.2 billion education market,
2. Students struggle to connect theory with practice, leading to skill gaps.

Global Trends:

The global VR/AR market in education is expected to reach NZD 12 billion by 2027, positioning VR/AR as a key tool for achieving Education 4.0 goals.



The Importance of Engineering to New Zealand's Economy:

Theoretical Foundation:

- VR/AR enhances memory retention through hands-on, interactive modules. The platform fosters knowledge sharing through collaborative virtual environments.

Key Modules:

- **Structural Visualization:** Dynamic understanding of complex concepts.
- **Construction Training Simulation:** Safe, risk-free practical skill-building.
- **Fire Escape Training:** Realistic emergency scenarios for improved preparedness.

2 The Solution: A Virtual Platform

Current Development:

- Prototype VR/AR systems have been piloted in university with positive feedback.
- Collaborations with institutions like the University of Waikato ensure alignment with industry needs

SCAN ME

3 Module 1: VR/AR System for Engineering Education

System Features:

- Interactive modules for virtual stress testing, dynamic analysis, and 3D modeling.
- By addressing multi-level learning objectives.

3 Module 2: VR/AR System for Construction Training

Theoretical Basis:

- Multimedia learning principles improve engagement and retention through interactivity and immersion.
- The modular training design.

System Features:

- Simulates real-world construction environments for safe, efficient training.
- Includes operation & hazard identification modules

Current Development:

- VR/AR bridge construction training modules have received positive feedback

3 Module 2: VR/AR System for Construction Training

Theoretical Basis:

- Cognitive Load Theory ensures practical scenario designs that reduce mental overload.
- Experiential learning theory emphasizes realistic practice to enhance preparedness.

System Features:

- Realistic elements like smoke, heat zones, etc. are cues for better emergency response training.
- Customizable escape scenarios for diverse building types.

Current Development:

- Developed fire escape training modules
- Modules provide safe, controlled environments to practice

4 Research Theoretical Support

Alignment with Education 4.0:
Addresses key competencies of problem-solving, collaboration, and adaptability.

Learning Theories:

- Kolb's experiential learning emphasizes the value of active experimentation and reflection.
- Vygotsky's sociocultural theory highlights the importance of interactive, collaborative learning environments.
- Mayer's multimedia learning principles advocate for combining visual and auditory elements for improved comprehension.

Industry Demand:
VR/AR technologies can **efficiently** deliver **cost-effective**, **standardized training solutions** that align with **safety standards**, addressing the needs of industries.

5 Economic and Societal Impact

Educational Benefits:

- **Reduces** the transition time from classroom learning to industry practice.
- **Enhances** students' problem-solving and practical skills.

Industry Benefits:

- **Lowers training costs** by reducing reliance on physical facilities.
- **Increases safety and productivity** in engineering and construction sectors.

Societal Benefits:

- Improves **fire safety** awareness, reducing real-world losses.
- Contributes to **developing a highly skilled** workforce for New Zealand's infrastructure.

References

Kolb, D. A. (2014). Experiential learning: Experience as the source of learning and development. FT press.
Mayer, R. E. (2002). Multimedia learning. In Psychology of learning and motivation (Vol. 41, pp. 85-139). Academic Press.
Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes (Vol. 86). Harvard University Press.
https://www.mbie.govt.nz/assets/building-and-construction-sector-trends-annual-report-2023.pdf

Chemical Modification of Nanocellulose For Use in Insulating Aerogels

Mahith Widanage, Supervised by Dr. Mohammad Dalour Beg & Dr. Christian Gauss

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Background

- Cellulose is a biopolymer which can be modified to change its chemical properties. The aim of this research was to develop variants of cellulose nanofibres through chemical modification.
- Modified nanofibres can be used in the creation of aerogels which have key insulating properties due to having very low thermal conductivity.
- Unmodified cellulose fibers have the issue of forming agglomerates when dispersed, due to hydrogen bonding between adjacent -OH groups.
- Agglomeration is a key issue, as it prevents the highly porous structures of aerogels from being formed when the final freeze drying process is performed.

Maleic Anhydried Cellulose (Maleic Anhydride Esterification)

Experimental

- Cellulose Fibres (1g) + Molten Maleic Anhydride (100g).
- Reacted for 3 hours at 104°C.
- Small amount of moisture present forms Maleic Acid.
- Maleic Acid undergoes substitution with hydroxyl (-OH) group. **(see graphic)**

- FTIR spectra shows carbonyl (C=O) peak at ~1700 cm-1
- Successful chemical modification confirmed.
- Dispersion testing shows desirable decrease in agglomeration.

Dialdehyde Cellulose (Periodate Oxidation)

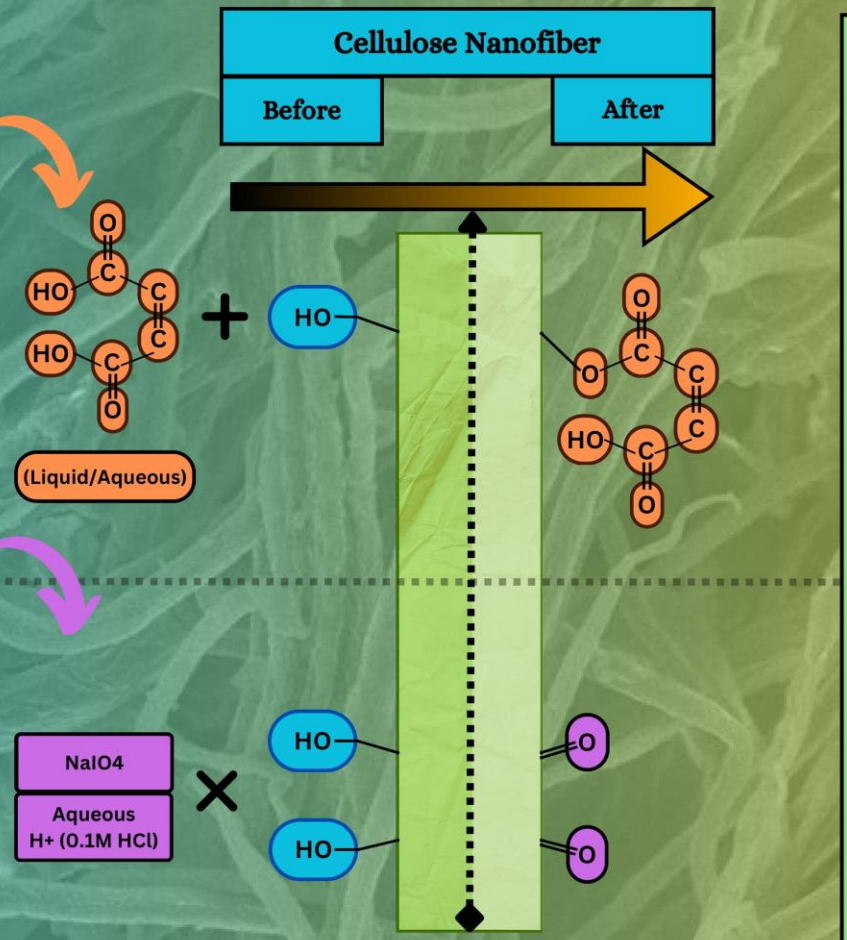
- Cellulose Fibres (0.35g) + Sodium Periodate (0.92g).
- Aqueous acidic conditions, pH = 3.3.
- Reacted for 15 hours at 35°C in the dark.
- Oxidation converts hydroxyl (-OH) pairs into aldehyde (C=O) groups. **(see graphic)**

- FTIR spectra shows no significant difference compared to control sample.
- Absence of characteristic carbonyl (C=O) peak.
- Further review of preparation and characterization necessary.

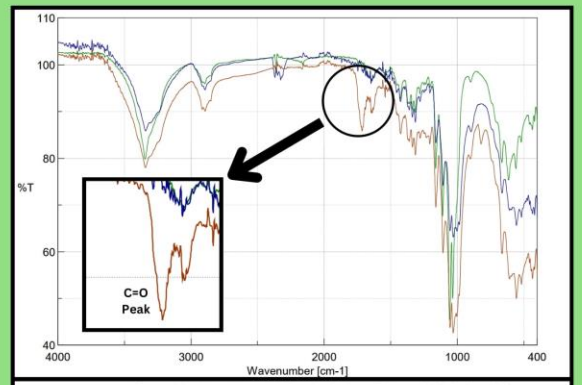
Conclusions and Next Steps...

- Maleic Anhydride esterification was determined to be a successful means of chemical modification, which had the desired effect of decreasing agglomeration.
- Inconclusive data on the effectiveness on periodate oxidation.

- Further characterization of both modified cellulose samples are to be conducted.
- TEMPO-Oxidised Cellulose are to be produced next.
- Modified cellulose fibres are to be used to produce aerogels.



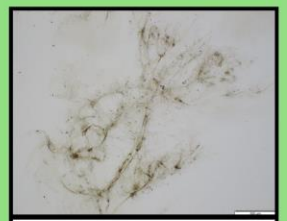
Data/Results



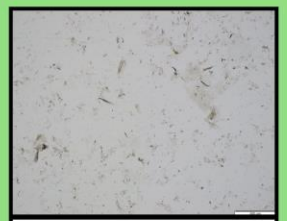
FTIR Spectra of Unmodified Cellulose, Maleic Anhydride Cellulose, Dialdehyde Cellulose

Unmodified Cellulose Dispersion 0.2 wt%)

Maleic Anhydride Cellulose Dispersion (0.2 wt%)



Unmodified Cellulose Nanofibers



Maleic Anhydride Cellulose Nanofibers

Acknowledgements

- Dr. Christian Gauss and Dr. Mohammad Dalour Beg for their guidance.
- Darshi Egodage for her continued help in the lab.

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Te Whare Wānanga o Waikato

Te Kura Rorohiko Me Ngā Pūtaiao Pāngarau – School of Computing & Mathematical Sciences

GIVING WORDS A VOICE

Creating a Māori Text-to-Speech System

Kingsley Eng, supervised by Te Taka Keegan

Au Reikura School of Computing and Mathematical Sciences

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Introduction

Te reo Māori has different dialects specific to various regions of New Zealand, but as a low-resource language, the language and dialects lack support. We developed a Māori Text-to-Speech (TTS) system to preserve these dialects and protect cultural heritage.

