IEEE Instrumentation and Measurement Society
New Zealand Chapter

Workshop on Sensing, Measurement and Instrumentation

10th – 11th November 2025

University of Canterbury, Christchurch

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Workshop webpage

https://www.canterbury.ac.nz/ieee-ims

Welcome

On behalf of the University of Canterbury, the Electrical & Computer Engineering (ECE) department, and the IEEE Instrumentation and Measurement Society NZ Chapter, it is our pleasure to extend a heartfelt welcome to all delegates, presenters, and attendees of the 2025 Workshop on Sensing, Measurement, and Instrumentation.

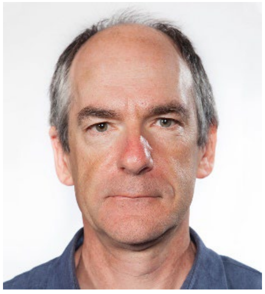
We warmly invite you to contribute to dynamic discussions and share your latest research, innovative ideas, and practical applications in the field of sensors and measurement technologies.

This workshop offers a collaborative platform for networking and exchanging insights with fellow researchers. With an extensive program featuring 48 oral presentations—including an invited speaker—and a wide range of topics, this year's event promises stimulating conversations and meaningful collaborations.

We are especially grateful for the support and interest shown by all attendees, speakers, and volunteers, without whom this event would not be possible. Our sincere appreciation goes to our sponsors for their generous financial contributions, enabling the realization of this workshop at the University of Canterbury.

Lastly, we invite you to join us at the Monday evening conference meal, providing a relaxed setting to foster further connections and discussions.

Michael Hayes
Workshop General
Co-Chair



Bill Heffernan
Workshop General
Co-Chair

Dr Akbar Ghobakhlou
IEEE IMS NZ Chapter
Chair

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Director of EPECentre

Thank you to all our event partners and sponsors

Workshop Venue

John Britten 102 conference foyer, 69 Creyke Road, Ilam, Christchurch 8041

Invited Speaker

Jonathan Bradshaw

Cleverscope

Cleverscope has been building a transistor digitizer to measure all the parameters of a switching high or low side transistor. Our original plan was presented at PCIM in May this year in Nürnberg. Since then, our Jonathan Bradshaw (PhD, ABB worker for 4 years) has been debugging the initial spin of the hardware design and writing the software interface system.

In this talk he will work through getting the design up and running, the trade-offs we have had to work through, and the changes we have had to make. Nothing is ever simple! The digitizer (actually 7 ADC's) is part of a larger system, and there is a lot of software to write. Our goal of continuous measurement, as well as Double Pulse Test, has affected the approach we have taken quite a lot. Jonathan will talk about all of this.

Workshop on Sensing, Measurement and Instrumentation

Monday 10th November 2025 (Day 1)

Start	End	Activity	Description	Speaker
8.30AM	8.55AM	Break	Registration and welcome coffee	
9.00AM	9.05AM		Opening: Welcome and H&S briefing	Michael Hayes
9.05AM	9.30AM		Invited talk: A New GaN/SiC Transistor Digitizer	Jonathan Bradshaw
9.30AM	10.30AM		Session 1	
9.30AM	9.45AM	Session 1	Novel current-transformer-based current sensor for high-bandwidth measurement of power transistor switching characteristics	Reece Cateley
9.45AM	10.00AM	Session 1	FPGA-based control scheme for voltage-balancing of series arrangement of GaN HEMTs	Vedang Gaikwad
10.00AM	10.15AM	Session 1	DC-Biased current transformer for shunt resistor replacement	Andrew Limmer-Wood
10.15AM	10.30AM	Session 1	Electrical Measurement of Core Loss in Solenoid Transformers	John Morris
10.30AM	11.00AM	Break	Morning tea	
11.00AM	12.30PM		Session 2	
11.00AM	11.15AM	Session 2	Next Generation Vision Measurement Systems - What you see, how you see, how you decide	Melanie Ooi
11.15AM	11.30AM	Session 2	Integration of Proximal Hyperspectral Imaging Technology and Deep Methods for Intelligent Measurement: Applications in Precision Agriculture and Forensic Analysis	Shah Faisal
11.30AM	11.45AM	Session 2	Forensic Analysis Using Hyperspectral Imaging	Yaminn Thawdar
11.45AM	12.00PM	Session 2	Revealing Invisible Forensic Evidence with Hyperspectral Imaging	Anna Savitskaia
12.00PM	12.15PM	Session 2	Light as a Sensor	Sanush Abeysekera
12.15PM	12.30PM	Session 2	Creating Datasets for Camera Calibration	Minu Joy
12.30PM	1.30PM	Break	Lunch	

Workshop on Sensing, Measurement and Instrumentation

Monday 10th November 2025 (Day 1)

Start	End	Activity	Description	Speaker
1.30PM	3.00PM		Session 3	
1.30PM	1.45PM	Session 3	In-Situ Techniques for Soil Moisture Monitoring in Precision Agriculture: Improving Irrigation Water Efficiency	Jorden Nom
1.45PM	2.00PM	Session 3	Automated “bucket tests” from space to detect and localise faults in centre pivot irrigation systems	Jaco Fourie
2.00PM	2.15PM	Session 3	Assessment of Mandarin Maturity Using Visible–NIR Hyperspectral Imaging and Machine Learning	Mengmeng Wu
2.15PM	2.30PM	Session 3	Attention Guided Band Pruning AGBP	Chenyang Ma
2.30PM	2.45PM	Session 3	Treetap9: a standing tree stiffness measurement tool	Michael Hayes
2.45PM	3.00PM	Session 3	Gated-Attention U-Net for Adaptive Channel Selection in Hydrometeorological Event Detection	Achmad R. Pahlevi
3.00PM	3.30PM	Break	Afternoon tea	
3.30PM	5.15PM		Session 4	
3.30PM	3.45PM	Session 4	Electromagnetic Detection of Foreign Bodies Flowing in a Pipe with Continuous Longitudinal Electric Field Excitation	Jarrod Zhu
3.45PM	4.00PM	Session 4	Estimation of Object Volume using Surface Electric Potential and Neural Network Regression	Kin Wai Lee
4.00PM	4.15PM	Session 4	Sensitivity of Varying Electric Field Geometries to the Presence of Foreign Objects	Syn Hei (Ethan) Yong
4.15PM	4.30PM	Session 4	Impedance-based detection of foreign objects flowing in food pipelines	Niloofar Rezaei
4.30PM	4.45PM	Session 4	Simulated Analysis of Foreign Object Detection in Food Processing Using a Tubular Capacitive Sensor	Chathurka Karunanayake
4.45PM	5.00PM	Session 4	Simulation of an Electrical Sensing Approach for Online Fouling Detection in Milk Pipes	Gihan Kuruppu
5.00PM	5.15PM	Session 4	Spectral–Spatial Feature Learning for Milk Powder Classification	Shufan Luo
5.30PM	6.00PM		IMS Committee Meeting	
5.30PM	6.30PM		Drinks	
6.30PM	8.00PM		Conference dinner	

Workshop on Sensing, Measurement and Instrumentation

Tuesday 11th November 2025 (Day 2)

Start	End	Activity	Description	Speaker
9.00AM	10.30AM		Session 5	
9.00AM	9.15AM	Session 5	The Effect of Skin Tension on the Efficiency of Jet Injections	Julio Christian Martadi
9.15AM	9.30AM	Session 5	Quantifying Heating during Jet Injection	Ben Hutchison
9.30AM	9.45AM	Session 5	Thermopiles for isothermal microcalorimetry	Connor Sutton
9.45AM	10.00AM	Session 5	An Integrated Workflow for Measuring the Complex Modulus of Actively Contracting Cardiac Muscle	Zisen Zhou
10.00AM	10.15AM	Session 5	Using EMG Autocorrelation to Estimate Impulse Conduction Velocity and Its Viability as a Muscle Fatigue Metric	Harvey Morison
10.15AM	10.30AM	Session 5	Deterministic control at high data rates using LabVIEW and FPGAs	Gregory B. Sands
10.30AM	11.00AM	Break	Morning tea	
11.00AM	12.30PM		Session 6	
11.00AM	11.15AM	Session 6	Far Red Light (700-750 nm) for Cyanobacteria Growth	Allan Donald Tirkey
11.15AM	11.30AM	Session 6	Designing a Far red LED light panel for Cyanobacteria protection	Nil Shihora
11.30AM	11.45AM	Session 6	The MBIE LakeCast Project: Short-term forecasting of lake chlorophyll-a concentration based on multi-instrument observation fusion	Lanxi Li
11.45AM	12.00PM	Session 6	The MBIE LakeCast Project: Forecasting Stratification to Understand Cyanobacterial Bloom Dynamics in Lake Rotorua Using High-Frequency Lake Monitoring and Data-Driven Models	Sepideh Heydari
12.00PM	12.15PM	Session 6	Edge Device for Long-Term New Zealand Forest Sound Scape Monitoring	Amin Barzegar
12.15PM	12.30PM	Session 6	Cross-Model Confusion Mapping: Reducing False Positives in Edge-AI Bioacoustic Detection of Possums	Amin Barzegar
12.30PM	1.30PM	Break	Lunch	

Tuesday 11th November 2025 (Day 2)

Workshop on Sensing, Measurement and Instrumentation

Start	End	Activity	Description	Speaker
1.30PM	3.00PM		Session 7	
1.30PM	1.45PM	Session 7	Development of a national thruster test facility for electric propulsion at Robinson Research Institute, New Zealand	Emile Webster
1.45PM	2.00PM		Thermal characterisation of an HTS applied field module for incorporation with a miniaturised magnetoplasmadynamic thruster	Max Goddard-Winchester
2.00PM	2.15PM		Super conducting magnet and coil testing system to enable development of electric propulsion at Robinson Research Institute, New Zealand	Cameron Shellard
2.15PM	2.30PM		In-plume low-parasitic thrust stand	Andrew Limmer-Wood
2.30PM	2.45PM		Methods for calibrating horizontally-acting force transducers	Andrew Taberner
2.45PM	3.00PM		Thermal time-of-flight measurement of low-velocity liquid metal flows	Taiji Endo
3.00PM	3.30PM	Break	Afternoon tea	
3.30PM	5.00PM		Session 8	
3.30PM	3.45PM	Session 8	Transient-Contact Excitation Acoustic Modelling for Lamb Wave Distance Estimation	Sam Spekreijse
3.45PM	4.00PM		The Polynomial RF Tuning Method	Toby Bell-Ramsay
4.00PM	4.15PM		Development and Characterization of Chitosan-Doped TiO_2 ETLs for Performance Enhancement and Stability in Perovskite Solar Cells	Huma Shahid
4.15PM	4.30PM		Towards Submicron Discontinuous Thin Films for Neuromorphic Computing	Thomas McKellar
4.30PM	4.45PM		Time-resolved magneto optic Kerr effect (TRMOKE)	Vinay Gudala
4.45PM	5.00PM		Development and Characterization of Hybrid Nanoparticle Photocatalysts for CO_2 Conversion	Lin Chao-Yang
5.00PM	5.15PM		Awards and Close	

Table of Contents

Novel current-transformer-based current sensor for high-bandwidth measurement of power transistor switching characteristics

Reece Cateley

University of Canterbury

Accurate characterisation of power transistor switching transients is necessary for optimal power electronics design. However the high-frequency current transients of wide-bandgap transistors are challenging to measure. In this paper, a hybrid current sensor is proposed which features a DC/low-frequency sensor such as a Hall-effect or magnetoresistive sensor, whose output is combined with high-frequency measurement from a current transformer (CT). The low-frequency measurement is also used to cancel low-frequency flux in the CT core to avoid saturation. This architecture is combined with other technologies aimed at increasing the high-frequency capabilities of the current sensor. Specifically these technologies are: the cascading of CTs to reduce the number of turns and resultant parasitic effects; and the use of a transimpedance amplifier rather than a burden resistor at the output of the CT. Preliminary LTspice simulations of the current sensor present a flat frequency response from DC up to a -3dB cutoff frequency of 100MHz. A +/-60A version of the sensor has been built and validated at low frequencies. Improvements to the experimental setup are required to measure the sensor's high frequency response. This is the focus of ongoing work.

