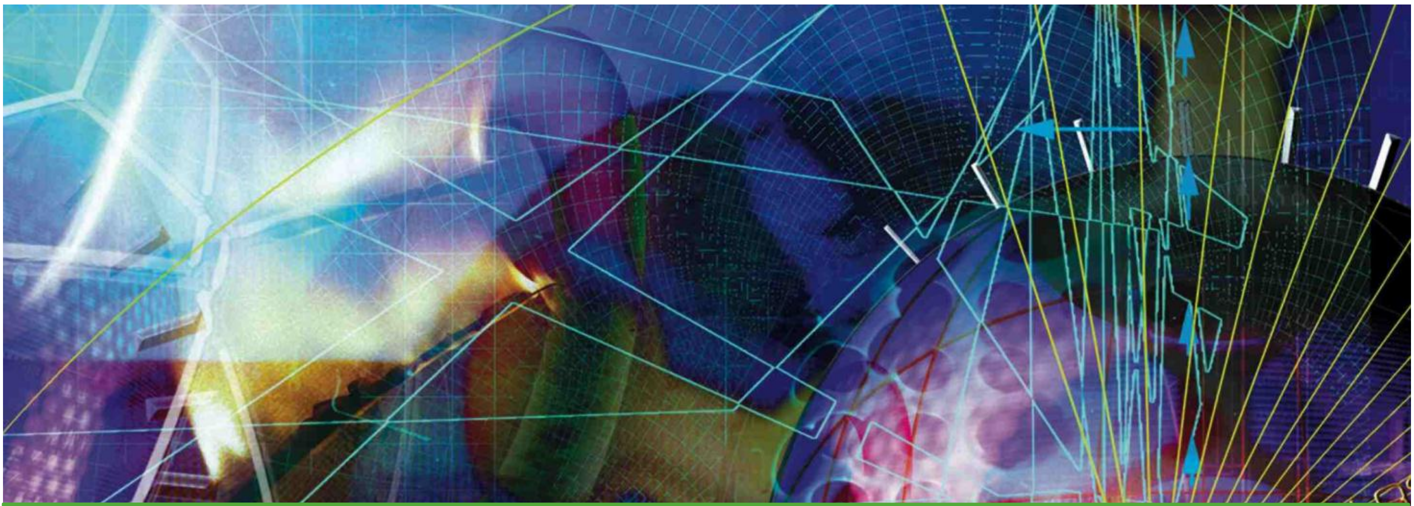

Workshop on Smart Sensors

Instrumentation and Measurement

Date:
Monday and Tuesday, 18-19 February 2013

Location:
University of Waikato, Hamilton, New Zealand.

Web page:
www.sci.waikato.ac.nz/imsnz-13

Convener:
Rainer Künnemeyer

Program

IEEE instrumentation & measurement society

LELY — innovators in agriculture —

DAL Dairy Automation Limited ...your partner in innovation.

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The University of Waikato Te Whare Wānanga o Waikato

Welcome

Prof. Janis Swan
Assoc. Dean – Engineering

Assoc. Prof.
Rainer Künnemeyer - Engineering

The University of Waikato, the School of Engineering, and the IEEE Instrumentation and Measurement Society, New Zealand Chapter, warmly welcome all delegates, presenters and attendees to the 5th Annual Workshop on Smart Sensors – Instrumentation and Measurement. We invite you to discuss and present your latest research findings, ideas, developments and applications in the area of Sensor and Measurement Technologies.

The workshop is intended to provide a common forum for interested people and an opportunity to network and discuss current research with colleagues. This year we have a wide range of topics and have presenters with diverse backgrounds and levels of experience. A good number of people have indicated that they will attend the workshop. We hope there is something in the two day program that will stimulate your thoughts and make this workshop worthwhile for you. Don't forget the Monday night dinner where you have more opportunity to network.

We would like to thank all attendees, speakers and helpers for their support and interest in this workshop. Most importantly, we would like to acknowledge our sponsors who provided the generous financial support that made this event possible.

12 February 2013

Sponsors

Please support our sponsors. Their generous support made this workshop possible.

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www.dairyautomation.co.nz Dairy Automation Limited is a New Zealand owed company which develops and manufactures industry leading sensing technologies for Dairy Farmers. Current products include CellSense for the inline measurement of somatic cells and YieldSense+ for the inline measurement of Yield, Fat, Protein and Lactose. Dairy Automation also supplies RFID, Herd Management Software and integration packages to optimise animal health management and performance.

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www.ieee-ims.org The IEEE Instrumentation and Measurement Society is dedicated to the development and use of electrical and electronic instruments and equipment to measure, monitor and/or record physical phenomena. The fields of interest include metrology, analog and digital electronic instruments, systems and standards for measuring and recording electrical quantities (in both frequency and time domains), instrumentation and transducers for measurement of non-electrical variables, calibration and uncertainty, instruments with automated control and analysis functions, safety instrumentation, and new technology applications. With scientific, literary, and educational concerns, the Society seeks to promote a high level of technical excellence by encouraging close cooperation and exchange of information among its members.