What is a TTS System?

A TTS system converts text to spoken audio and is widely used in virtual assistants. The system's voice is created by training a model with recorded audio paired with text transcripts. To replicate the tone, clarity and dialect of the speaker, accurate pronunciation, transcripts, and high-quality recordings are needed.

Methodology

We recorded 10 hours of Māori speech from a native Waikato speaker and transcribed it automatically using Whisper. This data trained Tacotron2 and produced mel spectrograms, which HiFi-GAN converted into speech. Whisper, Tacotron2, and HiFi-GAN are AI models we modified explicitly to work for Māori.

Conclusion

This project showed how AI can be utilised to preserve low-resource languages. Each step was documented and shared publicly to aid low-resource language preservation worldwide.

References

- Shen, J., Pang, R., Weiss, R. J., Schuster, M., Jaitly, N., Yang, Z., Chen, Z., Zhang, Y., Wang, Y., Skerry-Ryan, R. J., Saurous, R. A., Agiomyrgiannakis, Y., & Wu, Y. (2018). Natural TTS synthesis by conditioning WaveNet on mel spectrogram predictions. https://doi.org/10.1109/ICASSP.2018.8461368
- Kong, J., Kim, J., & Bae, J. (2020). HiFi-GAN: Generative adversarial networks for efficient and high fidelity speech synthesis. *Advances in Neural Information Processing Systems*, 33, 17022–17033. https://doi.org/10.48550/arXiv.2010.05646

Predicting Lung Cancer using Machine Learning Algorithms

By Leneshen Govender, Dr Han Gan, Dr Jason Kurz, Dr Yuri Zubenko, Dr Tim Edwards

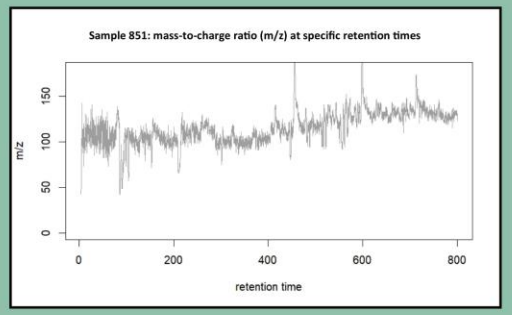
THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Background

The University of Waikato has been researching the efficacy of non-invasive methods of detecting lung cancer through the use of breath samples. What started off as an experiment using dogs as the primary method of identification slowly changed to using various machine learning algorithms with data sourced from the GC-MS (Gas Chromatography- Mass Spectrometry) runs.

Introduction

Throughout this research project, I explored many different facets of the research process. My speciality is in Data Analytics and Computer Science, however, I got to see a lot of Analytical Chemistry and a bit of biology. This summer research project highlighted the importance of the collaboration of different disciplines during the scientific process.



Method: Part 1

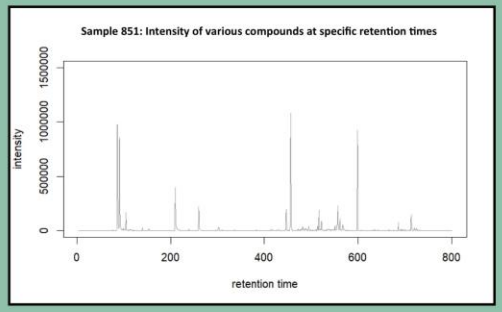
I was provided files that were in both open source formats and proprietary formats. Since we can not perform analysis with these file types, as they require an intermediary software package to analyse them, I converted this data into a more user-friendly format. We could easily analyse the data to see what needed to be changed and how we could do this without losing information.

To do this, I used open-source R libraries such as XCMS[1], MSExperiment, MSnbase and mzR.

Method: Part 2

In the secondary analysis, Dr Zubenko found that the data needed to be aligned since there were variations in the data due to environmental differences when the GC-MS machine ran its samples. This meant that I had to realign the data so that there was a reduction in the deviation of the mean.

I found a solution by adjusting the retention time with a constant median. This is called Landmark-based Alignment [2]



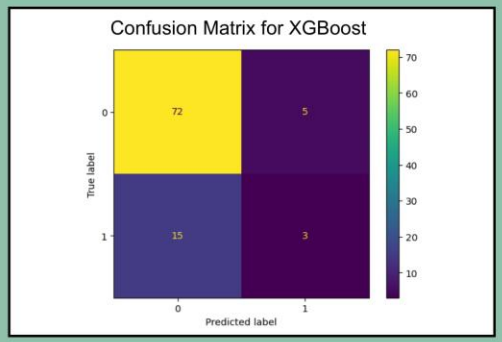
Results

Using Python as my language of choice when working with this data, I tried a few different models to see which garnered the best result. These models include:

i. XGBoost (Extreme Gradient Boost)
ii. SGD Classifier (Stochastic Gradient Descent)
iii. PCA Analysis on Logistic Regression (Principle Component Analysis)
iv. Logistic Regression (Regression Model)

When considering Machine Learning Algorithms, we are concerned with the accuracy of the predictions and the ROC (Receiver Operating Characteristic) curve. While all models had a high level of accuracy, we did not have a high value for the area under the curve. This was due to the lack of positive samples in our population. Even so, Dr Gan pointed out that our high accuracy scores could have been achieved by the ML algorithm predicting 'no cancer' for every single sample. To confirm this was not the case, we used a confusion matrix to view the predictions and see how well it performed.

From our confusion matrix, we can see that the XGBoost algorithm predicted a range of values, not only 'no cancer' , which indicated it is a robust model. This made XGBoost our preferred algorithm going forward for this analysis.



Next Steps

Future work on this project includes:

1. Working on the new data so that it is aligned with the old data. This would allow for us to work with a larger dataset, improving the accuracy of our predictions.
2. Creating a dataset with a large ratio of positive samples in it. By doing this, we would be able to reduce our false negative ratio. In a healthcare setting, having a low false negative rate is very important as a higher false positive rate would mean we would have misdiagnosed patients who then may not seek medical attention when they need it.
3. Further fine tuning of hyperparameters in the selected ML algorithms. While I did perform a bit of fine tuning, we could consider more in-depth methods that might garner better results. While we did fine tune quite a few of the results, it might be more suited to further reinforce the learning the algorithm has made.

References:

[1] https://bioconductor.org/packages/release/bioc/html/xcms.html

[2] https://pmc.ncbi.nlm.nih.gov/articles/PMC3933976/

Acknowledgements

I would like to thank Te Mata Kairangi - School of Graduate Research for the opportunity to participate in the Summer Research Scholarship Program. I would also like to thank my supervisors for their time and commitment over the past 10 weeks. Not only have they helped to broaden my knowledge, but they also demonstrated the teamwork that exists between departments.

Co-designing SMART Cities

Student: Ben Jones
Supervisors: Jessica Turner, Holly Simons, and Dave Parsons

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Tauranga City

Introduction

In partnership with Tauranga City Council (TCC), this project engaged the community to co-design smart city solutions for one of New Zealand's fastest growing cities. The research aimed to identify and ideate technologies that could enhance city services and inform possible future developments in the CBD.

Background

Smart cities use connected technologies to enhance urban services and quality of life. Community involvement in designing these solutions is crucial for ensuring relevant and effective implementation. Internet of Things (IoT) ideation toolkits, such as the Tiles IoT Inventor Toolkit and Futurice IoT Service Kit, enable inclusive participation in technology design regardless of technical expertise.

Methodology

The research involved two phases:

1. Community Technology Survey: Distributed through the "Kōrero mai - Let's talk Tauranga" newsletter to assess technology attitudes and identify priorities for improvements.
2. Ideation Workshop: Selected community members were invited to a workshop at the University campus to develop solutions for challenges identified using the toolkits.

More details

Results

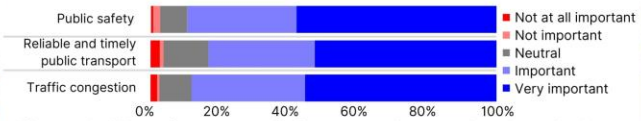


Figure 1: "How important is it to you that technology helps improve the following?" survey question.

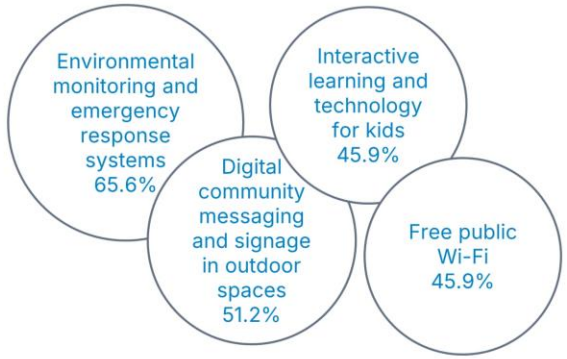


Figure 2: "What technology would you like to see more of in the community?" survey question.

Discussion

The Community Technology Survey gathered 248 responses from Tauranga residents, identifying the following areas for technological enhancement: environmental monitoring, emergency response, digital signage, and public Wi-Fi. Key issues emerged around transportation infrastructure, environmental sustainability, and public safety.

Workshop participants used the IoT ideation toolkits to develop solutions to these challenges, producing two notable concepts, as evaluated by the researchers: a "manu meter" for water quality monitoring and instant replays, and an interactive CBD cultural tour.

Figure 3: Manu meter idea using Tiles kit.

Figure 4: Cultural tour idea using Futurice kit.

Conclusion

The learnings from this research are two-fold: Tauranga City Council have gained insights and inspiration into potential community technology projects, and feasible and novel solutions are possible using the toolkits.

Wearable Fatigue: Because Coffee Isn't Always the Answer.