FPGA-based control scheme for voltage-balancing of series arrangement of GaN HEMTs

Vedang Gaikwad

University of Canterbury

Using multiple lower-power switches in high-power applications has been shown to deliver better performance compared to a single high-power device. By connecting several switching devices such as gallium nitride (GaN) high electron mobility transistors (HEMTs) in series, the combined array can sustain higher voltages, offering a more efficient and scalable alternative. However, for the series-connected switches to operate as a single, unified device, it is essential that the total voltage is evenly shared among all HEMTs at all times.

DC-Biased current transformer for shunt resistor replacement

Andrew Limmer-Wood

University of Canterbury

A difficult problem when operating a current-mode DC-DC converter is how to measure the current in the system. Conventionally this is done by utilising a current shunt resistor on the low side of the switching bridge to convert the current into a voltage for the controller to compare against. Unfortunately, this current sense resistor can dissipate a significant amount of heat if it has too high a resistance. The tradeoff between the amplitude of the signal and the power loss must be balanced against each other. Current transformers are an attractive way to measure the current and allow for a high amplitude output signal, but are typically used only in AC applications due to the need to keep balanced volt-seconds on the windings. To solve this problem a negative peak sensing circuit has been combined with an integrator to allow a self-zeroing current transformer system to be built that can handle pulsed DC waveforms as seen in DC-DC converters

Electrical Measurement of Core Loss in Solenoid Transformers

John Morris

University of Canterbury

Present research into solenoid transformers* requires quantification of inductively coupled loss effects in the transformer core and windings. Due to the nature of the solenoid transformer flux profile, significant eddy current loss may occur in the windings, and standard estimations for core losses may not be valid. The present work seeks to apportion such inductively coupled losses at full working voltage in the frequency range of 8-50kHz.

A technique is presented to isolate core losses by modifying the windings. The measurement issue arising from this technique is explored and the technique is modified by using a different winding material to achieve better core loss estimation.

The technique assumes equal eddy current loss in primary and secondary windings due to their identical bifilar construction. Power loss measurements are made for the open circuit transformer with and without the secondary winding in place. Without the secondary winding, power loss is lower, and the difference is assumed to be the eddy current loss contribution of the secondary winding. If true, doubling this loss would represent the eddy current loss in both windings and when subtracted from total induced loss, the remainder should be the power dissipated in the core.

The results show however, that as frequency increases, calculated core loss is uncharacteristically low. Other proximal inductive coupling effects may be at play and therefore eddy current loss in the windings remains undefined and core loss cannot be isolated by this method when the windings are made from solid conductors.

The same approach is attempted using windings made from bunched conductor, and a much clearer estimation of core loss is achieved. Bunched conductor is shown to be near invisible to the influence of proximal and radial magnetic fields that cause eddy current loss in solid conductor windings, and therefore by using bunched conductors, core loss can be measured directly.

*A solenoid transformer is constructed on a slender open core with a length-to-diameter ratio of between 15 and 100. e.g. for a ratio of 80, a core with diameter 10mm has a length of 800mm. In addition, solenoid transformer windings are formed in one layer, and the present case, the experimental transformers are 1:1 bifilar wound (side-by-side primary and secondary) over the full length of the core so that the windings are electrically identical to each other.

Next Generation Vision Measurement Systems - What you see, how you see, how you decide

A/Prof. Melanie Ooi

Waikato Instrumentation & Measurement Research Group, University of Waikato

The journey from “what you see” (the physics of light) to “how you see” (the measurement process) and ultimately “how you decide” (data analysis and decision-making) is fraught with complexities, because light is fundamentally an operational measurement. The meaning of measurements from an imaging system is determined by the operation of the system, not just the physics or machine learning model. State-of-the-art machine learning algorithms are used as a passive, “backend” tool that analyses images after capture. This forces reliance on impossibly large training datasets to account for every real-world variable, which is an insurmountable bottleneck in real-world vision measurement systems. This presentation takes an overview on building reproducible, and standardised practices across the entire vision-based measurement and data analysis pipeline, from how light is controlled and captured, to how imaging systems are calibrated, and how the resulting data is analysed and reported with appropriate uncertainty quantification. It questions whether the next generation vision measurement systems can push the machine learning to the “frontend” of the imaging pipeline by allowing the AI to actively control the physical illumination source in a closed-loop, allowing AI to physically tune its incoming images based on the rules it discovers during modelling, and the light it controls. For example, the system can test its own decision by stating, “I illuminated the scene with 635nm light to test for the presence of blood, and the resulting spectral response violated Rule X, confirming it is not blood.”

Integration of Proximal Hyperspectral Imaging Technology and Deep Learning Methods for Intelligent Measurement: Applications in Precision Agriculture and Forensic Analysis

Mr. Shah Faisal

Waikato Instrumentation & Measurement Research Group, University of Waikato

Hyperspectral imaging (HSI) captures detailed spectral and spatial information, and it is a robust and non-destructive measuring instrument in a wide range of applications. In this study, the use of HSI with statistical machine learning and deep learning methods, i.e., Partial Least Squares Regression (PLSR), Artificial Neural Networks (ANN), Convolutional Neural Networks (CNNs), and transformer-based networks, is investigated to enhance analysis accuracy, precision, and interpretability. Our work focuses on pixel-wise spectral-based regression, classification and clustering for two primary applications such as smart agriculture and forensic analysis. For smart agriculture, we are measuring the chemical compounds of plants (e.g., THCA: tetrahydrocannabinolic acid, CBDA: cannabidiolic acid, nitrogen) and analyzing surface characteristics and harvesting conditions of blueberries. For forensic analysis, we are classifying biological samples (e.g., blood, semen, urine) on various fabrics. At the same time, we are formulating uncertainty quantification and visualization techniques to quantify model confidence and support reliable decision-making under variable data conditions. To capture the full potential (spatial-spectral dependencies) of hyperspectral data in an efficient manner, our ongoing research interest is developing such models which incorporate both spatial-spectral relationship efficiently to enhance contextual understanding and robustness. This study goal how deep learning methods with hyperspectral technology can enrich the performance of measurement technologies across different real-world application scenarios from precision agriculture to forensic science.

Forensic Analysis Using Hyperspectral Imaging

Ms. Yaminn Thawdar

Waikato Instrumentation & Measurement Research Group, University of Waikato

The forensic analysis using hyperspectral imaging project builds well-structured and reproducible datasets from both visible and NIR cameras. Unlike traditional forensic analysis using a destructive chemical presumptive test, forensic HSI is a non-destructive and eco-friendly approach to maintain the integrity of evidence without producing hazardous waste. However, forensic investigations with HIS still have limitations, particularly non-uniform illumination, limited datasets, and difficulties in benchmarking among studies. To eliminate these limitations, we designed and built high-quality datasets, which are in-house datasets of 24 hyperspectral images collected from six fabric types with 18 individual and a mixture of fluid samples, and forensic datasets containing 160 images of 9 different fabric types from the New Zealand Institute of Public Health and Forensic Science (PHF Science). Imaging was operated with two HSI cameras: a Specim IQ camera (visible range, 400–1000 nm) and a Specim FX17e (NIR, 900–1700 nm), under controlled illumination and calibrated with dark and white references. Then, data preprocessing such as annotation, normalization, and data splitting for the train and test sets for supervised machine learning. The datasets are evaluated by using unsupervised spectral clustering to find out the spectral separability without having predefined labels and supervised machine learning models (SVM, Decision Tree, and KNN) to get the classification accuracy for individual samples. The results show that the datasets are usable and have high quality for forensic investigations. However, proper illumination systems are still required to get accurate normalization to improve the sample detection accuracy. This project contributes to developing HSI datasets which is reproducible for both laboratory and real-world forensic applications.

Revealing Invisible Forensic Evidence with Hyperspectral Imaging

Ms. Anna Savitskaia

Waikato Instrumentation & Measurement Research Group, University of Waikato

As a dataset, we have hyperspectral images with many segments, each of which contains a trace of a certain liquid. Our task is to develop an algorithm that can identify the location of the spot in the image; that is, in essence, our task is high-quality image segmentation using unsupervised learning. We proposed an algorithm whose core idea is to use spectral clustering for segmentation. However, during the development of the solution, we encountered a number of problems, such as how to eliminate noise in the data, the excessively large dimensionality of the data due to the fact that the images are hyperspectral, how to optimally select hyperparameters for segmentation, and what metric to use to evaluate the result. All these issues and potential solutions are discussed in this presentation. For each image, there is a set of hyperparameters that will be used in the algorithm and which must be selected for the best result. One of our goals is to build an algorithm that will also optimize the search for these hyperparameters. Several algorithms have been proposed for hyperparameter optimization, including the use of reinforcement learning to find the best hyperparameter to change. Several different metrics were also used to evaluate the results, including metrics that evaluate the hyperspectral information of the image, so we tried to understand how useful the spectral information contained in the images is for identifying clusters. We are currently focused on developing an algorithm for identifying and optimizing hyperparameters that will improve segmentation quality. We then plan to use reinforcement learning to classify the resulting segments.

Light as a Sensor

Dr. Sanush Abeysekera

Waikato Instrumentation & Measurement Research Group, University of Waikato

Recent advances in imaging have largely focused on algorithmic post-processing, while the role of illumination as an active sensing modality remains underexplored. Our research rethinks this balance by developing light-based imaging systems that integrate machine learning, spectral modeling, and adaptive illumination to enhance scene contrast and feature visibility. We design and fabricate multichannel, spectrally programmable luminaires capable of dynamically controlling wavelength composition and intensity distribution. These devices serve as both measurement tools and controllable optical sources, enabling new forms of object classification under optimized illumination spectra. At the algorithmic level, we investigate how different definitions of pixel intensity contrast influence machine learning–based spectral optimization, introducing a framework where contrast functions act as loss metrics. This allows the illumination spectrum itself, not just the imaging pipeline, to be optimized for a given task, thereby minimizing the need for complex downstream image processing. Applications include light-based forensics, and surface material discrimination. Ongoing work focuses on automated adaptive illumination, where feedback from the camera or classification model continuously adjusts the spectral profile to maximize discriminative contrast in real time. This presentation will showcase our system prototypes, spectral optimization results, and analytical models linking irradiance, pixel intensity, and camera spectral sensitivity. We aim to explore collaborations in optical hardware design, adaptive imaging algorithms, and domain-specific applications such as forensics, agriculture, and medical diagnostics.