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http://ewh.ieee.org/r10/nzc/
IEEE New Zealand Central Section

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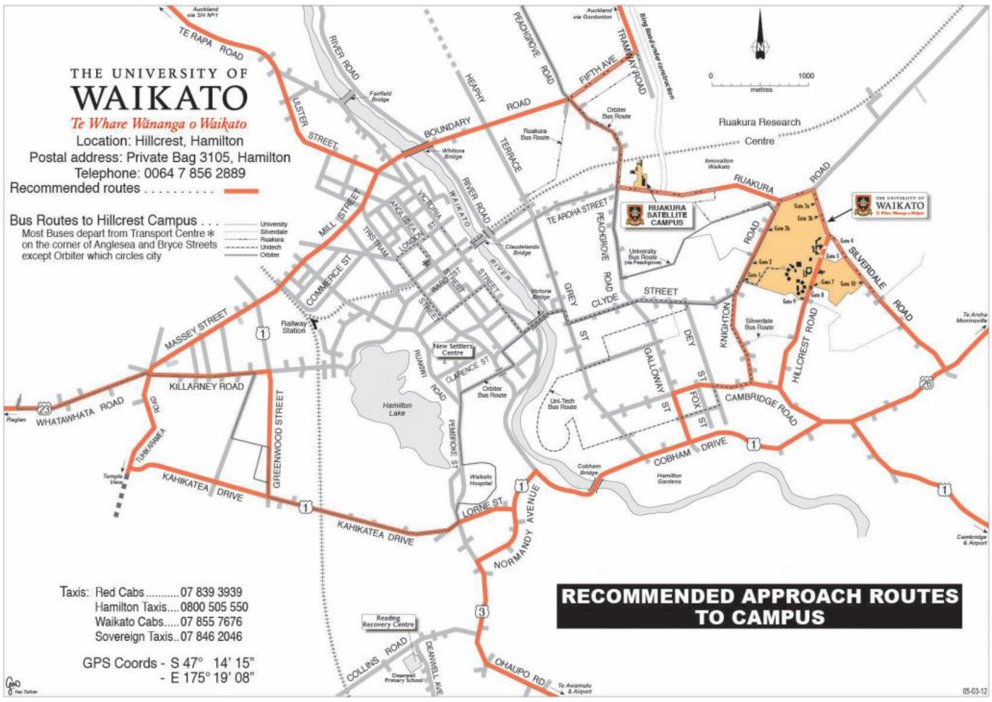
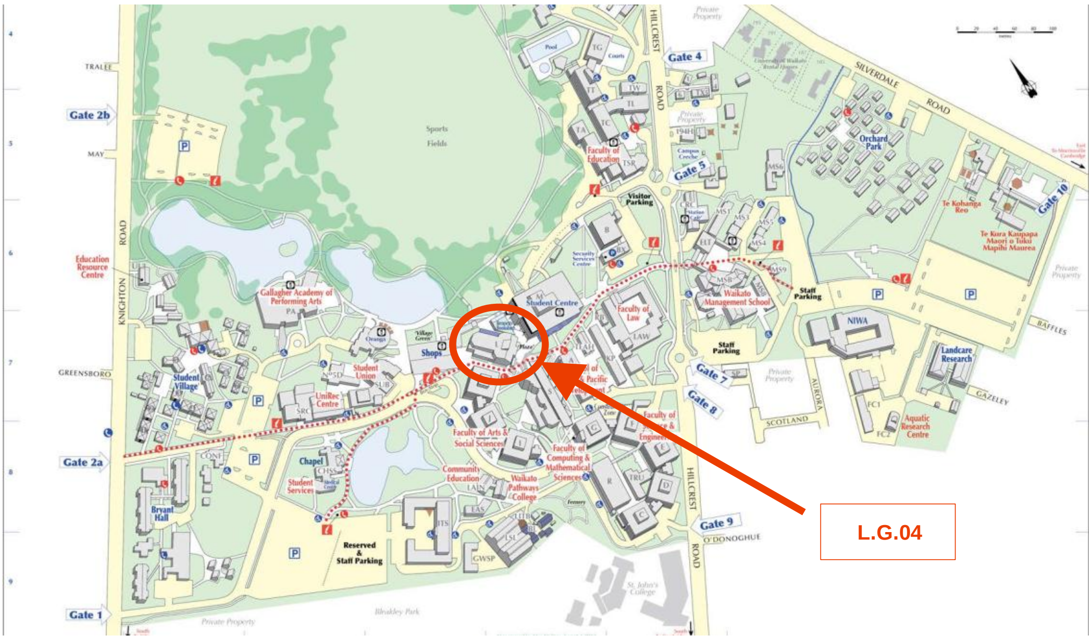
sci.waikato.ac.nz/about-us/people/rainer Applied Optics research was introduced to the School of Engineering (initially Department of Physics) of the University of Waikato in early 1995. Since then the group has carried out research and development work in the broad field of biophotonics. The main emphasis is on the development of solutions for the non-destructive evaluation of biological material using various optical measurement techniques utilising optics, electronics, and optoelectronics. The group has established excellent links with local industry and Crown Research Institutes. Most research projects are carried out in close collaboration with these external, often overseas based partners.