Using Device Data to Make a Machine Learning Model that Recognises Cognitive Fatigue

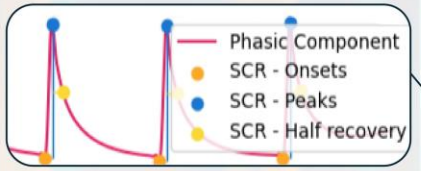
Introduction

Identifying Cognitive Fatigue Digitally could save many lives' and injuries lost to cognitive fatigue, by being able to implement safety procedures such as forced rest, and improve training.

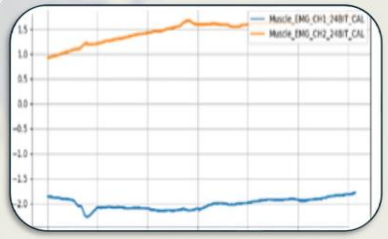
Background

The Data was collected during a prior study using wearable sensor devices to monitor participants. They were instructed to perform tasks designed to be cognitively fatiguing . Participants completed tasks inducing cognitive fatigue, with data captured before, during, and after the tasks.

We identified data drift that could unintentionally enhance model performance. To help address this, we applied **min-max scaling** and **baseline adjustments.**



*The Peaks from Skin Conductance resistance **(SCR)** indicate a heighted emotional state.*



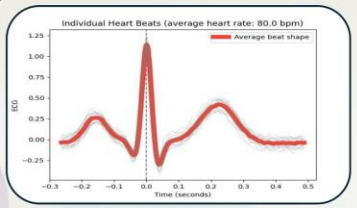
Visualisation of the EMG channels

Feature Extraction

ECG: Heart rate variability (HRV) was extracted as a key indicator of cognitive fatigue, showing decreased variability during mental workload

EDA: SCR peaks and recovery times highlighted emotional arousal.

EMG: Muscle activity amplitudes and onset patterns provided insights into physical manifestations of mental effort.



The averaged beat shape of one of the participants

Results:

Individual	All-in	Hold-One-Out
99.6%	99.2%	91.3%

These are the best results obtained using various methods of incorporating participant data into the training sets for machine learning models applied to binary classification

Support Vector Classifier	**99.6%**
K-Nearest Neighbour	**99.4%**
Logistic Regression	**98.9%**

The best model results for individual participant data, split into training and test data for evaluation

Conclusion

Wearable sensor data can highlight physiological markers of cognitive fatigue. Despite limitations of small sample size and sensor noise, the findings show potential for real-time fatigue monitoring in real - world environments.

Future work could focus on applying this to real world conditions or creating new data.

Find out More:
By Ryan Manchester

Special Mention to ...
Jemma König (Supervisor)
The Wearable Computing Lab
The Summer Research Project Group

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

E-WASTE: A JOURNEY TOWARD A GREENER FUTURE

INTRODUCTION

Electronic waste (e-waste) has become the fastest-growing waste stream globally ([1], [2]), with **83%** of e-waste going undocumented [3].

The average New Zealander produces more than 20 kilograms of e-waste every year, one of the **highest per capita amounts on the planet**. Only an estimated **2%** is recycled (1,600 Tonnes) [4].

AIM

The aim of this research is to explore e-waste awareness, opinions, and current practices among STEM division staff at the University of Waikato.

WHAT IS E-WASTE?

- Physical E-Waste: discarded, unwanted or broken electronic devices and electrical equipment [3].
- Software E-Waste: Inefficient software that increases energy use, hardware strain, environmental impact, and resource consumption, accelerating hardware obsolescence and physical e-waste ([5], [6]).

METHOD

Conducted survey of STEM division staff at the University of Waikato to collect data about e-waste perspectives and opinions, and unused equipment.

ACKNOWLEDGEMENTS

Design & Research: Celine Mason

Supervisor: Judy Bowen

References:

[1] Owen, V., Stead, M., & Coulton, P. (2024). Fostering IoT Repair Through Care: Learning from Emotional Durable Gaming Practices and Communities. Designing Interactive Systems Conference, 102–105. https://doi.org/10.1145/3656156.3663702

[2] Voskergian D, Ishaq I. Smart e-waste management system utilizing Internet of Things and Deep Learning approaches. Journal of Smart Cities and Society. 2023;2(2):77-98. doi:10.3233/SCS-230007

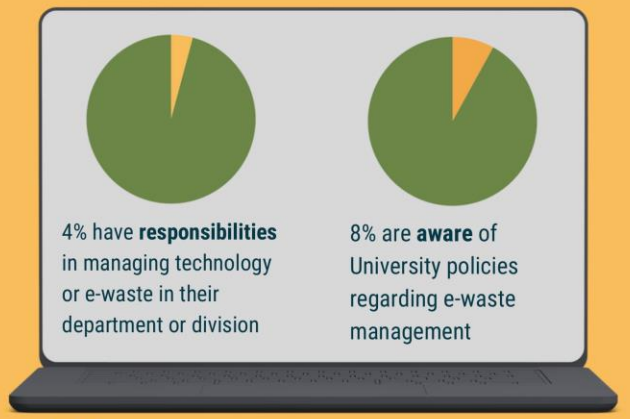
[3] Oke, E.A., Potgieter, H. Discarded e-waste/printed circuit boards: a review of their recent methods of disassembly, sorting and environmental implications. J Mater Cycles Waste Manag 26, 1277–1293 (2024). https://doi.org/10.1007/s10163-024-01917-7

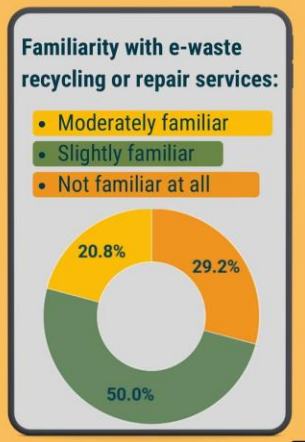
[4] Rnz. (2020, February 12). Our gigantic e-waste problem. RNZ. https://www.rnz.co.nz/programmes/the-detail/story/2018733818/our-gigantic-e-waste-problem

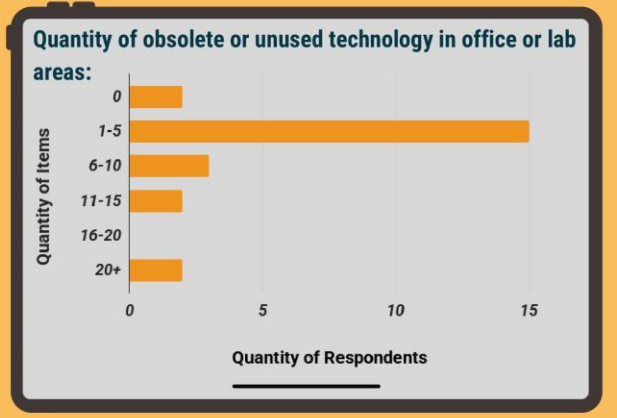
[5] Rosencrance, L. (2022, August 1). green software. Search Software Quality. https://www.techtarget.com/searchsoftwarequality/definition/green-software

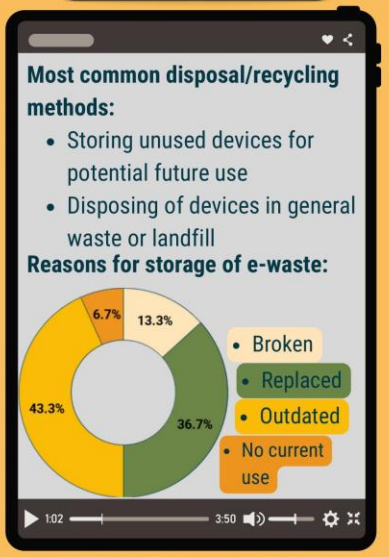
[6] What is Green Software and how does this emerging discipline help enable sustainable transformation? | CI&T. (2024, February 9). CI&T. https://ciandt.com/us/en-us/article/what-green-software-and-how-does-emerging-discipline-help-enable-sustainable-transformation

RESULTS









DISCUSSION & CONCLUSION

Next Steps for E-Waste at the University

The survey highlights critical areas where improvement is needed for e-waste awareness, access to recycling services, and management.

Further research should focus on enhancing technology sustainability through improved policy visibility, expanded recycling options for hard-to-recycle items, and incentives such as repair subsidies and trade-in programs.

MALWARE: INDUSTRIAL CONTROL systems UNDER SIEGE.

INTRODUCTION

Industrial Control Systems (ICS) malware is designed to target and disrupt critical infrastructure systems. E.g, power grids, manufacturing plants, and water treatment facilities. Cybercriminals use ICS malware to steal sensitive data and manipulate and damage operations. [1] [2]

AIM

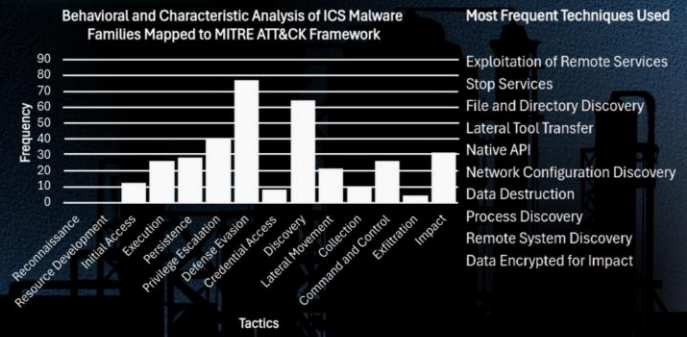
To gain insight into the behavior, structure, and capabilities of ICS malware enabling us to understand the attack vectors, propagation methods, and exploitation techniques to devise appropriate countermeasures against the analyzed malware.

METHOD

Gathered data on the behaviour and characteristics of 23 ICS malware families discovered between 2008 and 2024, focusing on the tactics, techniques employed, their targets, and the potential impacts on industrial systems through publicly available databases.

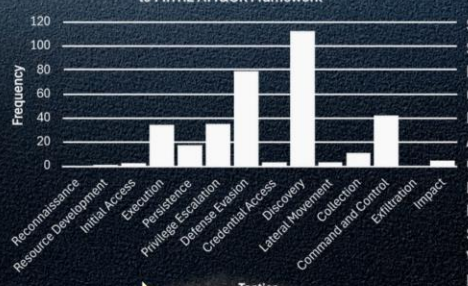
Collected 12 ICS malware samples from the ICS malware families discovered using Malware Bazaar [6] and academic papers. Lastly, used a secure sandbox environment like Joe Sandbox [7] and analyse the malware, mapping observations to the MITRE attack enterprise and ICS frameworks [3].