Creating Datasets for Camera Calibration

Ms. Minu Joy

Waikato Instrumentation & Measurement Research Group, University of Waikato

Camera calibration is critical for accurately mapping physical scene properties to digital pixel values. The spectral sensitivity of a camera, which determines its response to different wavelengths, is affected by illumination, surface reflectance, and sensor characteristics. Direct measurement of spectral sensitivity is challenging and often impractical, motivating the development of standardized datasets that enable reproducible estimation. This work presents a comprehensive dataset framework to support accurate calibration and estimation of camera spectral sensitivity. The framework comprises three components: an LED Illumination dataset, capturing the spectral power distributions of eleven narrowband LED sources, a ColorChecker Reflectance dataset, containing 140 patches measured using a spectrometer under controlled conditions, and a Pixel Intensity dataset, including raw and normalized RGB values recorded with a Basler acA1300-200uc RGB camera under controlled illumination. The datasets establish a reliable link between physical measurements and RGB pixel intensities, enabling the training and validation of models to estimate the camera's spectral sensitivity function. The proposed framework provides a standardized, accessible, and reproducible foundation for calibration and characterization of imaging systems. By connecting measured physical properties to observed RGB pixel data, it facilitates accurate colour reproduction, supports the development of machine learning models for spectral estimation, and enhances the performance evaluation of imaging systems in both experimental and practical applications.

In-Situ Techniques for Soil Moisture Monitoring in Precision Agriculture: Improving Irrigation Water Efficiency

Jorden Nom, Christopher Hann and Ciaran Moore

Electrical and Computer Engineering Department, University of Canterbury

Precision agriculture relies on accurate and representative soil moisture measurements to optimise irrigation, improve crop productivity, and reduce environmental impacts such as runoff. Conventional soil moisture sensor types, such as time domain reflectometry and capacitance probes interrogate highly localised soil volumes, limiting their usefulness in paddocks with high spatial variability.

This research explores an alternative approach: a microwave soil moisture sensor that uses a pair of buried planar Vivaldi antennas in a transmit–receive configuration, as shown in Fig. 1. By propagating a microwave signal through the soil volume between the antennas, the system can interrogate a much larger sampling volume than traditional point-based probes, providing more representative information on soil water content. The received microwave signal is used to estimate the soil's effective permittivity, which can then be converted to volumetric water content.

Current work is focused on electromagnetic simulations to optimise antenna geometry, enclosure design, and operational frequency range. A key challenge is preventing soil loading of the buried antennas, which can detune performance. To address this problem, an optimised enclosure is under development to encompass the antenna's near-field, isolating it from direct soil contact and thereby preserving calibration and stability.

Simulation results from CST Studio Suite show that enclosed Vivaldi antennas can maintain impedance stability in soil-like environments, as shown in Fig. 2. Ongoing work will transition to controlled experiments in sand to characterise system response across moisture gradients and validate model predictions. Ultimately, the aim is to demonstrate a soil moisture sensing platform for precision agriculture that provides greater data confidence by interrogating larger soil volumes, thereby supporting more informed irrigation decision-making.

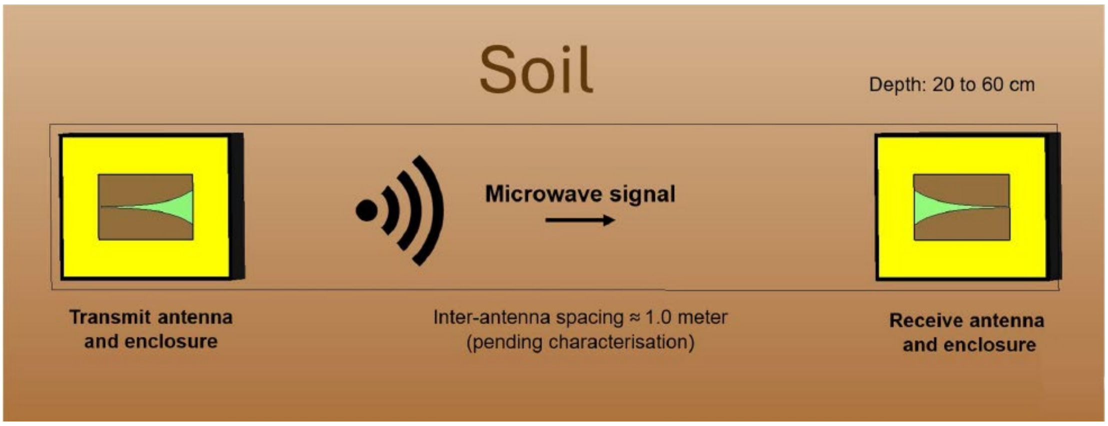

Figure 1. Microwave-based soil moisture sensing: a microwave signal is transmitted between two Vivaldi antennas, which are housed in epoxy filled enclosures and buried opposite each other.

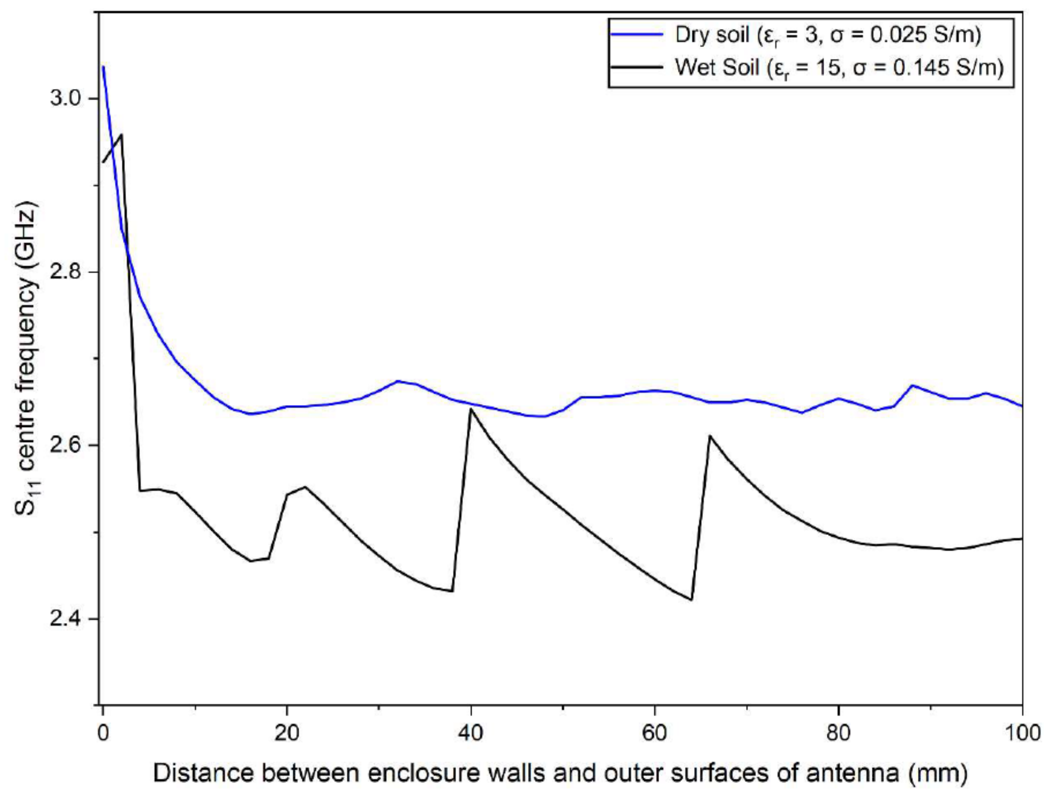

Figure 2. CST simulation results showing dependence of centre frequency on soil moisture and enclosure size. Loading due to the enclosure decreases for enclosures ≥ 80 mm from the antenna, while strong discrimination between wet and dry soil is preserved.

Automated “bucket tests” from space to detect and localise faults in centre pivot irrigation systems

Jaco Fourie

Lincoln Agritech, Lincoln University

Detecting irrigation irregularities is essential for preventing uneven water distribution in fields. Manual bucket tests remain the gold standard; however, their use is limited by effort and cost. We automatically identify and localise irrigation anomalies in centre pivot irrigation systems using high resolution satellite or aerial imagery. Our algorithm is based on the premise that irrigation anomalies cause circular patterns on the irrigated pasture that is distinct from other circular patterns caused by the irrigator itself, for example, wheel ruts from the irrigator wheels.

These patterns are caused by some areas receiving less irrigation, causing the underlying pasture to be less healthy compared to neighbouring areas. By using plant vigour as a proxy for water stress, we can identify patterns of irregular irrigation by using vegetation indices (VIs) constructed from multispectral images. Most VIs that highlight plant vigour rely on the near infrared (NIR) spectral band, but other options are also explored when NIR is not available.

Due to the high levels of noise and ambiguous circular features in the images, we use a custom circular feature detection algorithm. Unlike traditional approaches that rely on counting edge features that contribute to a circle parameter space (Hough transform), we use a curve detection and pruning algorithm to find arc candidates. These are then filtered and refined into a collection of circle candidates. This set is then fitted to the existing edge features using a least-squares optimiser before final refinement and refitting is done to produce the complete set of circle features. These circular patterns are then highlighted on the original aerial images to indicate where irrigator maintenance may be required.

Assessment of Mandarin Maturity Using Visible–NIR Hyperspectral Imaging and Machine Learning

Mengmeng Wu[1], Wei Yu[1], David Wilson[2] and Brent Young[1]

[1] Department of Chemical and Materials Engineering, University of Auckland, New Zealand

[2] Department of Data Science and Artificial Intelligence, Auckland University of Technology, New Zealand

Rapid, accurate field assessment of citrus ripening is vital for harvest timing and economic return. Yet orchards still depend on destructive Brix tests and subjective visual checks. A robust, non-destructive method that can deliver both ripening stage and sweetness in one pipeline is still missing.

We address this gap using visible–NIR (400–1000 nm) transmission hyperspectral imaging. Spectra were captured from peel and outer flesh across multiple harvest dates. Preprocessing used Standard Normal Variate normalisation. We explored structure with Principal Component Analysis (PCA) and *k*-means clustering, then built a Support Vector Machine for three ripening classes and a Partial Least Squares (PLS) model for Brix.

Outer-flesh spectra were the most informative for ripening. Bands near ~520 nm (microstructure/chemistry) and ~680 nm (chlorophyll) dominated separation. K-means suggested 3 maturity classes. The SVM achieved 90% accuracy for three maturity classes in the first two principal components. The PLS model predicted soluble solids (Brix) with R^2 = 0.86.

These results indicate that VIS–NIR HSI can non-destructively classify citrus maturity and estimate Brix in a single, field-oriented workflow, supporting more objective in-orchard grading and harvest decisions.

Attention-Guided Band Pruning for Lightweight Hyperspectral Imaging in Early Grapevine Disease Detection

Chenyang Ma, Akbar Ghobakhlou and Sira Yongchareon

Department of Data Science and AI, Auckland University of Technology

Presymptomatic detection of grapevine viruses is often constrained by the high spectral dimensionality of hyperspectral imaging (HSI) and the limited computational capacity of field-deployable instruments. This study introduces an Attention-Guided Band Pruning (AGBP) framework designed for visible near-infrared HSI in early disease detection. The proposed AGBP architecture, a lightweight spectral-attention module, is embedded within a 3D ResNet-18 backbone. Entropy regularization is employed to enforce sparsity in the learned band-importance distribution, while per-sample attention responses are stabilized through aggregation using an exponential moving average and trimmed-mean procedure. The aggregated profile ranks wavelengths for compact k-band retraining, allowing inference cost to scale directly with k.