Housekeeping

Location:

Lecture theatre L.G.04 and L-Foyer, University of Waikato, Hamilton.





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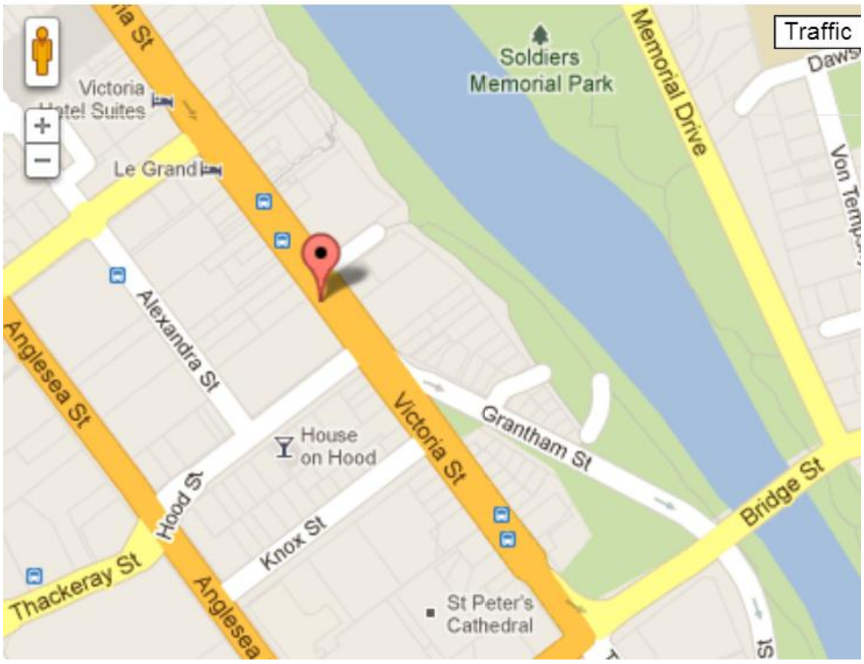
Dinner:

Day:	Monday
Date:	18 February 2013
Time:	7:00pm
Location:	Agenda Restaurant, 145 Victoria Street, Hamilton 3204



Presentations

Timetable

Time	Length	Talk #	Title / Author
			Monday, 18 February 2013
8:45	0:05	W1	Welcome. Rainer Künnemeyer
8:50	0:10	W2	Welcome. Janis Swan, Assoc. Dean - Engineering
9:00	0:35	Key 1	Infrared imaging applied to performance and health traits assessments in the bovine. Yuri R. Montanholi
9:35	0:20	1	Technological Challenges in Monitoring New Zealand Bird Species. Amal Punchihewa
9:55	0:20	2	Near real time, accurate, and sensitive bacterial enumeration in aquatic environment using an all-fibre spectroscopic fluorescence system. Frederique Vanholsbeeck, Simon Swift, and Evgeny Bogomolny
10:15	0:20	3	Lessons Learnt from On-Farm Sensor Development. Paul Johnstone
10:35	0:35	Tea	
11:10	0:35	Key 2	Design and implementation of the world's first Cellular Security and Forensics system. Stuart Wilson
11:45	0:20	4	Wireless Sensor Network: Sharing the working experience. Subhas Mukhopadhyay
12:05	0:20	20	Applying SARIMA Time Series to Forecast Sleeping Activity for Wellness Model of Elderly Monitoring in Smart Home. Nagender Suryadevara, Subhas Mukhopadhyay, and R. K. Rayudu
12:25	0:20	6	A cost-effective way to construct a vector network analyzer using an oscilloscope and directional couplers. Gaojie Chen, Jonathan Scott, and Michael Cree
12:45	0:10	Trade 1	HRS
12:55	0:10	Trade 2	RF Test Solutions
13:05	0:55	Lunch	
14:00	0:35	Key 3	Advances in time-of-flight 3D cameras. Adrian Dorrington
14:35	0:20	7	Cancellation of Harmonic Content in Time of Flight Range Imaging. Lee Streeter and Adrian Dorrington
14:55	0:20	8	Mobile Sensing for 3D Content Creation. Robert Valkenburg, David Penman, and Johann Schoonees
15:15	0:20	9	Fast electromagnetic imaging. Ian Woodhead and Ian Platt
15:35	0:35	Tea	
16:10	0:20	10	Opportunities for environmental sensors. Rod McDonald
16:30	0:20	11	Scaling Soil Moisture Profiles using Ray Tracing on GPR Data. Ian Platt and Ian Woodhead
16:50	0:20	12	Characterising noise on a TDR image sensor. Michael Hagedorn, Ian Platt, and Ian Woodhead
17:10	0:20	13	Low cost autonomous 3-D monitoring systems for hydraulic engineering environments and applications. Nihal Kularatna and Dulsha K. Abeywardana
17:30			
19:00		Dinner	Agenda Restaurant, 145 Victoria Street, Hamilton 3204