RESULTS



Most Frequent Techniques Used

- Exploitation of Remote Services
- Stop Services
- File and Directory Discovery
- Lateral Tool Transfer
- Native API
- Network Configuration Discovery
- Data Destruction
- Process Discovery
- Remote System Discovery
- Data Encrypted for Impact



Most Frequent Techniques Used

- Security Software Discovery
- System Information Discovery
- Process Injection
- Obfuscated Files or Information
- Encrypted Channel
- Archive Collected Data
- Command and Scripting Interpreter
- Deobfuscate/Decode Files or Information
- Remote System Discovery
- System Services: Service Execution
- Virtualization/Sandbox Evasion
- File and Directory Discovery
- Process Discovery

ANALYSIS

Discovery and defence evasion tactics have the highest frequency in both ICS malware families researched and individual malware samples tested.

Discovery allows an adversary to gain knowledge about the topology of a system and internal network. Discovery helps adversaries assess their environment, identify controllable elements, and determine how to traverse the system to achieve their objectives [5].

Defence Evasion is where the adversary is trying to avoid detection throughout their attack. Techniques used for defence evasion include uninstalling/disabling security software or obfuscating/encrypting data and scripts. Adversaries also leverage and abuse trusted processes to hide and masquerade their malware [4].

A comparison of a previous dataset on cyber attack events [8] with my ICS malware shows that ICS malware emphasizes discovery and defence, while focusing less on initial access, collection, and exfiltration.

The infrequent use of collection and exfiltration techniques suggests that ICS malware primarily aims to manipulate, disrupt, or destroy systems and their environment, rather than steal sensitive information.

Overall, these findings suggest ICS malware is designed to infiltrate, explore, and navigate industrial environments, evade detection for prolonged periods, and prioritize process disruption over data theft.

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Te Whare Wānanga o Waikato

ACKNOWLEDGEMENTS

Design and Research: Dean Mason
Supervisors: Farzana Zahid & Vimal Kumar

REFERENCES

[1] CISCO. (2024). What Is Malware? - Definition and Examples. Cisco. https://www.cisco.com/site/us/en/learn/topics/security/what-is-malware.html
[2] What Is ICS (Industrial Control System) Security? (n.d.). Fortinet. https://www.fortinet.com/resources/cyberglossary/ics-security
[3] MITRE ATT&CK. (2024). Matrix - Enterprise | MITRE ATT&CK(TM). Attack.mitre.org. https://attack.mitre.org/matrices/enterprise/
[4] Defense Evasion, Tactic TA0005 - Enterprise | MITRE ATT&CK®. (2019, July 19). attack.mitre.org. https://attack.mitre.org/tactics/TA0005/
[5] Discovery, Tactic TA0007 - Enterprise | MITRE ATT&CK®. (n.d.). Attack.mitre.org. https://attack.mitre.org/tactics/TA0007/
[6] MalwareBazaar | Browse Checking your browser. (n.d.). Bazaar.abuse.ch. https://bazaar.abuse.ch/browse/
[7] Automated Malware Analysis - Joe Sandbox Cloud Basic. (n.d.). Www.joesandbox.com. https://www.joesandbox.com/#windows
[8] Kaur, H. (2024). Cyber attack events dataset [Unpublished dataset].

Using an Internet-in-a-box Approach to Experimentally Study Attacks against Networks

Nathan Shakes, Marinho Barcellos
School of Computing and Mathematical Sciences (STEM)

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

1. Context & Motivation

The increasing adoption of online services has made the Internet critical to everyone. This is an incentive for miscreants to exploit the Internet infrastructure, compromising machines and launching attacks against networks of companies providing or dependent upon online services. Attackers can discover vulnerable machines, steal information from them, make online services slow or even unavailable.

Studying how such attacks operate and the effectiveness of potential defenses is key, but hard to achieve in-the-wild as an ethical approach is needed. In this research, we investigate whether it is possible to emulate attacks and defenses using an "Internet in a box" approach. To do so, we overcome several technical challenges, extending the mini-Internet platform created by ETH Zurich **[1]**, and show that these attacks and defenses can be demonstrated realistically in an contained environment.

2. Internet Security

Supported by a SRG, we considered the main cybersecurity attacks with Internet infrastructure, as summarised next.

Prefix Hijacking. An attacker controls a network and announces prefixes (a range of addresses) that belong to a different network, attracting to itself all the traffic that was addressed to the hijacked prefix **[2]**. This attack can be done to discard all the traffic to a network, or to inspect it before forwarding it to the original destination. The attack has been used against banks and cryptocurrency systems. An existing partial defense is called Route Origin Validation (ROV with RPKI).

Spoofing. An attacker modifies the source IP address of the packets it transmits **[3]**. For example, the attacker can send packets with random source addresses, so that the victim does not know who the attacker is. Spoofing is also the basis for what is called a "reflection-amplification Distributed Denial-of-Service (DDoS) attack" **[6]**. The defence is called Source Address Validation (SAV) **[3]**.

Botnets. An attacker, a botmaster, controls an army of bots. These bots run in compromised network devices (such as modems and wireless routers) and other machines. An user does not know that their device is infected and controlled by a bot. A common situation nowadays is the botmaster commanding the botnet to launch a powerful DDoS attack against a network or a server, then demanding ransom.

Scanning. The attacker (or researchers and security staff) can use scanning to learn more about targeted networks or the entire Internet. Scanning tools eg Zmap **[5]** can be used to discover vulnerable services in networks.

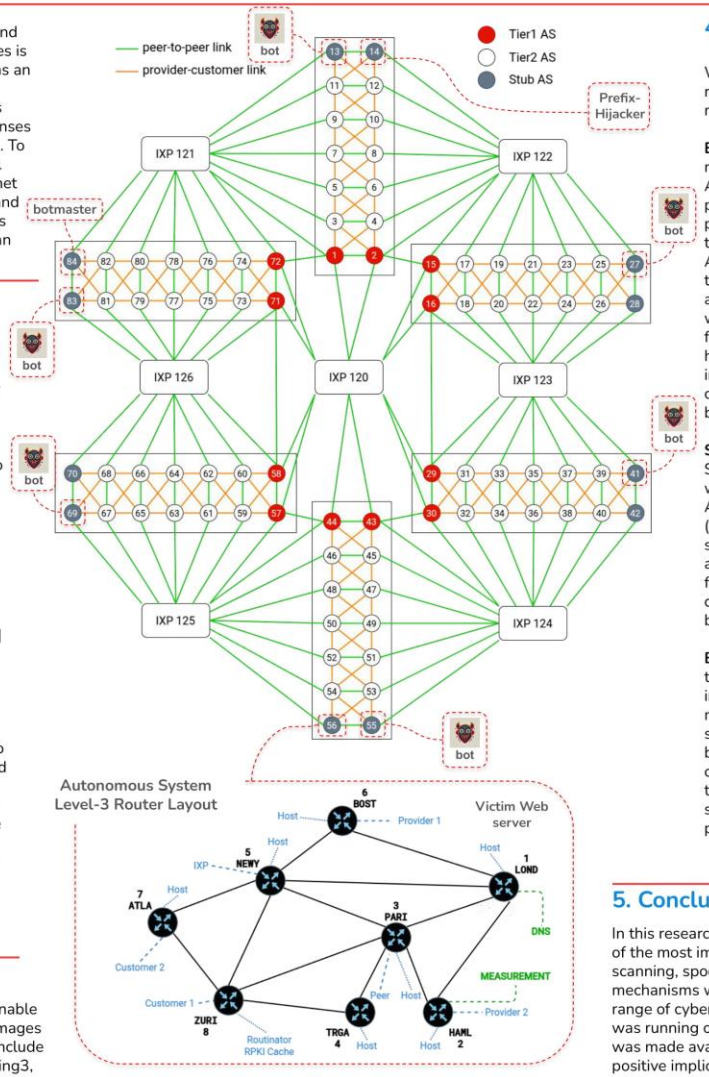
DDoS. In this type of attack, a victim server or network is flooded with packets or requests. The volume is so great that the service is disrupted and becomes offline **[6]**. The modus operandi is: the attacker either sends spoofed traffic to multiple vulnerable servers, which are used to "amplify the power" of the attack towards the victim and hide their identity. or controls a botnet whose bots flood a server or network with packets.

3. Extending the Mini-Internet

The Mini-Internet platform was developed by ETH Zurich University **[1]**. The platform is based on Docker and allows the realistic emulation of a full Internet topology, however in small scale (e.g. the University of Waikato has been using the platform since 2021, in the COMPX304 course, with topologies containing up to 100 different networks. Each student controls tier own network (called Autonomous System, or AS). The number of students using the platform in a class is 40-80 students.

We have extended this platform to enable us to perform network attacks. The images (Docker) for hosts were modified to include a range of attack tools, e.g. scapy, hping3, ZMap, Masscan were also added which allow for scanning which is useful for finding open ports which can lead to vulnerabilities. It will directly benefit UoW students learning about network security.

This modified Mini-Internet environment has been published to GitHub as a community contribution for future uses in cybersecurity for research, teaching, and business uses.



4. Implementing Attacks & Defenses

We now explain how the key attacks and respective defenses can be showcased using the mini-Internet we set up.

BGP Prefix Hijacking. In the mini-Internet, all the networks (Autonomous Systems, identified by ASNs) are pre-configured with the BGP routing protocol. Each network (AS) announces a /8 prefix. The mini-Internet already included a script to run a prefix hijack. To hijack all routes to ASN55 /8 prefix, the attacking ASN14 announced two *more specific* prefixes of size /9 that covered all addresses in ASN55. All the traffic to ASN55 was diverted to ASN14. Mini-Internet has support for RPKI **[2]**, which is used to avoid one type of hijack. We demonstrate the use of this infrastructure to only accept routes with valid origins (ensuring that the prefix announced belongs to the origin AS).