Evaluation was conducted on a grapevine leaf dataset with polymerase chain reaction (PCR) ground truth, comprising 40 visible bands (510–710 nm, 5 nm spacing), fixed plant-level splits, and a unified preprocessing and training procedure. The 40-band reference model achieved a mean test AUROC of 0.7920, while the entropy-regularized AGBP model improved performance to 0.8173 under the same conditions. Compact AGBP-k models maintained near-baseline accuracy at drastically reduced spectral budgets: at k=4 and k=6, AUROC retention reached 0.9886 and 0.9921, respectively, with latency reduced from 24.52 ms to 2.64–3.57 ms and FLOPs lowered by approximately 9–10 times and 6–7 times.

Comparative analyses with filter-based selection methods show that AGBP outperforms Pearson, ReliefF, and Competitive Adaptive Reweighted Sampling (CARS) at k=4, making it preferable for strict latency or power constraints. At moderate budgets (k≥6), CARS attains slightly higher AUROC, supporting operating-point selection based on accuracy–efficiency priorities. Overall, the results demonstrate that learned band pruning produces sensor-ready wavelength subsets and predictable computational footprints for edge devices, enabling practical deployment in vineyard scouting and broader precision-agriculture applications.

Treetap9: a standing tree stiffness measurement tool

Michael Hayes

Electrical and Computer Engineering, University of Canterbury

Tree breeders want to breed trees with stronger timber since this can be used for construction and is thus more valuable. Unfortunately, strength measurement is destructive and instead timber stiffness is used as a proxy for strength. The longitudinal tree stiffness of a standing tree can be found using stress-wave time of flight. The standard approach is to insert a pair of vertically spaced accelerometers and to hit one of the accelerometers with a hammer. This induces a stress wave in the tree that is detected by the second accelerometer. Knowing the accelerometer separation and measuring the onset time of the two accelerometer signals allows the speed of propagation of the longitudinal compression wave to be estimated. Finally, the longitudinal stiffness can be determined knowing the wood density.

This presentation describes a device, Treetap9, that uses an alternative approach, where stress waves are induced in the tree with a mechanical impactor and a pair of vertically displaced accelerometers measure the difference in propagation time. Unlike the traditional approach, this approach does not require calibration for the accelerometer delays. The device consists of an electronics unit and a cellular phone or tablet. The electronics unit samples the measured waveforms from the accelerometers and sends them to the cellular phone via Bluetooth. The phone provides data storage, data processing, and the user interface. The electronics unit sleeps whenever possible to conserve battery life but wakes on detection of an accelerometer signal or by tilting of the unit.

Results from measurements with the device are discussed. An experiment is described showing the difficulty of estimating the frequency dependent stiffness using four time of arrival techniques: threshold, first peak, second peak, and windowed-correlation. All these techniques are shown to overestimate the stiffness due to the dispersive nature of the stress-wave signals.

Gated-Attention U-Net for Adaptive Channel Selection in Hydrometeorological Event Detection

Achmad R. Pahlevi and Akbar Ghobakhlou

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Satellite observations provide critical insights for monitoring hydrometeorological events across large spatial and temporal scales. However, selecting the most informative spectral channels remains a key challenge, as using all available bands may degrade model performance when training data are limited. The so-called Hughes phenomenon, where increasing dimensionality leads to overfitting and higher computational cost a Gated-Attention U-Net (GA-U-Net) framework for adaptive channel selection in multispectral geostationary imagery, with applications in rainfall estimation, cloud segmentation, aerosol retrieval, and wildfire detection. The architecture builds on the encoder–decoder design of U-Net to preserve spatial resolution, while gated attention modules in the decoder introduce task-specific weighting mechanisms to emphasize informative spectral channels. Sixteen channels from the Himawari-9 satellite were used as input to estimate the target, such as rainfall, using IMERG, as well as to analyse cloud type, aerosol, and hotspots with Level-3 satellite data. An event-aware sampling strategy was implemented to mitigate class imbalance and emphasize extreme events, including heavy rainfall, convective outbreaks, smoke plumes, and hotspots. The result displays the top 6 channels for each target, which are used to automatically split the windows. Model evaluation across contrasting geographic regions in New Zealand and Indonesia demonstrates the approach's generalizability and robustness. By integrating learnable channel selection within a deep learning framework, GA-U-Net enhances both interpretability and efficiency in real-time hydrometeorological monitoring.

Electromagnetic Detection of Foreign Bodies Flowing in a Pipe with Continuous Longitudinal Electric Field Excitation

Jarrod Zhu

Electric Power Engineering Centre, University of Canterbury

A novel scanning device has been developed to detect foreign bodies within food mixtures flowing through pipes. Foreign bodies are undesirable solid objects such as metal, plastic, glass, or rubber that can enter products from errors during production or harvesting.

The system applies a 10 kHz longitudinal excitation into an electrolyte, such as milk, and monitors changes in the electric and magnetic fields. It operates on the principle that most foreign bodies are either insulating (plastics or rubber) or highly conductive (metals) relative to the food medium. These foreign bodies alter the magnetic and electric fields. The resultant disturbances are detected by sensors positioned around the pipe: high-sensitivity search coils for magnetic fields and displacement current sensors for electric fields.

The prototype employs a microcontroller-based architecture for real-time data acquisition, capable of simultaneously sampling 320 sensors at a rate of 160 ksps. High-speed communications and on-board signal processing provide near real-time transfer and analysis of sensor data. Laboratory testing demonstrates that the device can reliably detect conductive and insulating objects as small as 2mm in diameter travelling through the pipe at speeds up to 2ms−1. The device provides a scalable platform for continuous, minimally invasive monitoring of liquid food streams, offering a promising solution for enhancing food safety in industrial processing environments.

Estimation of Object Volume using Surface Electric Potential and Neural Network Regression

Kin Wai Lee

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In dairy processing plants, filter traps remove unwanted foreign objects from food media to prevent physical contamination. To ensure normal production operations, these filters are cleared periodically based on the specific requirements for different food production processes. Typically, two alternative isolated parallel flow sections are installed, each containing filters. During the filter-clearing process, the food media is unloaded from the disconnected section, thereby making it unusable regardless of the condition of the filters, i.e., presence or absence of foreign object accumulation. This leads to inefficiency in operational cost and production output. This abstract presents an innovative approach to estimating the volume of foreign objects based on a lightweight neural network-based regression model. The lightweight model design ensures fast inferences for estimating the volume of foreign objects, which contributes to a more informed production operation, i.e., filter clearing is initiated only when the accumulated object volume exceeds a certain threshold value. The principle of detection is based on the signature produced by the perturbation of a uniform electric field within the sensing region, where distinctive characteristics between electrical conducting and insulating objects have been observed and validated in both experimental data and finite element model (FEM) results. By learning the complex mapping between low-resolution surface potential data and the target volume using only simulated data from the FEM, the proposed regression model shows promising volume estimation performances, despite the presence of signal ambiguity and noise interference. Evaluation of experimental results in a laboratory setup shows less than 6% percentage error in the estimated volume using a stainless steel sphere object.

Sensitivity of Varying Electric Field Geometries to the Presence of Foreign Objects

Syn Hei (Ethan) Yong

Electric power Engineering Centre, University of Canterbury

Dairy products are the most profitable export from New Zealand, and it is crucial that they meet quality standards. Foreign objects are unexpected items that can end up in dairy products and can include metals, plastics, pebbles, and glass. Existing foreign object prevention includes filters, metal detectors, and X-ray machines. Metal detectors cannot detect non-metallic objects and X-ray machines cannot detect objects if the dairy product and the foreign object have similar densities. Although filters can prevent foreign objects from the final dairy products, a build-up of foreign objects along the pipeline can potentially lead to contamination. Thus, it is important to use a detection method that can alert the dairy workers that a foreign object is present in their pipes. A method adapted from Electrical Impedance Tomography (EIT) is used for the concept of this novel detection. One similarity to EIT is the large array of electrodes. The difference lies in how the electrodes are used. While conventional EIT systems excite a pair of electrodes and read from the other electrodes, this novel detection method aims to have continuous excitation and continuous measurement. This method turns a traditionally high-spatial resolution, low-temporal resolution imaging technique into a high-spatial resolution, high temporal resolution imaging technique which is appropriate for this application. COMSOL modelling will be used to verify the effectiveness of varying the electric field geometry in the pipe and implementing multi-frequency excitation to increase the sensitivity to foreign objects.

Impedance-based detection of foreign objects flowing in food pipelines

Niloofar Rezaei

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This study presents an impedance-based sensing method for detecting foreign bodies within a conductive flowing medium in a food pipeline. The sensing principle relies on the difference in electrical conductivity between a foreign object and the surrounding food product. By measuring and analysing the system impedance, it is possible to determine the presence and type of foreign objects (conductive or insulating). A 100 kHz AC excitation voltage is applied across the pipeline, where stainless steel sections serve as electrodes and are separated by insulating sections. To improve measurement accuracy, a coaxial excitation method is employed to reduce coupling of magnetic fields, while a dual sensor configuration minimises common-mode interference. The resulting current is measured to calculate impedance variations caused by the presence of foreign objects.

In this study, the sensing geometry was parameterised to investigate the influence of structural factors on detection sensitivity. Parameters such as insulator length, object radial position, and object radius were varied to assess their effect on impedance response. Simulation results obtained using COMSOL Multiphysics indicate that, for small ratios of insulator length to pipe diameter, sensor sensitivity increases when the object moves closer to the pipe wall, and that a smaller electrode gap produces a higher relative difference in impedance. The results are compared with a laboratory set-up where the foreign objects are pumped in an ionic aqueous medium along the pipe and pass through the pair of sensors. Future work will focus on developing the configuration that, according to simulation results, provides enhanced sensitivity to foreign objects in liquid food processing systems.

Simulated Analysis of Foreign Object Detection in Food Processing Using a Tubular Capacitive Sensor

Mihiraj Karunanayake, Gihan Kuruppu, Wei Yu, Brent Young

Chemical and Materials Engineering Department, University of Auckland

The detection of low-density, non-metallic, and fine-sized contaminants remains a major challenge in food processing. This study presents a computational investigation of real-time foreign object detection using a tubular capacitive sensor designed for food processing monitoring. The sensor comprised a longitudinally split stainless-steel pipe (50 mm diameter, 50mm length) forming two electrodes separated by a thin insulating rubber layer and filled with flowing milk as the dielectric medium. A plastic sphere with a diameter of 5 mm, representing a low-dielectric foreign object, was introduced into the milk stream to examine the resulting capacitance variation. The measurement principle relied on impedance analysis using an LCR meter operating at 1 kHz, where the capacitance change corresponded to variations in the dielectric properties of the medium. MATLAB-based simulations were performed to visualize the object trajectories and estimate the capacitance response under different flow patterns and velocities. Two representative motion models were considered: (i) axial flow along the sensor's central axis and (ii) helical (spiral) flow with varying radii, simulating realistic turbulent transport. The capacitance was further analysed at flow speeds of 2, 10, 50, and 100 cms-1 for both motions. The results indicated that the presence of the plastic sphere significantly decreased the capacitance due to its low permittivity ($\varepsilon \approx 3$) relative to that of milk ($\varepsilon \approx 80$), with the effect being more pronounced and dynamic under spiral trajectories. In contrast, the axial motion produced minimal temporal variations. These findings demonstrate the feasibility of capacitive sensing for the in-line detection of dielectric anomalies in conductive food matrices and highlight the potential of combining trajectory modelling with capacitance monitoring for robust contamination detection in continuous food processing environments.