Tuesday, 19 February 2013

Time	Length	Talk #	Title / Author
9:00	0:35	Key 4	Sorting out the bad apples. P. Martinsen, R. Oliver, C. Clark, R. Seelye, K. Moynihan, and V. A. McGlone
9:35	0:20	14	Optically Sensing Fruit Firmness. Philip Rowe, Rainer Künnemeyer, Andrew McGlone, and Sadhana Talele
9:55	0:20	15	Light Emitting Diode (LED) spectrometer based on optimised discrete wavelengths selection method. Khairul Anuar Shafie, Rainer Künnemeyer, Andrew McGlone, and Sadhana Talele
10:15	0:20	16	TDR moisture sensing in bread. John Christie, Ian Woodhead, and Kenji Iri
10:35	0:35	Tea	
11:10	0:35	Key 5	The Cardiac Myometer: Measuring heat- and force-production in exercising heart muscle fibers. Andrew J. Taberner, Callum M. Johnston, Bryan P. Ruddy, Denis S. Loiselle, and Poul M. F. Nielsen
11:45	0:20	17	Towards tissue recognition using dispersion in optical coherence tomography. Norman Lippok, Stuart Murdoch, Stéphane Coen, Poul Nielsen, and Frédérique Vanholsbeeck
12:05	0:20	18	Printable Plasmonic Sensors for Low-Cost Alcohol Vapour Detection. John S. Mitchell, Richard Oliver, and Bob Jordan
12:25	0:20	19	Characterisation of SnO2 and ZnO Nanostructures. Enobong E. Bassey, Krishnamachar Prasad, and Philip Sallis
12:45	0:10	Trade 3	Nichecom
12:55	0:10	Trade 4	
13:05	0:55	Lunch	
14:00	0:35	Key 6	Perimeter security sensor implementation. Keith Gallagher
14:35	0:20	26	Wireless sensor network for microclimate monitoring. Akbar Ghobakhlou
14:55	0:20	25	Electrochemical Capacitive Sensing of Alcohol in Human Breath. Asif I. Zia
15:15	0:20	22	Designing Smart Grids Using Wireless Sensors & Actuator Networks. Anuroop Gaddam
15:35	0:35	Tea	
16:10	0:20	23	The Use of Vissim Real Time in Data Acquisition, Analysis and Feedback. Alista Fow and Mike Duke
16:30	0:20	24	A physically-based dielectric model for moisture sensors. Sean Richards, Ian Woodhead, Ian Platt, and John Christie
16:50	0:20	21	An Analysis of the New Affordable DepthSense Range Imaging Sensor. Michael Cree
17:10			

Keynotes

Infrared imaging applied to performance and health traits assessments in the bovine.

Design and implementation of the world's first Cellular Security and Forensics system.

Advances in time-of-flight 3D cameras.

Sorting out the bad apples.

The Cardiac Myometer: Measuring heat- and force-production in exercising heart muscle fibers.

Perimeter security sensor implementation.

1. Infrared imaging applied to performance and health traits assessments in the bovine.

Yuri R. Montanholi
University of Guelph, Stone Road East, Guelph, ON, Canada N1G 2W1
ymontanh@uoguelph.ca

A blooming of infrared imaging applications for the livestock sector occurred over the last decade. Researchers and industry partners, fascinated with the potentialities of such non-contact technology, have been working towards commercial applications to facilitate the observation of thermo-biological phenomena that could be used to improve productivity, health, fertility, product quality, welfare, etc of farm animals. Considerable emphasis has been given to the bovine (both dairy and beef cattle), with a myriad of potential infrared imaging solutions in development. However, the great majority of these solutions are still limited to the scientific grounds. The feasibility and applicability of such solutions require further thoughts before considering avenues for implementation in commercial operations.

Despite of the commercial challenges involved with developing and incorporating infrared imaging products in the livestock industry, it is also important to recognize that such applications could greatly differ in the technological challenges due to the nature of the targeted phenomena to be sensed. There are animal and environmental factors that may skew the thermograph readings. These factors are more or less important players in the quality and accuracy of infrared imaging according to the body localization and magnitude of the thermo-response associated with the phenomenon. Easy infrared assessments are very robust to these constrains and do not require animals to be in certain physiological condition for a successful assessment. Examples of these applications are: tick counting, assessment of local inflammation and body shape. Doable infrared assessments require some extend of standardization (i.e. distance from target, solar load, physical activity, artefacts). A few examples are: systemic illness, assessment during handling procedures and reproduction traits. Challenging infrared assessments require a great deal of standardization and instrumentation. Feed efficiency (and enteric methane production) assessment and temperament tests are challenging infrared imaging assessments in the bovine. Finally, infrared imaging is a powerful tool to improve livestock production but caution should be exercised in order to develop functional solutions that will really add to the existing technologies that farmers and other segments of the dairy and beef chains already have access.