Spoofing. The mini-Internet does not come with SAV against spoofing attacks. The hping3 tool was used in ASN56 to send packets to a host in ASN55 with source IP address spoofed (pretending to be a host in ASN70). We successfully perform this experiment and were able to get the host in ASN28 receive a response from ASN55. To block spoofing, networks should deploy Source Address Validation. Spoofing is the basis for certain kinds of DDoS attacks.

Botnets. We implemented a botmaster as a script that runs in a host in ASN84. It controls the bots in many ASes (ASN 13, 27, 41, 54, 69 & 83) and makes them perform DDoS attacks against a server machine in ASN55. The defense against botnets would include avoiding the contamination of network devices and computers & inspecting the traffic in and out of the network, looking for suspicious activity. We did not implement such protections.

Scanning. Scanning is used to find vulnerabilities, by attackers and researchers. It is also used by botnets to find vulnerable devices they can compromise and make join the botnet. We run the Masscan tool in ASN42 to scan ASN56, looking for the IP addresses of any existing hosts and routers, and next checking for open ports on them. We discovered all the routers/hosts inside network ASN56 and a few ports open. The defenses include the use of firewalls configured to detect and block incoming scanning packets.

DDoS Attacks. One of the most common attacks nowadays is DDoS performed by a botnet. The botmaster in ASN84 commands the many bots, in ASN 13, 27, 41, 55, 69 & 83, to send packets to a victim, a host in ASN56. The victim server (or entire network) is overwhelmed and stops working, disrupting service. The miscreant asks for ransom, extorting the victim. In some cases, the attack uses reflection/amplification: the attacker sends small requests to a server (e.g. DNS in tier-1 ASN29), which replies with large responses; however, if the attacker is allowed to spoof the source address of the requests, the (large) responses go the victim instead, clogging up all the communication channels with ASN56. We implemented both direct and reflection-amplification attacks. Defenses include the use of firewalls and "traffic scrubbers", configured to detect DDoS attack traffic and discard it, and hiring DDoS mitigation providers to deal with large-scale volumetric attacks.

5. Conclusion and Future Work

In this research, we extended the Internet-in-a-box platform called mini-Internet to enable the emulation of the most important attacks against Internet infrastructure nowadays: prefix hijacking, botnets, scanning, spoofing, and DDoS. Our platform provides a good level of realism: all attacks and protection mechanisms were constructed with the real technologies and tools. This required learning about a wide range of cybersecurity tools and techniques, as well as dealing with resource contention, as the Internet was running on a single server. In line with the open source philosophy of SCMS, the resulting platform was made available to the community as a project in GitHub, along with detailed documentation. This has positive implications for teaching, research, and businesses interested in exploring Internet security.

6. Key Bibliography

[1] Holterbach, T., B¨uhler, T., Rellstab, T., & Vanbever, L. (2020). An open platform to teach how the internet practically works. SIGCOMM Comput. Commun. Rev..

[2] T Holterbach, T Alfroy, A Phokeer, A Dainotti, and C Pelsser, "A System to Detect Forged-Origin BGP Hijacks," NSDI 24, pp. 1751–1770.

[3] L Muller, M Luckie, B Huffaker, KC Claffy, M Barcellos, 2020. Spoofed traffic inference at IXPs: Challenges, methods and analysis. COMNET 182.

[4] A Wang, W Chang, S Chen, and A Mohaisen, "Delving Into Internet DDoS Attacks by Botnets: Characterization and Analysis," IEEE/ACM Transactions on Networking, vol. 26, no. 6, pp. 2843–2855, Dec. 2018

[5] Z. Durumeric, D. Adrian, P. Stephens, E. Wustrow, and J. A. Halderman, "Ten Years of ZMap," in ACM IMC 2024, pp. 139–148

[6] R Hiesgen, M Nawrocki, M Barcellos, D Kopp, O Hohlfeld, J Kristoff, R Dobbins, T Schmidt, M Waahlisch, D Thomas, R Mok, KC Claffy, 2024. The Age of DDoScovery: An Empirical Comparison of Industry and Academic DDoS Assessments, in: IMC.

February 2025

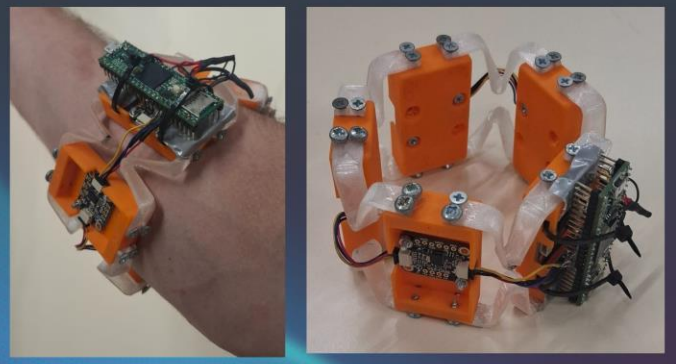
Prosthesis control via accelerations and rotations

Different hand movements

The Goal

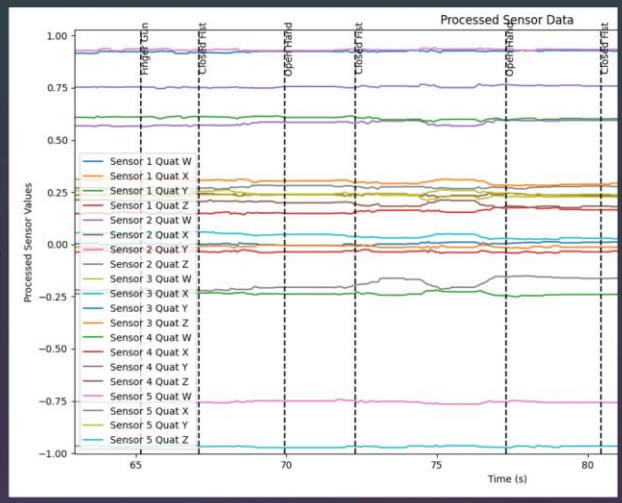
Controlling prosthetics is an ongoing area of research. One way to do this for people with hand amputations is to detect movements in the forearm muscles. An arm band is used to collect movement data and train machine learning models to associate forearm movements to hand movements. This could then be used for applications such as prosthesis control or gesture sensing in virtual reality.

Muscle Movement Detection via Accelerations & Orientations



An armband was developed with 6 accelerometers and gyroscopes that are used to detect minute movements in the forearm muscles.

Preprocessing



Various pre-processing algorithms were developed that can be applied to the data to correct for noise and arm movement. The optimal algorithm is yet to be determined as different algorithms can affect how obvious the signal is.

Data Collection and Training

A python application was written that allows for recording movement data and simultaneously recording the hand position via buttons on the screen. 50 hand movement datapoints were recorded.

Machine Learning to detect movements

The next steps are to apply different machine learning algorithms to the movement data to predict hand positions using the armband. The effectiveness of the methodology can then be evaluated.

Authors: Kieran Smith
Supervisors: Dr. Anany Dwivedi & Dr. Mahonri Owen

Te Ipu o te Mahara Artificial Intelligence Institute

The University of Waikato
Te Whare Wānanga o Waikato

Impact of Heading Styles on Information Search Efficiency

An Eye-tracking Study

Student: Elena Yarkova (ID: 1631948) **Supervisors: Dr. Claire Timpany, Prof. Nic Vanderschantz**

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Introduction

Research investigating how different heading styles affect reading comprehension and information processing in digital texts.

Study Focus

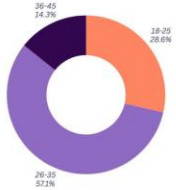
- Impact of heading styles on search efficiency
- Eye movement patterns during information search
- User preferences and performance metrics

Methods

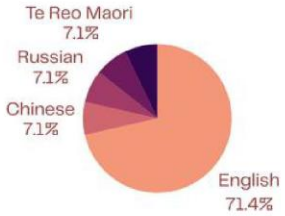
Participants:

14 participants from varied demographics.
7 Male, 7 Female

Age range



Native Language



Education level

Materials:

Three articles of similar readability metrics (College level, average grade score ~10.84, difficult to read).

Articles presented with three conditions:

- Bold headings (same font size as the paragraph);
- Paragraph-sized headings (same size as body text, no bold emphasis);
- No headings.

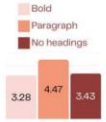
Procedure:

1. Using eye-tracking device (Tobii) for data collection.
2. Tasks involved finding answers to specific questions in each article format (3 questions per article).
3. Performance metrics:
   - Time to find answers;
   - Accuracy (number of errors);
   - Review frequency (returning to questions).
4. Post-task surveys collected feedback on usability and comfort.

Results

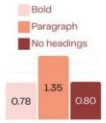
Time Efficiency

Bold: Avg. ~3:28 per task
Paragraph: Avg. ~4:47 per task
No headings: Avg. 3:43 per task



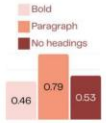
Accuracy

Bold: Avg. ~0.78 errors/question
Paragraph: Avg. ~1.35 errors/question
No headings: Avg. ~0.8 errors/question



Review frequency

Bold: Avg. ~0.49 reviews/question
Paragraph: Avg. ~0.79 reviews/question
No headings: Avg. ~0.53 reviews/question



User Feedback:

Bold headings were most preferred for clarity and usability.

Lack of headings significantly increased cognitive load and navigation difficulty.

Conclusion

- Bold headings proved most effective across all measured metrics
- Paragraph headings performed worse than having no headings
- No headings showed unexpectedly good results, indicating poorly implemented headings are less effective than no headings

References:

1. Djamasbi, S., Siegel, M., & Tullis, T. (2011). Visual hierarchy and viewing behavior: An eye tracking study. In J.A. Jacko (Ed.), Human-Computer Interaction, Part I, HCII 2011, LNCS 6761 (pp. 331-340). Springer-Verlag Berlin.
2. Dyson, M. C. (2004). How physical text layout affects reading from screen. Behaviour & Information Technology, 23(6), 377-393.
3. Dyson, M. C., & Beier, S. (2016). Investigating typographic differentiation. Information Design Journal, 22(1), 3-18.
4. Hyönä, J., & Lorch, R. F. (2004). Effects of topic headings on text processing: Evidence from adult readers' eye fixation patterns. Learning and Instruction, 14(2), 131-152.
5. Rahma, R., Sudana, U., & Aswan. (2020). Eye movement patterns on screen readers: An eye-tracking study. Paper presented at The 4th International Conference on Language, Literature, Culture, and Education.
6. Tinker, M. A. (1965). Nature of legibility. In Bases for effective reading (pp. 10-124). University of Minnesota Press.