Simulation of an Electrical Sensing Approach for Online Fouling Detection in Milk Pipes

Gihan Kuruppu, Mihiraj Karunanayake, Wei Yu, Brent Young

Chemical and Materials Engineering Department, University of Auckland

Fouling in stainless-steel milk pipes presents a major operational challenge in dairy processing, causing reduced heat transfer, energy inefficiency, and unplanned cleaning cycles. Accurate and continuous *online detection* of fouling remains difficult because of the complex interactions between milk composition, temperature, and surface conditions. This study describes the simulation of an electrical sensing approach designed for the real-time monitoring of fouling inside milk flow systems. The experimental electrical sensing configuration consisted of a horizontally split cylindrical stainless-steel pipe (1 m long × 0.1 m diameter), forming two separate electrodes. The pipe electrode halves were electrically isolated by a thin rubber insulation layer that prevented metal contact while maintaining the full milk flow through the interior. Milk acted as a dielectric and conductive medium, while an LCR meter measured the impedance, capacitance, and resistance across the electrodes under controlled heating at 70 °C.A MATLAB simulation model of the experimental electrical sensing configuration was developed to replicate the time-dependent electrical response as a fouling layer gradually forms on the inner wall of the pipe over a three-hour duration. The simulated results demonstrated a 70 % decrease in capacitance and a 20-fold increase in resistance, theoretically confirming a strong correlation between electrical parameters and fouling thickness. These trends highlight the evolution of the dielectric and conductive properties during deposit formation. This study demonstrates that electrical impedance sensing, supported by this simulation analysis, potentially offers a low-cost, non-invasive, and scalable technique for early fouling detection in milk processing pipelines. This approach therefore has potential to provide a foundation for predictive maintenance and inline monitoring systems in future smart dairy plants.

Spectral–Spatial Feature Learning for Milk Powder Classification

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Hyperspectral imaging (HSI) has emerged as a powerful tool for non-destructive quality assessment in food engineering; however, the high dimensionality and redundancy of spectral data present challenges for robust classification. This study uses a spectral–spatial learning framework integrating a 2D Convolutional Neural Network (CNN), termed *SpectralNet*, with Haar wavelet transformation, principal component analysis (PCA), and an attention mechanism to enhance feature representation for milk powder classification. Haar wavelet decomposition was employed to capture multi-resolution spectral characteristics, providing localized frequency information and scale invariance. PCA was then applied to mitigate spectral redundancy and reduce computational complexity. These transformed features were embedded into the 2D CNN SpectralNet architecture, augmented with an attention block to adaptively weight salient spectral–spatial representations.

The framework was evaluated on three categories of milk powder—whole milk powder, skim milk powder, and infant formula—under controlled hyperspectral imaging conditions (400–1040 nm, 462 bands). The proposed model achieved an Overall Accuracy (OA) of 75.00% and an Average Accuracy (AA) of 74.96%. The results demonstrate the efficacy of integrating classical signal processing with deep learning architectures to address the curse of dimensionality while retaining discriminative spectral information.

This study highlights the potential of hybrid spectral–spatial modelling for advancing vision-based soft sensors in food process monitoring. Beyond the dairy domain, the proposed methodology offers a transferable approach to agricultural and environmental applications where high-dimensional spectral data are prevalent.

The Effect of Skin Tension on the Efficiency of Jet Injections

Julio Christian Martadi, Andrew Taberner, Poul Nielsen, Alexander Dixon, James McKeage

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Needle-free jet injectors offer a minimally invasive method for transdermal drug delivery, enabling rapid administration, alleviating needle phobia, and eliminating risks associated with conventional needles. Despite these advantages, adoption remains challenging due to inconsistent performance and injection failures, which may stem from an incomplete understanding of key injection parameters, including skin pretension.

This study investigated the effects of biaxial skin tension on jet injection performance, focusing on delivery volume and penetration depth. Porcine skin samples were mounted in a biaxial mechanical stretcher that comprised eight motors and force sensors arranged evenly around circular samples. This system was used to achieve three strain conditions: slack, in vivo, and 0.15 strain. Three injection conditions were compared: contact (0 mm standoff distance), needle-assisted (0.4 mm diameter, 1.5 mm long microneedle), and adhered (nozzle fixed to skin with cyanoacrylate glue). The tissue movement, force at each of the eight attachment points, injection success, and injection depth were measured during injections into the samples.

Skin tension significantly reduced the skin deformation induced by the jet and improved both delivery volume and consistency. The use of microneedle-assisted injections also improved delivery relative to needle-free injection into slack skin. Glueing the injection tip to the skin resulted in successful injections regardless of the initial tension state suggesting that skin tension may improve delivery consistency simply by reducing jet-induced tissue deformation. These findings provide new insights into the role of skin pretension during jet injection and inform the development of safer and more reliable needle-free jet injection designs.

Quantifying Heating during Jet Injection

Ben Hutchison, Andrew Tan, James McKeage and Andrew Taberner

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Many modern drugs are highly viscous and required in large doses, resulting in a large delivery volume that must be delivered intravenously. Reducing the delivery volume by increasing the drug concentration makes these drugs too viscous to inject through the skin using a conventional needle and syringe. Recent research has suggested that during the jet injection of viscous fluids, the outer layer of the jet undergoes significant heating. This has a lubricating effect on the jet, resulting in unexpectedly high jet speeds. Preheating the nozzle of a jet injector further enhances this effect, to the point where fluids one thousand-fold more viscous than water can be injected at similar jet speeds. Our group has developed a calorimeter capable of measuring the average temperature change of a jet immediately after an injection. This measurement allows us to separate the heat present in the injected fluid into that arising from kinetic energy, viscous heating, or externally applied heat. This measurement tool will inform the design of just-in-time temperature-controlled jet injection nozzles capable of delivering highly-viscous drugs.

Thermopiles for isothermal microcalorimetry

Connor Sutton

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Microcalorimetry is the practice of measuring small heat outputs of processes such as chemical reactions or biological processes. One of the devices commonly used to perform microcalorimetry is thermopiles. Thermopiles are devices that can be used to measure temperature by exploiting the Seebeck Effect, an effect generated when dissimilar materials are joined together at a point, and a temperature difference along the materials generates a measurable voltage difference at their free ends. Thermopiles also can be used to exploit the Peltier effect, where applying a voltage difference across the device results in the transfer of heat from one side to the other.

Isothermal microcalorimetry aims to keep the temperature of the measured process constant, by allowing heat to flow outside the process via a well-defined heat pathway. The flow of heat can be actively controlled using a single thermopile by exploiting the Peltier effect, or heat flow can be allowed to slowly equilibrate towards a steady-state temperature difference, creating a voltage across the thermopile. Heat production can be inferred from the Peltier current arising in a short-circuited thermopile, or from the Seebeck voltage arising from the temperature difference across the thermopile.

Given the vast array of commercially available thermopiles, I discuss the considerations in choosing a thermopile for the different methods of isothermal microcalorimetry, and the advantages and disadvantages of each method. I will also briefly discuss the application of this technique to measure the <1 mW heat production of small pieces of living gut tissue.

An Integrated Workflow for Measuring the Complex Modulus of Actively Contracting Cardiac Muscle

Zisen Zhou, Andrew Taberner, June-Chiew Han, Julia Musgrave and Kenneth Tran

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Understanding how myocardial microstructure and cross-bridge (contractile unit of the muscle) kinetics influence the mechanics of heart tissue requires a combination of instrumentation, experimental protocols, and mathematical modelling. We share here a comprehensive approach that includes sample preparation, glue-free mounting, small perturbation testing, and frequency domain analysis of cross-bridge dynamics.

Firstly, we developed a custom vibratome to produce ventricular slices from rat hearts in cold, oxygenated Tyrode, with precise control of temperature, blade angle, vibration parameters, and feed speed. This preserved fiber alignment and muscle viability under field stimulation for further mechanical testing.

Secondly, we designed a hook-based muscle mounting system for the Mechanometer testing device, integrating a voice-coil actuator, cantilever force transducer, and multi-well bath. This glue-free mounting approach reduced setup time, maintained tissue viability, and enabled consistent protocols for passive/active complex modulus and isometric force measurements, and post-activation testing across ventricular muscle strips derived from tissue slices. Experimental results indicate that myocardial fibers exhibit distinct elastic and viscous moduli, corresponding to different phases of the cross-bridge cycle.

Thirdly, we employed the Kawai model to fit experimental data, which consistently captured tissue-specific differences and linked the empirical terms to a physiologically meaningful three-state cross-bridge model, providing a mechanistic interpretation of frequency domain signatures.

This integrated workflow combines custom instrumentation with model-based analysis, offering a practical and efficient approach to investigating myocardial viscoelasticity. It is particularly suited for studies on frozen human myocardial samples, where whole heart is difficult to obtain, thereby providing a feasible pathway for drug testing in human myocardium.

Using EMG Autocorrelation to Estimate Impulse Conduction Velocity and Its Viability as a Muscle Fatigue Metric

Harvey Morison

University of Canterbury

The objective quantification of muscle fatigue remains a significant challenge. Popular EMG metrics such as RMS magnitude and mean/median frequency have significant limitations, including their correlation with muscle force and their indirect link to physiological processes. This work proposes a new metric based on impulse conduction velocity (ICV), estimated via EMG autocorrelation, that overcomes these limitations while remaining practical.

The autocorrelation of an EMG signal shows a large central peak followed by a dip of negative correlation. The time between these two points relates to the travel time of an action potential impulse between the positive and the negative electrodes. If the interelectrode distance is known, the ICV can be estimated from this autocorrelation interval. Importantly, ICV is not inherently affected by muscle force, but it does decrease as a person fatigues. This decrease in ICV is attributed to the increase in the sarcolemma extracellular potassium concentration as the muscle is used. This results in a slower action potential cycle, causing the ICV to decrease.

To validate this metric, a trial was conducted where participants statically held loads of varying weights while bicep EMG was recorded. Across all 8 participants, the starting ICV was between 4 m/s and 6 m/s, and the average intrasubject spread was 0.97 m/s. The average rate of decline in ICV was 0.005 m/s2 when subjects were holding 10% of their maximum voluntary contraction (MVC) and 0.03 m/s2 when holding 40% of their MVC. As such, experiments showed that while initial ICV was consistent, its rate of decline was directly proportional to the fatiguing load, reaffirming its viability as a force-independent fatigue metric. Therefore, estimating ICV via autocorrelation offers a physiologically grounded option for monitoring fatigue, with potential applications in ergonomics, sports science, and clinical rehabilitation.