I would like to thank Dr. Steve Miller (University of Guelph, Canada) for facilitating, by all means, our research in cattle involving infrared imaging. Thanks also to Bill Thompson (Dairy Automation Limited, New Zealand) for the opportunity of seeing the infrared imaging needs of the dairy industry and letting me to take part on the development of solutions. Special thanks to Melissa Lim, Madison Kozak, Kevin Colliver, Brock Smith and the 38 beef enthusiastic volunteers for their tremendous assistance with data collection and edition. The financial support from Beef Cattle Research Council, Agriculture and Agri-food Canada, Ontario Cattleman Association, Beef Improvement Opportunities and Ontario Ministry of Agriculture and Rural Affairs is also greatly acknowledged.

2. Design and implementation of the world's first Cellular Security and Forensics system.

Stuart Wilson
Endace Measurement Systems Ltd., PO Box 12894, Penrose, Auckland 1642
stuart@endace.com

Cellular data is fuelling the largest amount of growth in the communications sector, and mobile data is set to exceed broadband data around about now. CellCos (Cellular Communications companies) are spending the majority of communications budgets at the moment just to cope with latent demand, let alone establish capacity in advance. The huge growth in bandwidth of course is driven by smartphones.

The threat landscape in cellular network space is still very well behind the well-established security market in the conventional land based systems where rootkits and attack tools are a well-developed economy in themselves. Some unique aspects to the cellular infrastructure make the generation of attack and infiltration vectors much more difficult than in conventional networks. Despite this we already see some attacks taking place, and expect covert and overt attack vectors continue to grow and to become commonplace.

So, how protected are cellular networks? The truth is not very well protected at all ! Cellular systems have grown from the analogue systems of the 80s, through 2G, into 3G and 4G networks, and the designers of these systems have a very RF centric view of the world, in other words, no idea about data security. And security experts, and the security industry don't understand cellular systems, and their peculiar intricacies. The result is that these systems are open to a variety of DOS attacks which are able to, and do, bring down cellular systems. We consider this to be a significant latent issue.

In 2010 we embarked on a project, (working with a CellCo) to provide tools to allow them to more effectively look for a variety of attack vectors. Specifically these tools were designed for Cellular networks and consider special aspects of their design.

In this presentation we discuss the peculiar aspects of cellular systems that make them both vulnerable, and difficult to monitor. We explain some of the attack vectors that pose a threat and the tool we built to allow security operators to monitor these systems. We'll also present the field trials and the results, and some of the commercial realities of business in this space.

3. Advances in time-of-flight 3D cameras.

Adrian Dorrington
School of Engineering, University of Waikato, Private Bag 3105, Hamilton 3240
adrian@waikato.ac.nz

Time-of-Flight imaging literally adds a new dimension to machine vision systems, letting computers perceive the world in 3D. This relatively new breed of cameras is capable of measuring distance for each pixel in the image simultaneously, allowing the detection of object shape, size and location in a scene.

These cameras work by flood illuminating the scene with intensity-modulated light at frequencies in the order of tens to hundreds of megahertz. This light scatters off objects in the scene, some of which returns to the camera. A specialised modulatable image sensor is used to determine the phase change of the detected illumination modulation, and hence the optical path length it has traversed and distance to the object.

This time-of-flight approach has advantages over the more traditional triangulation approach in that it is smaller, is faster, and within reason has a larger measurement volume. Of course, the technology also has disadvantages compared to triangulation, most notably, worse precision and accuracy. No one technology is better than the other, but one is often more suitable for some applications than the others.

There are a number of off-the-shelf cameras currently available from manufactures such as Mesa Imaging, PMD Technologies, Panasonic, Soft Kinetic, and Fotonic. However, these cameras are still limited in several ways. For example, they are shipped with fixed lenses, meaning a fixed field of view. In some cases it is possible to custom order a camera with a specified field of view, but compared to traditional imaging technology this is a significant drawback. In addition, the cameras are limited in their performance, the most obvious of which is their pixel count, which is typically less than 40k pixels (imaging resolution of 200 by 200 or worse).

For metrology and instrumentation applications, these cameras find little favour because of their accuracy and precision limitations. Precision is basically a function of collected light, so can be addressed with illumination levels and integration time, but this is a trade-off with eye-safety and frame rate. Accuracy however is more difficult to address, with non-linearities arising from harmonics in the sensor and illumination modulation signals, and distortions caused by multi-path interference and reflections, both in the scene and in the camera optics.