CO-DESIGN SOFTWARE FRAMEWORK WITH INDIGENOUS COMMUNITIES

Case Studies of a Māori-Tauiwi Approach

Whakatōhea Iwi & University Members at Waiaua Marae

AUTHOR: WENQIAN ZHANG

Supervisors:

Dr Alvin Yeo

Professor Annika Hinze

Dr Nic Vanderschantz

Aaron Matenga

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

TE TĀWHARAU O TE WHAKATŌHEA

01 INTRODUCTION

Critical Gap:

- Traditional software development overlooks Māori traditions, causing cultural misalignment.

Objectives:

- Develop a co-design framework where Mātauranga Māori and tikanga (traditional protocols) guide software development for indigenous communities.
- Understand successful partnership practices to inform framework development.

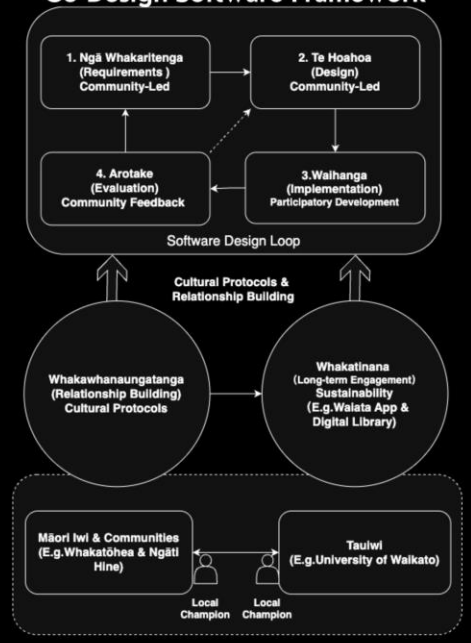
02 METHODOLOGY

A Mixed-method participatory approach:

- In-depth interviews with key stakeholders (Whakatōhea Iwi, Ngāti Hine Iwi and SCMS of University of Waikato)
- Documentation and analysis of collaboration processes.
- Thematic analysis to identify patterns.
- Framework refinement based on feedback.

03 FINDINGS

Co-Design Software Framework



Themes:

- Importance of relationship building (whakawhanaungatanga), cultural safety in technology, empowerment through technology ownership.

Principles:

- Cultural Protocols as the foundation of the partnership.
- Local Champions are key for relationship building.
- Long-term relationships enable sustainable development.
- Cultural practices are defined and led by the community.

Relationship Building & Long-term Engagement:

- "I think it's important for universities, [...] to acknowledge the value of the community they're working with. [...] Not making any assumptions about what the community might want. So being clear and having a continuous relationship helps the university, students, and staff members better understand what their client, their whānau, the iwi and the community really want in terms of the collaboration."
- "I think it's important for iwi to host and share their dreams and aspirations. Being clear with [the collaboration partner] about what you want to achieve before getting into the details of the relationship is crucial. "

Danny Paruru (Whakatōhea Iwi Key Stakeholder)

04 CONCLUSION

Current Outcomes:

- Documented, replicable co-design framework.
- Demonstrated value of long-term cultural partnerships.

Future Development:

- Expanding collaboration with Ngāti Hine.
- Refining framework through new partnerships.

Acknowledgements:

We thank our indigenous partners for their engagement with this research project.

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Te Raupapa – Waikato Management School

Modern Solow Paradox:

AI WILL CHANGE NEW ZEALAND'S LABOUR FORCE, BUT NOT IN THE WAYS YOU MIGHT THINK

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

FRANCHESCA FARNUM &
PROF. MARK HARCOURT

INTRODUCTION

The market for Artificial Intelligence (AI) has grown rapidly over the last decade, and with it has come fears of automation across a wide range of jobs. A survey of 1,001 New Zealanders found, among those aware of AI, 86% were at least a little concerned about job displacement due to AI, and 22% extremely concerned (Matika, 2023).

Following Frey & Osborne's (2017) framework to estimate an occupation's capacity to be automated suggested up to half of US jobs would be destroyed by AI and a global cost of living crisis, the concern is understandable.

Policy makers have a responsibility to assess the validity of these fears and take measures to prevent adverse impacts to people's livelihoods. This project draws upon a heavy body of existing research to identify vulnerable industries, occupations and communities in New Zealand so that policy recommendations may be formed.

OBJECTIVE

This project aims to provide insights into areas of vulnerability within New Zealand's labour market, including at-risk occupations and industries. Following this, it will evaluate possible solutions to address issues, and make final recommendations on this basis.

METHODS

Extensive literature review, looking at criticisms and reapplications of various studies across authors. Use this to construct a framework to the labour force of New Zealand.

⇩

Apply Arntz, et al's (2019) findings to 2023 Census data to estimate impacted jobs locally.

⇩

Review proposed initiatives to address adverse impacts of AI automation. Some key considerations included:

- Universal basic income (UBI)
- Technological diffusion
- A centralised labour market structure
- Comparative Advantage
- Collective bargaining
- Skills-based Pay

KEY FINDINGS

Routine, cognitive work can, theoretically, be performed by AI.

Clerical and administrative work has the largest proponent of routine, cognitive tasks at the occupational level.

- The "occupational level" refers to a group of jobs that have many similar characteristics.
- Typically, a person who performs one of these jobs can easily move into another; such as moving from a payroll clerk in one company to a bookkeeping clerk elsewhere.

When looking at the job level, many jobs within the same occupation have niche tasks unique to that role, as well as other differences such as the size of the firm, its location, demographic differences within staff, access to technology, etc.

- Accounting for heterogeneity across jobs at the individual level, Arntz et al (2017) find the realistic proportion of clerical and administrative jobs destroyed to be 18.2%.

Transferable skills are most important for protecting workers from long-term displacement. Most workers in theoretically automatable jobs are protected because they have additional skills beyond routine-cognitive. Thus, solutions which promote mobility across jobs by utilising skills within which humans have a comparative advantage over machines will be more effective in addressing automation due to AI.

REFERENCES

Arntz, M., Gregory, T., & Zierahn, U. (2017). Revisiting the risk of automation. Economics Letters, 159, 157–160. https://doi.org/10.1016/j.econlet.2017.07.001

Arntz, M., Gregory, T., & Zierahn, U. (2019). Digitalization and the Future of Work: Macroeconomic Consequences. IDEAS Working Paper Series from RePEc. https://www.proquest.com/docview/2587962148?pq-origsite=primo&sourcetype=Working%20Papers

Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? Technological Forecasting and Social Change, 114, 254–280. https://doi.org/10.1016/j.techfore.2016.08.019

Matika, C. (2023). New Zealand's Internet Insights 2023. Internet NZ. https://internetnz.nz/new-zealands-internet-insights/new-zealands-internet-insights-2023/

Stats NZ. (2024). 2023 Census. https://explore.data.stats.govt.nz/

AT-RISK JOBS

18.2% OF CLERICAL WORKERS ARE MORE VULNERABLE TO AUTOMATION BY AI.
THIS IS **51,429** PEOPLE, WHICH IS ONLY **1.3%** OF OUR WORKING-AGE POPULATION, **BUT,**
THIS ISSUE DOES PRESENT UNIQUE CHALLENGES FOR MATURE, FEMALE-IDENTIFYING WORKERS.

48% of the employed, working population identify as female, or around 1,257,000 people....

...yet among the 282,500 people in clerical jobs, **210,900** identify as female, or **75%**.

Clerical jobs account for just 10% of all occupations held by female workers, however when integrating for age groups, more than 80% of female workers over the age of 50 work in clerical spaces. This indicates job instability for around **30,600** female workers over the age of 50.

POTENTIAL SOLUTIONS

UNIVERSAL BASIC INCOME (UBI)

UBI is a social welfare initiative that entitles all members of a country to a minimum income that is based on the minimum cost of living. UBI is not a suitable solution to address the adverse effects of AI for the following reasons:

- The most significant adverse effects of automation by AI are highly niche, impacting a very specific group of New Zealand workers, requiring a targeted approach.
- UBI does not target any specific group. It provides no more support for people displaced by automation than it does for transitional unemployment.
- AI-based displacement is entirely related to a worker's set of skills. UBI is not a sustainable solution for people displaced due to a shortage of marketable skills as it is designed to meet minimum needs and is insufficient to fund retraining.

COLLECTIVE BARGAINING

Collective bargaining refers to negotiations between an employer and a representative of union of workers, rather than individual negotiation. Collective agreements are less common in small businesses, but among large businesses, union membership could be a good buffer for at-risk workers. Having access to a representative in case of termination or a reduction in hours, even prior to this, can provide some reassurance to worried New Zealanders. Furthermore:

- A union acts as a community of workers from similar backgrounds, providing connections to other organisations.
- Workplaces with collective agreements tend to have more transparency company-wide, working to reassure workers.
- A collective agreement provides more foresight for the medium-term. Technological diffusion or the pause between development and adoption of technology has been described as incredibly slow for 4.0 technologies (Arntz, et al, 2019). This, alongside unionisation, will help to prevent a large number of displacement at once.

SKILLS-BASED PAY

Skills-based pay is a pay structure where workers receive pay rises by acquiring additional skills through an approved training program. Skills-based pay encourages both employers and employees to upskill, which can help address displacement by AI:

- Employers are disincentivised to fund ongoing education for workers when there are opportunities for them to leave for greater pay, as is the case with skills complementary to AI in the near future.
- Skills-based pay initiatives establish a framework where arming existing staff with new skills, rather than competing for a share of those already qualified in the labour market, is less risky.
- Older workers with established lives may be more hesitant to leave or reduce work for reeducation compared to younger adults who tend to have less established lives. Skill-based pay allows reeducation as a part of the work.