Deterministic control at high data rates using LabVIEW and FPGAs

Gregory B. Sands

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Many data acquisition tasks require precise coupling between control and capture functions, typically handled internally in an acquisition device. Integrating multiple devices is often performed using timing signals, although this becomes a little more complex and challenging when also interfacing to a computer running a non-deterministic operating system, particularly as data rates increase.

We have designed and constructed a novel scanned-line confocal microscope that acquires large 3D images at close to 1GB/s, where all control and acquisition functions operate through two PCI-hosted FPGA cards located in a standard Windows PC. One FPGA card, running at a 100 MHz clock rate, interfaces to the camera and supports real-time image processing that enables image streaming to a RAID array at the maximum camera frame rate and bandwidth. The second FPGA provides analogue and digital I/O lines synchronised to the camera. Custom LabVIEW (National Instruments, Emerson) software enables deterministic synchronisation of the laser, camera and translation stages. LabVIEW provides a high-level language for easy FPGA programming that integrates transparently with a graphical user interface hosted on the PC.

The microscope is being used for 3D imaging of tissue structure at micron resolution over tens of millimetres in extent. Images are used to analyse microstructural organisation and to inform computational models of organ function with applications in both the research lab and the hospital clinic.

Far Red Light (700-750 nm) for Cyanobacteria Growth

Mr. Allan Donald Tirkey

Waikato Instrumentation & Measurement Research, University of Waikato

Light is the fundamental energy source driving photosynthesis in microorganisms that play an essential role in global carbon cycle and biotechnological applications. While most photosynthesis research emphasises the visible spectrum, certain cyanobacteria have evolved mechanisms to utilise far-red light (700–800 nm) through specialized pigments such as chlorophyll d and f. This adaptation known as far-red light photoacclimation (FaRLiP), enables these organisms to survive and grow in shaded or low-light environments where far-red wavelengths dominate.

This project investigates the impact of controlled far-red illumination on cyanobacteria growth using a custom-engineered LED light panel. By simulating far-red enriched environments, the study aims to understand how cyanobacteria adjust it's photosynthetic nature, pigment composition, and production. The panel is designed with constant-current regulation, programmable dimming, and thermal safeguards to deliver stable far-red output The ability of cyanobacteria to respond in far-red light has implications for production and sustainable agriculture, where efficient microbial growth under light conditions is critical.

Through the integration of engineering design and microbiological experiments, this project contributes to ongoing efforts to expand the usable spectrum of photosynthesis; inspired by recent findings that far-red light utilisation can significantly enhance productivity in both cyanobacteria and higher plants.

Designing a Far red LED light panel for Cyanobacteria protection

Mr. Nil Shihora

Waikato Instrumentation & Measurement Research, University of Waikato

This presentation will cover the development of a compact LED panel that produces far-red light (700–750nm), a wavelength range that is increasingly important for studying how organisms use light in photosynthesis and growth. The goal was to design a system that balances simplicity, safety, and repeatability. The panel is built around high-powered LEDs mounted on an Aluminium PCB which itself works as a heat sink to keep temperatures safe and stable. A transparent cover provides spectral-spill protection, while electronic safeguards such as fuses, polarity protection, and automatic thermal shut-off ensure robust operation. Light levels are controlled electronically, allowing smooth adjustment and consistent settings from one experiment to the next. The presentation also covers the integration of three kinds of operational monitoring aspects: electrical checks to measure the drive current, optical measurements to confirm far-red light output, and thermal sensors to monitor both the panel and the sample environment. Calibration steps are straightforward and repeatable, meaning users can easily confirm that the device is working as expected before each use. The result is a practical and reproducible lighting tool that can be quickly adopted into laboratory workflows. Because it is compact, low-cost, and supported by clear calibration data and safety features, it is also easy for others to replicate.

The MBIE LakeCast Project: Short-term forecasting of lake chlorophyll-a concentration based on multi-instrument observation fusion

Ms. Lanxi Li

Waikato Instrumentation & Measurement Research, University of Waikato

Accurate forecasts of chlorophyll a (Chl-a) concentrations are crucial for proactive lake management, as high Chl-a concentrations often contribute to harmful algal blooms and eutrophication. This presentation introduces LakeCast, an integrated data fusion and forecasting platform that combines high-frequency time-series observations from an Internet of Things (IoT) sensor network with high-frequency continuous measurements from multi-site handheld fluorometers and overview survey data to capture the spatial heterogeneity of Chl-a in complex lakes. First, a random forest model is used to interpolate and reconstruct sparse observations to generate a unified daily-scale Chl-a dataset. This data is then fed into a spatially distributed long short-term memory (LSTM) network to achieve spatiotemporal forecasts for the next week. A case study on Lake Rotorua, New Zealand, shows that using the median of repeated measurements improves forecasting performance, while fusing the mean from multiple instruments enhances stability and generalization. Validation with data from seven time points and four sites confirms the method's reliability, and stratified experiments across concentration ranges yield promising results.

The MBIE LakeCast Project: Forecasting Stratification to Understand Cyanobacterial Bloom Dynamics in Lake Rotorua Using High-Frequency Lake Monitoring and Data-Driven Models

Ms. Sepideh Heydari

Waikato Instrumentation & Measurement Research, University of Waikato

Freshwater lakes are increasingly impacted by climate change and nutrient enrichment, leading to more frequent and less predictable water quality issues, including harmful algal blooms (HABs). These events are closely linked to thermal stratification - the layering of warmer surface water over cooler layers - which influences vertical mixing, nutrient availability, and overall lake behavior. Anticipating stratification dynamics is therefore critical for managing bloom risk. This study focuses on Lake Rotorua, a shallow, polymictic lake in New Zealand known for short-lived and highly variable stratification. As part of the LakeCast project, which integrates several complementary datasets, the work centers on a centrally deployed high-frequency monitoring buoy - part of New Zealand's longest-running lake monitoring program. The buoy provides continuous observations of meteorological conditions and in-situ water column profiles, both collected at short intervals. This setup enables fine-scale assessment of thermal structure and lake stability. The data inform both machine learning and process-based models that predict the timing and drivers of stratification events. Early results show consistent diel cycles (daytime heating and nighttime wind-driven mixing) that shape lake dynamics. These insights support the development of scalable forecasting tools for early-warning water quality management and highlights the importance of sustained, high-frequency monitoring in polymictic systems.

Edge Device for Long-Term New Zealand Forest Sound Scape Monitoring

Amin Barzegar, Akbar Ghobakhlou, Edmund Lai

Artificial Intelligence Research Centre, Auckland University of Technology

Passive acoustic monitoring (PAM) uses fixed sensors or hydrophones to capture soundscapes; analysing these recordings reveals species presence, behaviour, and ecosystem change across land and sea, informing targeted conservation. Long-term soundscape monitoring thus offers actionable insights into abundance, occupancy, and activity, enabling data-driven planning. Automated bioacoustic monitoring—powered by machine learning and Internet-of-Things (IoT) technologies—scales continuous ecosystem observation. In this study, we developed (1) a deep-learning classifier that identifies multiple species, including birds and invasive mammals such as possums and stoats, from their acoustic signatures; and (2) a weather-sealed, solar-powered hardware platform integrating a microphone, battery, data link, and embedded processor for autonomous field operation. The recorder prioritises sampling during diel peaks in target activity; during low-activity windows, the on-board processor retrieves buffered audio and performs edge inference with selected deep-learning models. To conserve energy and bandwidth, it uploads only timestamped detections. The device detects both audible and ultrasonic vocalisations. Designed for scalable deployment across sensor networks, the system operates year-round on solar energy and transmits daily detection summaries, advancing large-scale, automated biodiversity monitoring in support of New Zealand's predator-free conservation goals.

Cross-Model Confusion Mapping: Reducing False Positives in Edge-AI Bioacoustic Detection of Possums

Amin Barzegar, Akbar Ghobakhlou, Edmund Lai

Artificial Intelligence Research Centre, Auckland University of Technology

Automated detection of brushtail possums using bioacoustics and deep learning approaches can suffer from a high false-positive rate, while the computational cost of state-of-the-art models limits their deployment on resource-constrained edge devices. This study introduces Cross-Model Confusion Mapping (CMCM), a targeted hard-negative mining strategy designed to improve the precision of convolutional neural networks (CNNs) without increasing computational complexity. CMCM leverages the error distribution of a probe network to identify bird calls most frequently misclassified as possum vocalisations. These hard-negative samples are then incorporated into the training data to refine class boundaries and suppress false alarms. Three CMCM-augmented audio sets were constructed and compared against size-matched sets generated through untargeted sampling. CNN architectures with 3, 5, 7, 10, and 13 layers were trained under identical augmentation pipelines. Experiments using Department of Conservation field recordings and community-sourced audio demonstrated that CMCM-trained models significantly reduced false alarms while maintaining high accuracy. The 10-layer CMCM-trained CNN achieved the best balance between accuracy and efficiency, providing inference speeds several orders of magnitude faster and with substantially lower computational demand than the Audio Spectrogram Transformer (AST). These results indicate that CMCM enables accurate, low-latency possum detection suitable for real-time bioacoustics monitoring on edge devices.

Development of a national thruster test facility for electric propulsion at Robinson Research Institute, New Zealand

Dr. Emile Webster

Robinson Research Institute, Victoria University of Wellington

The Robinson Research Institute is developing a type of electric propulsion (EP) system for spacecraft called an applied-field magneto-plasma-dynamic (AF-MPD) thruster. The applied field module of the thruster features a cryocooler-cooled high-temperature-superconducting (HTS) magnet generating central fields exceeding 1 Tesla. This presentation reports on the operation of a state-of-the-art EP thruster test facility, established to enable ongoing development of our HTS AF-MPD thruster and electric propulsion in general. The vacuum facilities utilise a 1 m diameter, 3 m3 cylindrical chamber and pumping systems to allow space like pressures of <5·10−7 mbar. This chamber houses a purpose-built pendulum thrust-stand able to withstand the high vibrational loads and strong magnetic fields encountered when operating our HTS AF-MPD. Thruster testing, whilst implementing both water-cooling and a cryocooler showed it to be capable of measuring forces to a resolution of 0.2 mN and with an absolute accuracy of ~3.5 mN (95%). An extensive suite of software tools has also been developed to coordinate the large set of instruments needed to run the vacuum facilities, the thrust-stand, HTS magnet and cryocooler in addition to the many other auxiliary- and logging systems. Additionally, a more compact and self contained HTS AF-MPD traveling artifact is nearing completion to allow international comparison of both test facilities and EP thrust measurements. Various upgrades to both the AF-MPD thruster and the test facilities are being planned for the next major experimental campaign, starting 2026.

Thermal characterisation of an HTS applied field module for incorporation with a miniaturised magnetoplasmadynamic thruster

Max Goddard-Winchester

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A second generation high-temperature superconducting (HTS) applied-field magnetoplasmadynamic thruster (AF-MPDT) is under development at Robinson Research Institute to advance this technology toward in-space applications. Thus far, a preliminary thermal characterisation has been conducted of an HTS applied-field (AF) module capable of operating at up to 0.8 T. The main purpose of this module is integration with a miniaturised sub-kW MPD thruster, which has been designed specifically for terrestrial testing and as a transferable comparison artifact. Ultimately, this miniaturised thruster will form the basis to verify the feasibility of in-space applications. Extensive testing with a larger AF-MPDT has revealed limitations on the duration of thruster discharge, imposed by heating of superconducting elements and thruster electrodes. Further, the miniaturisation of some systems has exacerbated geometric constraints when compared to the larger version, by reducing the physical separation between cryogenic and above-ambient temperature components.