This talk will first introduce the principles of time-of-flight cameras, the various models available and their differing configurations, and some simple example applications. Limitations that are currently a barrier to mass up-take will also be discussed, along with some of the work being done in the Chronoptics group at the University of Waikato to address these limitations.

4. Sorting out the bad apples.

P. Martinsen, R. Oliver, C. Clark, R. Seelye, K. Moynihan, and V. A. McGlone
Plant & Food Research, Private Bag 3230, Hamilton 3240
pmartinsen@plantandfood.co.nz

Bruised apples, which cost the New Zealand apple export industry more than $25 Million in 2000, are a precursor to rots and infections and are less palatable to consumers. Bruised tissue oxidises to a characteristic red/ brown colour which is easily visible in pale skinned varieties, such as Golden Delicious. But this colour change is often masked by the pigments on the skin of darker varieties — Red Delicious, for example — and takes about 20 minutes to develop, making it difficult to detect damage occurring during sorting and grading in a pack-house.

Apple tissue both scatters and absorbs light. Oxidation changes the absorption coefficient. But it was recently shown that impact damage changes the scattering coefficient as well: one study showed a drop of 30%, 28 hours after Golden Delicious apples were bruised. However, there are a number of challenges in directly measuring the scattering properties of apples fast enough (at least 10 fruit per second) for online grading.

The intensity of light diffusely reflected from a scattering volume depends on both the absorption and scattering of light within the volume. So when the scattering coefficient decreases, diffuse reflectance will also decrease, though the indirect effect is smaller. We found fresh bruises immediately decreased diffuse reflectance across the near-infrared spectrum by between 2 and 7%, depending primarily on wavelength. Though small, this is within the sensitivity of image sensors, which can typically achieve a signal-to-noise ratio of 100:1 at each pixel. However, such a small change in image intensity means that lighting uniformity and detector sensitivity play key roles in successful discrimination of bruised and sound tissue. We show how appropriate wavelength selection can improve the contrast of bruises and demonstrate successful detection of fresh bruises (less than 2 minutes old) on fruit travelling at more than 1 m/s.

5. The Cardiac Myometer: Measuring heat- and force-production in exercising heart muscle fibers.

Andrew J. Taberner[1,2], Callum M. Johnston[1], Bryan P. Ruddy[1], Denis S. Loiselle[1,3], and Poul M. F. Nielsen[1,2]
[1]Auckland Bioengineering Institute and Departments of [2]Engineering Science and [3]Physiology, The University of Auckland, Auckland. a.taberner@auckland.ac.nz

With each beat of the heart, its cells spark a brief pulse of calcium, which triggers force development and cell shortening, funded by expenditure of energy with its attendant liberation of heat and consumption of oxygen. To study cardiac muscle energetics quantitatively, it is of paramount importance to measure, simultaneously, the mechanical and thermal performance of cardiac muscles of small (~100 µm) radial dimension, as they perform mechanical work. However, the diminutive heat rate (~1 µW) and force-production (~10 mN) of such small samples, together with their need for a constant supply of nutrients and oxygen, makes this a demanding undertaking.

We have developed a number of microcalorimeter systems (Figure 1) to measure simultaneously the force-length work output and heat liberation of living excised cardiac trabeculae – naturally occurring cylindrical arrangements of cardiac muscle cells. In these instruments, force production and muscle length change are determined and controlled by a laser-interferometer and a real-time control system. Muscle heat production is inferred from measurements of the temperature increase (~1 mK) imparted by the muscle to a flowing fluid, as measured by thermopile temperature sensors.

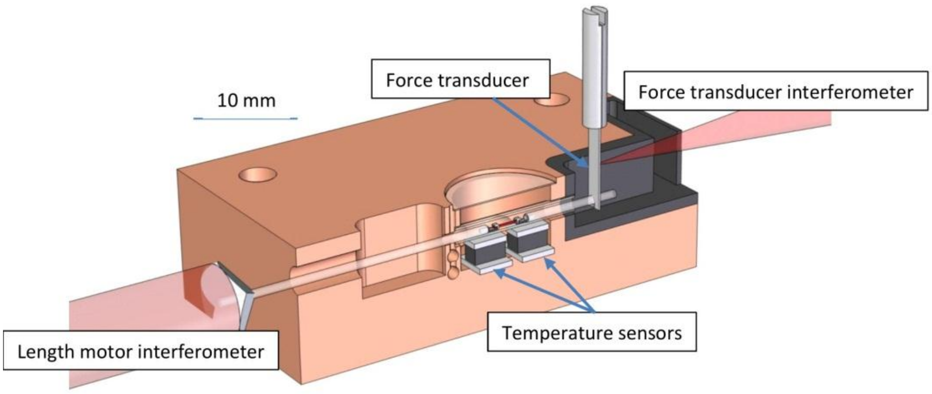


Figure 1 – Cut-away view of our microcalorimeter, showing heat- and force-sensors

With this approach, we are able to measure muscle heat production to a resolution of ~1 nW, and force production to a resolution of ~1 µN. Our measurements show that the net mechanical efficiency of heart muscle is ~12%.