RECOMMENDATIONS AND FUTURE RESEARCH

This project investigated and argues the benefits and consequences of a variety of solutions to automation of jobs and their validity for the New Zealand labour market. Given the findings made thus far, skills-based pay shows promise in addressing the unique needs for the AI in the New Zealand workspace, but there are other solutions to investigate further.

This project had a number of limitations, including the lack of detail in the 2023 Census data compared to PIAAC or O*NET data. Much of the existing studies on AI within New Zealand businesses thus far has been privately funded by AI enthusiasts, which provides useful insights into the local work sector but does make it difficult to account for potential bias.

Sin-Taxes: Quality vs Quantity

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato
Te Raupapa | Waikato Management School

1: Background

- Reducing tobacco consumption is essential for improving public health outcomes and reducing economic inequality. In Indonesia, tobacco use is highly prevalent, being the second largest expenditure for the poor (WHO, 2020).
- **Sin-taxes** are aimed at reducing tobacco consumption by increasing prices. Consumers can respond by decreasing the quantity and quality of the tobacco products they consume.
- **Price elasticities** tell us how people respond to price changes.

2: Problem

Most cigarette-demand studies ignore the consumer's ability to substitute to cheaper brands, resulting in overstated price-elasticity estimates, and an overestimation of consumption reductions in response to sin-taxes (Gibson & Romeo, 2017).

3: Objectives

1: Estimate the price elasticity of cigarette demand in Indonesia, controlling for quality substitution.

2: Highlight the consequences of ignoring quality substitution.

4: Methods

Data: Indonesia Family Life Survey, a longitudinal dataset with information on individuals' cigarette purchases and consumption.

Model: We used a double-log regression model to estimate the price elasticities for quantity consumed and purchased. To control for quality substitution, we used **brand-level fixed effects** as a proxy for quality.

$$ln\, Q_i^{c,p} = \propto_1 + \beta_1 ln\, x_i + \theta_1 ln\, p + \delta_H b_H + \gamma_1 z_i + \varepsilon$$

Comparison: By excluding brand effects from the model, we get price elasticity estimates that fail to control for quality substitution. Comparing the two estimates will highlight the consequences of ignoring quality substitution.

References

Gibson, J., & Romeo, A. (2017). Fiscal-Food Policies are Likely Misinformed by Biased Price Elasticities from Household Surveys: Evidence from Melanesia. *Asia & the Pacific Policy Studies*. DOI: 10.1002/app5.189

World Health Organization. (2020). *WHO statement: a healthy and prosperous Indonesia through raised tobacco taxes and prices.*

5: Results

- These results confirm that ignoring quality substitution leads to a significant overstatement of price elasticities.
- Tax simulations show that ignoring quality substitution leads to a **56% overestimation** of the reduction of cigarette consumption in response to sin-taxes.

6: Conclusion

These results highlight the importance of controlling for quality response when estimating price elasticities, and quantifies the impact of failing to do so.

Accurate demand modeling is crucial for designing effective sin-taxes, not only for cigarettes, but also for other goods such as alcohol and sugary drinks (Gibson & Romeo, 2017).

By John Flood, supervised by Prof. John Gibson & Dr. Susan Olivia

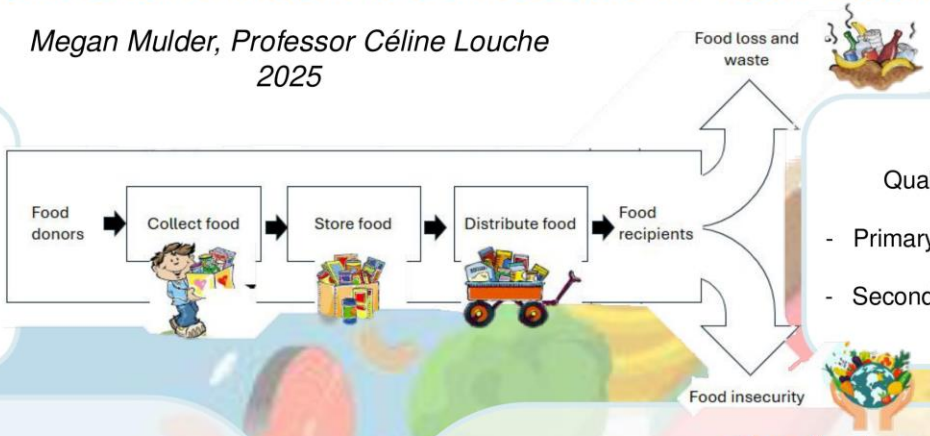
How COVID-19 transformed Food Rescue in New Zealand?

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Megan Mulder, Professor Céline Louche
2025

Background

Food rescue organisations in New Zealand play a vital role in reducing food waste and alleviating food insecurity (1). During the COVID-19 pandemic, these organizations experienced significant changes in their operations (2). In the post-pandemic era, the sector faces ongoing challenges. This research explored the impact of COVID-19 on the food rescue industry in NZ.



Methodology

Qualitative, explorative research

- Primary data: 18 interviews with NZ food rescue organisations
- Secondary data: reports, websites, news articles

Results

Funding shifts

⇧ in funding during COVID from MSD
= less competition, easy funding

⇩ in funding post-COVID
= more competition, hard to get funding

NOW = Exploring new funding sources and business models

Emergence of New Practices

Organisations have shown capacity to innovate to new challenges post-COVID

BUT the lack of funding remains a significant barrier

Professionalization of the Sector

⇧ Standardisation & structuration:
= Developing working standards
= Unifying organisations
BUT concerns about over-standardization and losing local focus.

Measurement & Accountability
= Showing and reporting on their impact

Systemic Challenges

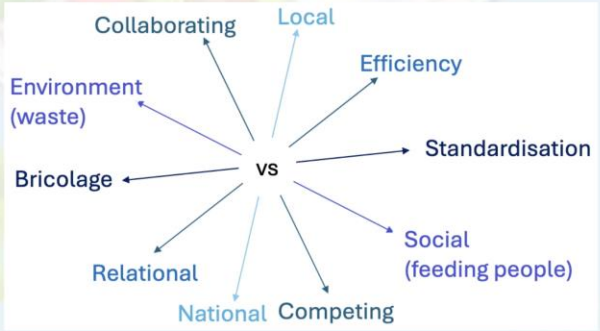
Food rescue is not a long-term answer to food insecurity or food surplus.

Tension between reducing surplus food and ensuring enough food for vulnerable populations.

Systemic changes needed to create a more sustainable and equitable food system.

Conclusion

Food rescue organisations face multiple paradoxical tensions



Challenges moving forward

Multiple paradoxical tensions	⟹	Embracing the tensions and building capacity to deal with tensions
Building resilience	⟹	Building new business models & practices
Addressing the systemic issues	⟹	Broadening the discussion to advocate for change

References
(1) Clare, G., Diprose, G., Lee, L., Bremer, P., Skeaff, S., & Mirosa, M. (2023). Measuring the impact of food rescue: A social return on investment analysis. *Food policy*, *117*, 102454. https://doi.org/https://doi.org/10.1016/j.foodpol.2023.102454
(2) Juliet Gerrard. (2022). *Food waste series - Report 2: Food rescue in 2022: Where to from here?* The Office of the Prime Minister's Chief Science Advisor. https://dx.doi.org/10.17608/k6.opmcsa.21218243.v3

Minh Hang Nguyen
Supervised by
Dr. Sandy Muller
Dr. Anthony Richardson

BRIDGING GAPS

Promoting Equitable Work-Integrated Learning (WIL) for Disabled Students

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Scan here for **References**!

Introduction & Methods

Disabled students often face barriers like **lack** of **accessibility**, **insufficient support**, & **limited employer awareness** during WIL course. *(Dollinger et al., 2022)*

Aims:
Understand the lived experience of **equitable** access of **WIL** for **disabled** students at The University of **Waikato,** identifying **challenges** & proposing **recommendations**

Gaps: limited research on disabled students experiences in WIL in New Zealand

Mixed-method

50 **survey responses** from disabled students in WIL

04 **focus interviews** for qualitative insights

well-accommodated
inclusive unclear requirements
late feedback kind supervisors
exclusion flexible anxiety
digital accessible
stressful supported
physical barriers online
remote long commute
(students' voices)

Finding 1

Support Systems

48% reported course adaptations
Flexible in course **delivery** (online, part-time), Weekly check-ins

52% reported Inconsistent support across courses, **reactive** rather than proactive accommodations
Lack of **preparation**, orientation
Communication gaps between students, convenors & placement sites

Finding 2

Inclusion & Belonging

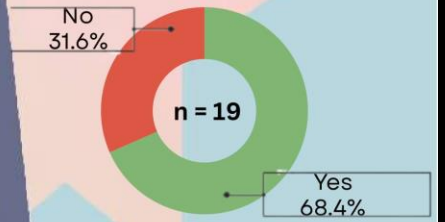
81% felt included by Supervisors and WIL support staff

19% felt unsupported:
- **Rushed** placement process & **limited** peer **interaction** (remote setups) caused isolation
- **Miscommunication** hindered full belonging

Finding 3

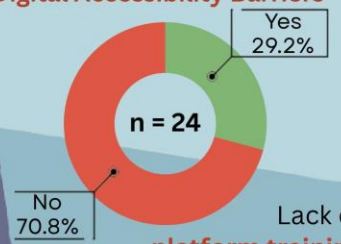
Accessibility

Physical Accessibility Barriers



Long **commutes**, lack of handrails, transportation difficulties

Digital Accessibility Barriers



Lack of **platform training**, inconsistent digital tool implementation, **scattered** information

We recommend

Despite encouraging signs, significant gaps remain, requiring further actions to achieve equitable WIL experiences.