The presented work will outline the preliminary test campaign of the HTS applied field module in the context of the miniaturised MPD thruster. The effective heat transfer from the thruster anode to the cryogenic HTS applied field module was measured during a simulated heat load to validate their relative thermal isolation. An 85% reduction in the combined heat load, caused by ohmic loss and thermal conduction from the ambient environment was achieved by replacing the copper current supply leads with a superconducting power supply (self-rectifier flux pump). These optimisations, among others introduced in this iteration of thruster design, will allow for simple integration with thrust measurement systems in both our facilities and elsewhere.

Super conducting magnet and coil testing system to enable development of electric propulsion at Robinson Research Institute, New Zealand

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As part of *electric propulsion (EP) for space* research, Robinson Research Institute is developing a unique Applied Field Magneto-plasma-dynamic (AF-MPD) thruster. One of the core components of an AF-MPD is the applied field module, generated by a high-temperature-superconducting (HTS) magnet. Two such HTS magnets, comprised of four individual HTS coils, have been designed and built, one for the AF-MPD (for terrestrial testing) and one which has recently arrived at the ISS in preparation for an in-space TRL readiness demonstration.

This presentation reports on the development and operation of the HTS testing setup used to characterise both coils and magnets in preparation for space and terrestrial EP thruster testing. The range of operating temperatures for the HTS magnets is 75 K to 78 K and is performed in a 125 L vacuum chamber that achieves pressures of $<1\cdot10{-}6$ mbar required for both operating a cryogenic magnet and operating in space. The system was developed concurrently with the coils and often under a restrictive time frame. This resulted in a specialised system for testing these specific coils. The test system encompassed a range of temperature, hall and voltage sensors integrated together to monitor both the test bed and the coils. The next steps for AF-MPD development is to build a larger HTS magnet and thus there are planned upgrades to accommodate larger coil with the lessons learned from the testing to date. Additionally, once the in-space testing has concluded that magnet will return to Robinson Research Institute and undergo a final regime of testing.

In-plume low-parasitic thrust stand

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The critical parameter to be measured when testing electric propulsion is the thrust generated by the system. Unfortunately this presents a serious problem, as the forces involved are very small, frequently less than a millinewton for small thrusters. This means that the mass of the thruster and the parasitic forces of the connections to it can easily drown out any measurement. An in-plume thrust measurement system has been designed, built and tested which circumvents these issues by separating the thruster and the thrust stand from each other, reducing the sources of error in the measurement.

Methods for calibrating horizontally-acting force transducers

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In many instruments, force transducers are used to measure force along a line in the horizontal plane –orthogonal to the direction of gravity. In such a case, it can be impossible or impractical to calibrate the transducer by applying standard forces by hanging weights. Moreover, if the force sensor has a range and resolution smaller than most commercially available pre-calibrated force sensors, calibration against a traceable force standard also may not be possible; if the transducer is highly stiff; calibration using the thermal method may not be possible.

In this talk, I will overview three methods that I have previously used for calibrating force sensors with a nominal range of ~ 1 mN or less, for use in instruments mounted on an optical table and constrained to measuring in the horizontal plane: *galvanometric*, *pendulum*, and *standing wave*. I'll summarise the basic physics of each method, and compare and contrast their pros and cons.

These methods are not always practical, nor necessarily simple to implement, but they are surely interesting to apply, and may thus appeal to the physicist in us all.

Thermal time-of-flight measurement of low-velocity liquid metal flows

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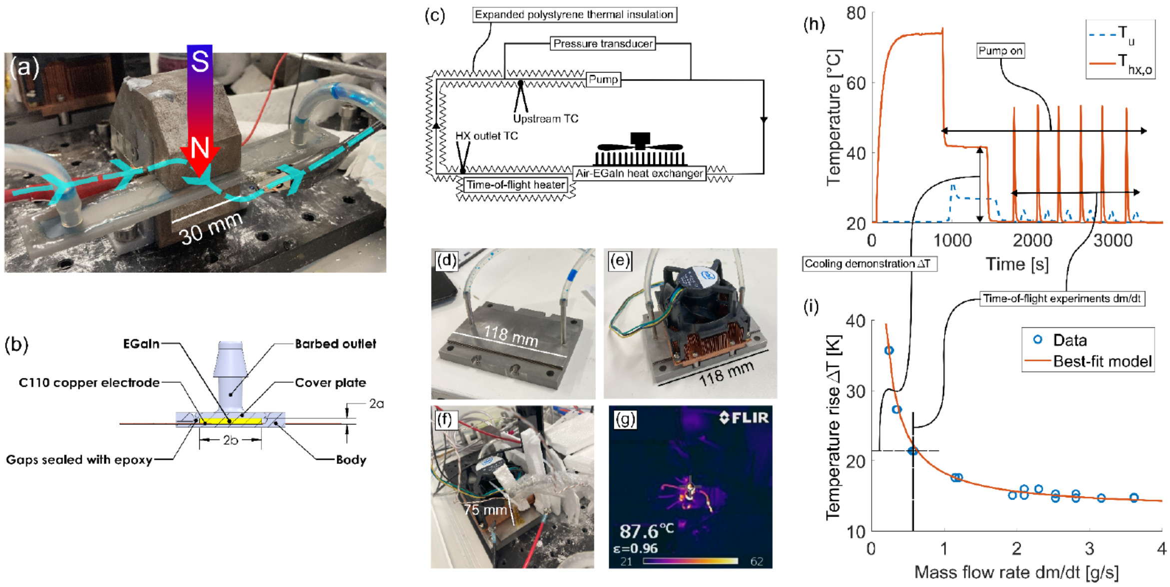
Liquid metal coolants are of increasing interest in electronics and electric motor thermal management applications, owing to their relatively high thermal conductivity. In such applications, measurement of low-velocity liquid metal flows is often necessary. At higher flow velocities and large geometries (e.g. in the cooling of nuclear power plants), electromagnetic methods may be used. These rely on measuring the back-EMF (BEMF) generated as the liquid metal flows through a region of strong magnetic flux density. However, on the scale of electric motors and power electronics for use in robotics, the measurement of the BEMF becomes a challenging instrumentation problem, with BEMFs on the order of tens of microvolts expected for a < 1 cm^3/s flow of a typical liquid metal.

These challenges can be circumvented by employing a thermal time-of-flight method. This involves rapidly and briefly heating a section of a liquid metal flow loop, and measuring the time taken for the temperature spike to travel from an upstream thermocouple to a downstream thermocouple along a thermally-insulated tube of known length.

In the course of our efforts to develop new types of direct current magnetohydrodynamic pumps for liquid metals, we have constructed a liquid metal flow loop instrumented with thermocouples and fitted with heaters, insulation, and radiators. This flow loop has allowed us to demonstrate thermal time-of-flight flow measurement for the liquid metal gallium-indium eutectic alloy. We show that this method can be used to measure time-averaged liquid metal flows at flow rates as low as 0.1 cm^3/s. To our knowledge, this measurement method has not previously been used to measure liquid metal flow rates.



Transient-Contact Excitation Acoustic Modelling for Lamb Wave Distance Estimation

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Lamb waves, a type of dispersive acoustic signal that propagates in thin plates, are routinely used in non-destructive testing and distance measurement for localisation and dimensioning.

In these contexts, the transducers that generate these waves are usually coupled mechanically, either via bolts or an acoustic compound.

This allows direct control and therefore knowledge of the transmitted signal, enabling the acoustic modelling necessary for various applications.

We present a method to determine the uncontrolled acoustic excitation produced by an impact solenoid, from only solenoid parameters and coil current.

A combined electromagnetic, impact, and acoustic model is used to simulate the excited Lamb waves, which are then compared with experimental validation.

To demonstrate the applicability of our method, we estimate the impact distance by comparing our modelled signal to experimental data from an accelerometer a known distance away from the impact site.

The robustness of the estimate is improved by enveloping the objective function used for optimisation.

This work enables Lamb wave excitation from moving sources and in contexts where bespoke coupled transducer systems cannot be used, opening up new potential applications.

The Polynomial RF Tuning Method

Toby Bell-Ramsay

Tait Communications

Toby Bell-Ramsay has significantly improved the efficiency of radio testing for the new Multiband TM9900 and TP9900 models by developing a polynomial-based tuning method. Traditional testing required up to 125 tuning steps per radio, resulting in long test cycles and excessive heat buildup. Toby's approach uses historical data and AI-assisted polynomial curve fitting to predict DAC values with high accuracy, reducing the need for repeated measurements. This method has cut testing time from 24 minutes to as low as 7 minutes per unit.

The innovation not only improves throughput but also addresses thermal concerns during transmitter tests. By reducing the time radios spend transmitting, the method lowers operating temperatures, enhancing safety and reliability. Additional cooling strategies, such as fan-assisted setups and optimized test sequencing, further support this improvement.

Toby's work has eliminated the need for additional Automated Testing Equipment (ATE), each costing approximately $80,000, saving the company significant capital while maintaining production rates. His methodology—fitting polynomial curves to known good radios and adjusting them based on real-time measurements—has proven effective across multiple radio variants. The technique enables rapid estimation of tuning values with minimal deviation, streamlining the entire testing process.

This advancement allows the manufacturing team to double output without expanding infrastructure and sets a foundation for future testing optimizations. Toby's contribution exemplifies innovation in engineering practice, combining data science, programming, and domain expertise to solve a critical production challenge.

Development and Characterization of Chitosan-Doped TiO_2 ETLs for Performance Enhancement and Stability in Perovskite Solar Cells

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Perovskites solar cells (PSCs) [1] have garnered a significant interest in recent years due to their maximum theoretical photovoltaic efficiency; however, there is still work to do to increase this efficiency, stability, and develop scalable PSC production techniques. In particular, fabricating electron transport layer with improved interfacial properties remains a significant challenge [2], [3]. To address these challenges, researchers have increasingly explored both inorganic [4] and organic [5] materials to enhance the efficiency and interfacial stability of PSC devices [6]. In this context, the present study fabricated chitosan doped titanium dioxide (TiO_2) thin films, as shown in Figure 1, and evaluated their potential as enhanced ETLs. The structural, morphological, and optical characteristics of the films were assessed using atomic force microscopy (AFM), X-ray diffraction (XRD), UV–Vis spectroscopy, and transmittance spectroscopy [7]. AFM results showed chitosan-doped films have reduced grain size and increased surface roughness, where XRD suggested that chitosan improved the crystallinity of TiO2 thin films. Additionally, optical investigations revealed a slight blue shift in the absorption edge, This shift broadens the range of photon wavelengths that can be transmitted to and absorbed by the perovskite layer, thereby improving light harvesting [8], [9]. Furthermore, optical transmittance studies, shown in Figure 2 revealed that chitosan-doped TiO_2 had greater transparency throughout the visible spectrum, allowing more light to reach the perovskite absorber. These findings indicate that chitosan-doped TiO_2 has tremendous potential as an effective ETL material for PSC applications.

Figure 1. Schematic illustration of synthesis procedure of Chitosan-doped TiO_2.