This sensor will soon form the heart of a new instrument: *The Cardiac Myometer,* in which we plan to expand our measurements to include calcium ion concentration, oxygen consumption, muscle shape, and muscle protein spacing.

6. Perimeter security sensor implementation.

Keith Gallagher
Gallagher Group Ltd, 181 Kahikatea Drive, Melville, Hamilton 3206
Keith.Gallagher@gallagher.co

Gallagher is a world-wide supplier of integrated Access Control and Perimeter Security solutions. Traditional electric security fences primarily act as a deterrent to intruders. Without the use of sensor technology, the ability to detect attacks on or interference with the fence has limitations. Gallagher are extending their product range by offering load sensor technology to detect a wide range of attack types. This presentation will explain the process from initial research to understand the problem domain, the scientific approach to problem solving, the subsequent development of a proof of concept, testing for feasibility, and ultimately the detailed design, development and validation.

Contributed papers

Technological Challenges in Monitoring New Zealand Bird Species.

Near real time, accurate, and sensitive bacterial enumeration in aquatic environment using an all-fibre spectroscopic fluorescence system.

Lessons Learnt from On-Farm Sensor Development.

Wireless Sensor Network: Sharing the working experience.

A cost-effective way to construct a vector network analyzer using an oscilloscope and directional couplers.

Cancellation of Harmonic Content in Time of Flight Range Imaging.

Mobile Sensing for 3D Content Creation.

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Scaling Soil Moisture Profiles using Ray Tracing on GPR Data.

Characterising noise on a TDR image sensor.

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An Analysis of the New Affordable DepthSense Range Imaging Sensor.

Designing Smart Grids Using Wireless Sensors & Actuator Networks.

The Use of Vissim Real Time in Data Acquisition, Analysis and Feedback.

A physically-based dielectric model for moisture sensors.

Electrochemical Capacitive Sensing of Alcohol in Human Breath.

Wireless sensor network for microclimate monitoring.

1. Technological Challenges in Monitoring New Zealand Bird Species.

Amal Punchihewa
School of Engineering & Advanced Technology, Massey University, 19 Abby Road, Palmerston North 4410
g.a.punchihewa@massey.ac.nz

Birds play a major role in almost all eco-systems. Gathering information about their behaviour can provide valuable insight for mankind through scientific and ecological studies. Acoustic communication of birds is well-known in the scientific community. New Zealand is the habitat for approximately 37 native birds including some rare and endangered species. As a consequence, national parks are attractive to many tourists as well as ecologists and conservationists.

Most native birds are naturally capable of distinguishing other bird species as well as interpreting their messages or signs by hearing only the sound of the other bird. However, humans face a serious problem in finding the locations of birds and identifying them without the support of a third party. Thus currently there is a dire need for an automatic bird monitoring system. Unfortunately, automatic bird song/call detection is a very demanding and challenging research field, but nevertheless it is having increasing commercial value.

Automatic bird recognition is associated with a wide variety of different difficulties. A major difficulty is managing different unavoidable environmental sounds (noise) associated with field recordings. Some bird species produce complex and vast variety of bird songs. The same bird may generate the same song having very short or very long durations in different recordings thus making time management in their analysis very critical. It is clear that to reliably classify and recognize any potential bird sound signal, it will be essential to build a large database - in spite of the difficulties associated with this task.

2. Near real time, accurate, and sensitive bacterial enumeration in aquatic environment using an all-fibre spectroscopic fluorescence system.

Frederique Vanholsbeeck[1], Simon Swift[2], and Evgeny Bogomolny[1]
[1]*Department of Physics,* [2]*School of Medical Sciences, The University of Auckland, Auckland*
f.vanholsbeeck@auckland.ac.nz

Enumeration of microorganisms is an essential microbiological task for many research fields. Various tests for detection and counting of microorganisms are used today such as a standard plate count with or without membrane filtration, Adenosine Triphosphate (ATP) testing, polymerase chain reaction (PCR), flow cytometry detection and others [1-3]. However, most of the currently available methods used to enumerate bacteria require either long incubation time for limited accuracy, or use complicated protocols along with bulky equipment.

We developed an accurate, portable, optical system, called the optrode, for near real time detection of bacteria in water. The concept is based on a well-known phenomenon that the fluorescence quantum yields of some nucleic acid stains significantly increase upon binding with nucleic acids of microorganisms. The fluorescence signal increase can be correlated to the amount of nucleic acid present in the sample. As all microorganisms contain nucleic acids, this sensor could be used for all microbial species. Fluorescent nucleic acid stains are routinely used in microscopy and cell biology [4]; however their use in optical sensing is relatively new for bacteria detection. While the development of optical methods for the detection of microorganisms is not new, only a few technologies have shown promising results that answer industrial and/or research needs for sensitivity, specificity and accuracy [5,6].