Create a **database** of **disability-friendly employers**
Train staff and workplace supervisors on disability support **guidelines** and inclusive practice
Improved support system: regular check-ins (weekly Zoom calls) → foster inclusion, address challenges
Digital accessibility: **Training** on **digital tools**, standardized accessibility guidelines, and **timely feedback**
Better **peparation**: early **needs assessment**, detailed placement information, **orientation** programs, consider **proximity** to students' residences

AI-Driven Risk Assessment for Vessel Bioinvasion

Xiaodong Yan[1], Nadia M Trent[1], Oliver Floerl[2], Minh Kieu[3]

[1] University of Waikato, [2] Land Water People, [3] University of Auckland

Introduction

Global shipping is a major pathway for the spread of non-indigenous species (**NIS**), posing significant ecological and economic threats to New Zealand's marine ecosystems.

Traditional risk profiling frameworks for international vessel arrivals rely on manual interrogation of voyage and maintenance history, resulting in limited accuracy.

This study leverages Automatic Identification System (**AIS**) data, **Marine Bioinvasion Risk Data**, **Deep Learning**, and **Machine Learning** to cluster vessels according to potentially risky vessel trajectories. These clusters can be used to prioritise vessel screening.

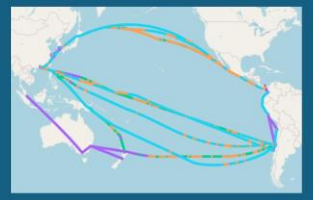


Figure 1 : A sample of AIS dataset

Methodology

Datasets

- Historical **AIS data** track vessel movements, port visits, and voyage patterns to analyse shipping trends and risks.
- **Marine Bioinvasion Risk Data** assess environmental similarity, geographic distance, and latitudinal crossing risks to evaluate bioinvasion threats.

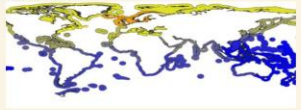


Figure 2: A Sample of the Marine Bioinvasion Risk Dataset

Data Preprocessing

- **Data Cleaning:** Filtering events, standardising port names, and handling duplicate records to ensure consistency.
- **Voyage Construction:** Defining unique voyages (≤2 months, ≥5 port visits) and mapping their paths across regions.
- **Risk Factor Calculation**: Assessing bioinvasion risks by calculating ecological risk scores across various geographic regions, using Marine Bioinvasion Risk Data for comprehensive analysis.

Model Architecture and Methodology

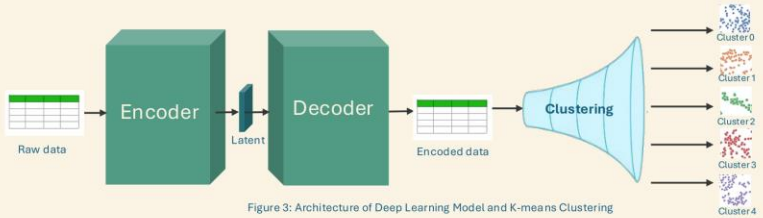


Figure 3: Architecture of Deep Learning Model and K-means Clustering

LSTM Autoencoder

- **Encoder:** Processes input data and encodes it into a **lower-dimensional** latent space, capturing key temporal dependencies.
- **Latent Representation:** Holds the compressed representation, acting as a foundation for data reconstruction and uncovering temporal patterns.
- **Decoder:** Reconstructs the original input data from the latent space, aiming to restore **temporal patterns** with a balance between accuracy and efficiency.

K-means Clustering

- Clusters encoded vessel trajectory data from the LSTM model to identify distinct navigation patterns.
- Employs **unsupervised learning** to group similar voyage patterns.
- The optimal number of clusters (5) was determined via the **elbow method** and **silhouette score** to assess cluster cohesion and separation.

Result

Cluster Quality Analysis

The K-means clustering via t-SNE shows distinct grouping, with some clusters well-separated and others slightly overlapping.

- **Clusters 1 and 4** show better cohesion.
- **Clusters 2 and 3** have lower consistency.
- The clustering reveals distinct navigation patterns.

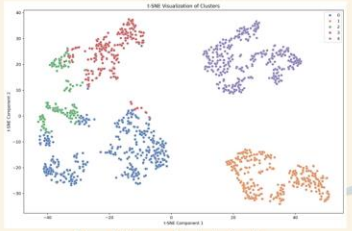


Figure 4: K-means Clustering Results

Cluster 1 Pattern Analysis

- All voyages connect major ports in Asia and Australia, crossing both tropical and temperate zones.
- Tropical-to-temperate crossings expose vessels to diverse conditions, potentially reducing NIS survival from Asia.
- Short intra-regional voyages from Australia may pose higher bioinvasion risks.

Figure 5: Cluster 1 Pattern Analysis

Conclusion

This study successfully identified five distinct vessel movement patterns through the application of an LSTM Autoencoder and K-means Clustering, producing valuable clustering insights. These findings contribute a crucial dataset for advancing risk assessment in vessel bioinvasion.

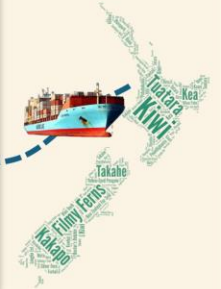
Parameter optimisation confirmed the model's stability, while dimensionality reduction visualisations validated the clustering structure, reinforcing its reliability.

Further Study

Clustering results can be further improved by optimizing feature engineering or hyperparameters.

Feature interpretation is needed to better understand the real-world significance of each cluster.

Exploring **semi-supervised** approaches can help integrate expert knowledge and effectively validate clustering results.



Acknowledgements

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PACIFIC TRADES SCALING GLOBALLY

International Agriculture Trades from the Pacific

By Blessing Pasi

INTRODUCTION

Pacific nations are primarily known for their hospitality and tourism. Yet they are enriched with natural resources such as palm oil, sugar canes, coconuts and coco beans. Over the years the South Pacific has seen growth and development in exportation values (USD) and quantities (tonnes) of products. Many of these nations operate at a much smaller scale in land area and population size compared to their trade partners such as Japan, Australia and New Zealand. Although the export of goods from the Pacific has grown over the years in value and quantity, they still fall behind other competitors and face competitive challenges with other nations. Through this research we analyse Pacific Island trade in primary produce and identify successes and challenges for Pacific Island nations.

METHOD

The database derives from FAOStat (food and agriculture statistics), World Bank, textbooks, Pacific trade related resources and individuals who have helped elevate this research. Data collected was analysed using Excel spreadsheets to generate tables and graphs of exports volumes and values of all Pacific Island nations' primary product exports.

FINDING

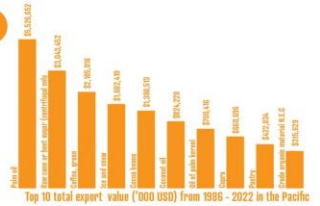
Findings from analysis of Pacific nations exports reveal an increase in volumes over the years from 1986 - 2022 (seen in Figure 3 and Figure 4). In recent years all Pacific countries have faced GDP growth challenges as they have recovered from COVID-19. Rich with raw materials and natural resources, the scale of trade for the Pacific has expanded over the years. With high export values and quantities of products such as palm oil, sugar cane and ice and snow (eg: Fiji water) - the Pacific region is beginning to make an established reputation in trading. MyNZTE states that the volume of trade from the Pacific has increased by "5% per year, on average, since 2000" and is also ranked 7th largest market by export value in New Zealand (2024).

With the growth of trades in the Pacific, the barrier of expansion is still evident. The lack of marketing, financing, infrastructures and changes both in the market and environment are some of the barriers the Pacific faces. Despite these factors and the additional barriers listed in Figure 1 - the vastness of the Pacific Ocean covers 1/3 of the earth's surface. The positioning and marketing of Pacific nations will not only rely on its tourism but venture into solidifying trading routes and deals. Also, considerations of other new products/new entrants that could enter the market eg: coconut jam (siamu popo) from Samoa.

RESULTS

1 EXPORTATION BARRIERS FOR PACIFIC NATIONS

2



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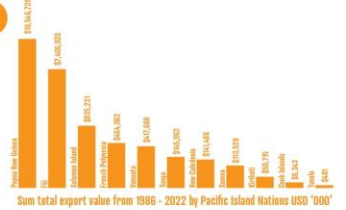
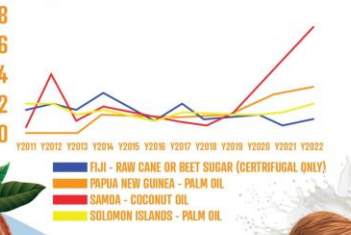


5 Index Line Graph of top export valued products from Pacific Nations:



PACIFIC ISLANDS EXPORTING ROUTE

DISCUSSION

From these findings we've identified the opportunities and challenges that the Pacific faces with trade. The opportunity of diversification through new products eg: coconut jam (siamu popo) from Samoa and concentrating on current top exported products from each Pacific nation (relating to Figure 5 and Figure 2) such as palm oil can grow in export value and quantity. Development around infrastructure and marketing will also enable upward movement for Pacific trading and see growth in economic benefits for these nations. From this it can enhance a better positioning for Pacific nations and can build resilience and adaptability to overcome environmental and market challenges.

CONCLUSION

To conclude, the importance of trading on a global scale will assist in the long run for many Pacific Island nations. There are many factors that are moderated by macro trends and can overrule the exportation of products. The overarching factor is that most of these Pacific nations are still on the road of development, but this does define nor conclude their efforts in scaling on a bigger scale - despite its smallness in size.

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Waikato University

Tessa Avelea
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References:

Food and Agriculture Organization of the United Nations. (n.d.). Faostat. https://www.fao.org/faostat/en/#data/TCL

Haas, A. (1977). New Zealand and the South Pacific: A guide to economic development in the Cook Islands, Fiji, Niue, Tonga, and Western Samoa. Asia Pacific Research Unit

MyNZTE. (2024, January 24). Is the Pacific the right market? myNZTE. https://my.nzte.govt.nz/article/20240124-is-the-pacific-the-right-market

Sawyerr, A. (1984). Economic development and trade in Papua New Guinea: Proceedings of the fourteenth Waigani Seminar, 1981, University of Papua New Guinea.

World Trade Organization. (2023, November 15). Services Trade Restrictions Index in the Index. Power BI. https://app.powerbi.com/view?

Designed by Tony Taie

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Congratulations to all our Summer Research Scholars