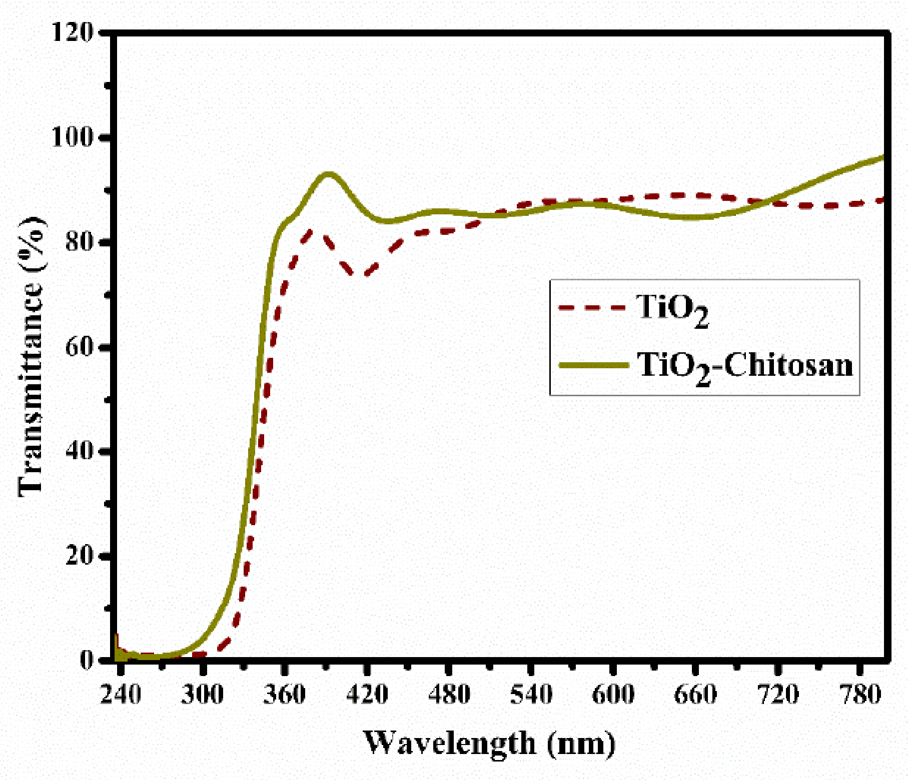

Figure 2. Transmittance spectra of TiO_2 (dashed) and Chitosan-doped TiO_2 (solid) thin films.

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Towards Submicron Discontinuous Thin Films for Neuromorphic Computing

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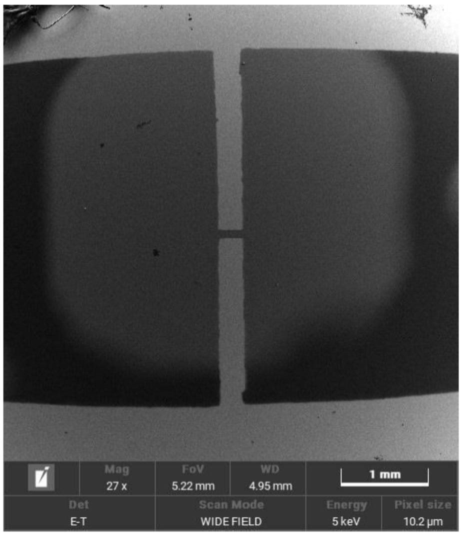
Discontinuous thin metal films are investigated for their partially-understood, typically nonmetallic physical properties which lead to a range of uses in sensing and technological applications. We prepare near-continuous thin films by thermal evaporation onto insulating substrates. The conductance of the film is monitored throughout the deposition, which is halted when the surface coverage of the conductive metal approaches the percolation threshold. The result is a network of nearly-continuous conductive pathways across the span of the film, which has a mean thickness <15nm. Such devices have memrisitve, time-varying conductance under applied electric fields, as atomic migration enables formation and destruction of filaments of the film material across nanometer-scale gaps between relatively large, connected domains. Characteristic brain-like patterns in the film's conductance motivate the exploration of these films as potential platforms for neuromorphic computing, a form of analogue computation where stimuli are applied to a nano-scale physical device and its response is used to classify or process the input in some way.

In this work, discontinuous gold film devices are constructed that display complex switching behaviour, as shown in Figure 1. A process is also reported to shrink the critical dimensions of these devices, with the goal of reducing power consumption and verifying the scale-free behaviour of the switching events. Depercolation, or permanent deformation of the film structure which lowers the net conductance, is reported under a variety of operating conditions. Understanding and controlling this depercolation process is a key goal going forward so that devices can be optimized for repeatable and useful switching behaviour.



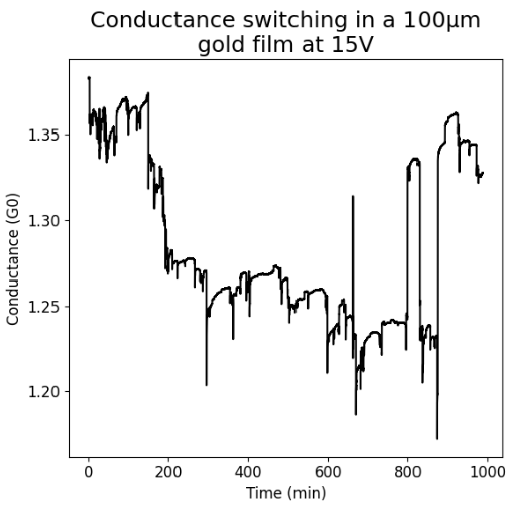


Figure 1: Left: a widefield SEM image of a discontinuous gold film (the pale square) on electrodes (the solid bands) with 100µm spacing across the active area (centre of image). Conductance is conventionally measured in units of G0 ≈ 77.5µS, the quantum of conductance. Right: this device showed particularly vigorous switching with many spontaneous conductance changes up to 12µS, or 0.15 G0.

TIME-RESOLVED MAGNETO OPTIC KERR EFFECT (TRMOKE)

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Understanding the time-resolved spin dynamics of magnetic materials is essential for advancing the design of spintronic devices. One powerful technique for probing these dynamics is the Time-Resolved Magneto-Optic Kerr Effect (TRMOKE). In this method, a pump pulse induces demagnetisation in the sample, while a probe pulse, delayed in time, monitors the recovery process. The technique relies on the Magneto-Optic Kerr Effect, where changes in the polarisation of reflected light occur due to variations in the sample's magnetisation under an applied magnetic field. TRMOKE enables the observation of laser-induced reorganisation of the electronic density of states, providing insights into ultrafast magnetic phenomena. Our system uses femtosecond Ytterbium fiber laser(Tangerine SP, Amplitude Systems), with 1030nm pump pulse and 515nm probe pulse. CMGa was used as the standard sample to calibrate the setup. The integration of a cryostat into the system allows measurements at temperatures as low as 5K, making it suitable for studying materials with magnetic phase transition. To detect subtle changes in polarisation, the setup employs a balanced detection scheme. The probe beam is split into right and left circular polarisations, each measured by separate detectors. The difference in their intensities reflects the Kerr rotation, which is then measured using a lock-in amplifier. The whole system, including the amplifier, is controlled and automated by LabVIEW, offering intuitive control over the delay stage and real-time data visualisation, thereby completing a robust and user-friendly experimental setup.

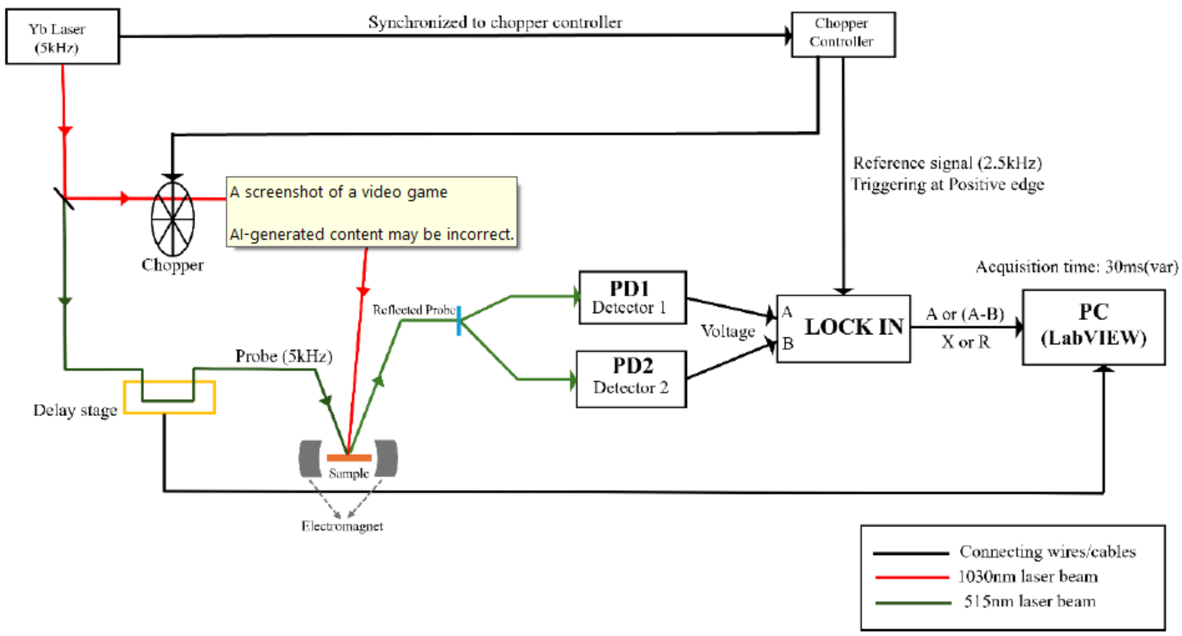

Fig: Schematic diagram of TRMOKE setup

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Development and Characterization of Hybrid Nanoparticle Photocatalysts for CO_2 Conversion

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Particulate photocatalysts dispersed in water offer low-cost solar-powered chemical production. [1] However, state-of-the-art inorganic and carbon nitride photocatalysts predominantly absorb ultraviolet light, which accounts for less than 5% of the solar spectrum, severely restricting their efficiency. [1, 2] In contrast, organic semiconductor nanoparticles absorb visible and near-infrared light, collectively spanning ~80% of the solar spectrum. Recent studies have shown that nanoparticles derived from organic solar cell materials can serve as efficient photocatalysts. [1, 3–5] These systems typically comprise surfactant-stabilized organic nanoparticles dispersed in water, with photo-deposited metal co-catalysts on the nanoparticle surface. While most efforts have focused on H_2 evolution with platinum, an example of CO_2 reduction using gold or silver has also been reported. [4]

In this project, we aim to design and characterize hybrid organic–inorganic nanoparticle photocatalysts for converting CO_2 into value-added chemicals. Following the approach of Mariia Ferree et al., [4] we successfully prepared organic semiconductor PM6:Y6 nanoparticles with silver nanoparticles attached as co-catalysts. These materials were characterized using dynamic light scattering, transmission electron microscopy, and transient absorption spectroscopy, exhibiting features consistent with reported benchmarks. Building on these preliminary results, we are now exploring the effects of varying the stabilizing surfactant and co-catalyst composition to systematically evaluate performance, advancing the development of high-efficiency nanoparticle photocatalysts for sustainable CO_2 conversion.

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