The major advantages offered by our optical system are:

1) Sensitivity. This is due to efficient light delivery with an appropriate collection volume and in situ fluorescence detection as well as the use of sensitive CCD spectrometer.
2) Accuracy. By monitoring the laser power, we account for laser fluctuations while measuring the fluorescence signal. Also a synchronized laser shutter allows us to achieve a high SNR with minimal integration time, thereby reducing the photobleaching effect. Computerized data processing and multivariate analysis further decrease fluorescence variance.
3) Portability. Our system presents small dimensions (483mm x 335mm x 128 mm (h)) and is light (12 kg.)
4) Fast/near real time data acquisition.
5) Ability to detect a wide range of bacteria concentrations without dilution or filtration (102-108 CFU/ml).

The results have shown that bacteria count from different water origins using our optical setup along with multivariate analysis presents a higher accuracy and a shorter detection time compared to standard methods. For example, in a case where the fluorescence signal is calibrated to the water batch regression line the relative standard deviation of the optical system enumeration varies between 21-36%, while the heterotropic plate count counterpart is 41-59%.

In summary, our optrode offers a robust method for bacterial detection and enumeration in water. The major advantages of the optrode are sensitivity, near real time measurements and the ability to detect a high dynamic range of bacteria concentrations between 102 - 108 CFU/ml. In the future we believe that improvement of the fibre probe will allow a sensitivity of 10 CFU/ml.

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3. Lessons Learnt from On-Farm Sensor Development.

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Designing milk sensors for the NZ dairy industry presents many challenges. Technical challenges include making your sensor reliable, low cost and flexible, while maximising accuracy. Dairy sheds are a harsh environment for sensitive electronic devices, with extremes in environmental dust, temperature, water, wash chemicals and urea. Sensors are often exposed to the elements. NZ farming is based on an inexpensive method of pasture-based feed, and to be competitive any "add-on" technology needs to be low cost. No two dairy sheds are the same – in this industry any farm can be a mix of different technology types and platforms. Therefore any sensor design needs to be flexible enough to integrate into a wide variety of platforms. Other important aspects of sensor design are how to present data to the user in a simple and practical way, and how the information gets used. For information per cow it is essential to have an integrated cow ID system and database. Welcome to the world of commercial sensor design for dairy farms!

4. Wireless Sensor Network: Sharing the working experience.

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In recent time wireless sensors and sensors network have been widely used in many applications such as monitoring environmental parameters, monitoring and control of industrial situations, intelligent transportation, structural health monitoring, health care and so on. The advancement of electronics, embedded controller, smart wireless sensors, networking and communication have made it a possibility of the development of a low cost, low power smart wireless sensors nodes. The sensors data exchange, sharing and interoperability are the major challenges using wireless sensors network for the condition monitoring. It will help to solve majority of the problems faced if a standardized sensors data format and a communication protocol. But there are many challenges faced by the engineers to make the WSN available to the society.

This seminar will discuss about smart sensors, wireless sensors network, the challenges faced by the engineering community as well as the opportunities it offer.

5. Application of WSN in Smart Grid for Home Utility System.

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(Not presented at workshop)

The present work involves the design and development of a smart grid utility system using wireless sensor network (WSN) and interfacing with home (utility) monitoring system. Smart grid wireless application utilises developed electronic system to measure voltage, current and power at load points (house hold appliances) at home in order to recognise and identify daily activity/power monitoring (meant to save power). To implement the Smart Grid, most important parameters are the knowledge of electrical quantities of the load. The control mechanism is implemented by optimum power utilization based on daily usage with the (home) monitoring system. The presentation will discuss the current work, some achieved experimental results and conclude with future works.

6. A cost-effective way to construct a vector network analyzer using an oscilloscope and directional couplers.

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Background/Significance

The purpose of constructing a vector network analyser (VNA) using an oscilloscope and directional couplers is that we want to make an instrument that can handle transient signals such as single-shot events. The traditional VNAs are made like radio receivers, which pick up one frequency at a time, thus are not suitable for transient signals. In contrast, an oscilloscope is a good choice for measuring single-shot events. Here we report on the first step to wire four directional couplers with the oscilloscope and write software to make it to perform like a VNA, capable of processing single-frequency tones.

Design

At this stage, we have a VNA made with an oscilloscope and four cheap directional couplers and elegant software. It is useful for people who want a VNA but cannot afford the cost. The four directional couplers are used to sense the incident and reflected signals from two test ports. The oscilloscope samples the coupled waves at four channels. The sampled waveforms are transferred to computer for discrete Fourier transform (DFT) analysis. The twelve terms calibration technique is deployed to calculate the incident waves at ports of the device under test (DUT) from the measured waves at channel ports of the oscilloscope.

Results

We present the results of measuring known DUTs including open and closed circuits, 50 ohm termination and a more general device. The measurements are compared to a commercially available (but much more expensive) VNA. Useful measurement out to the Nyquist frequency of the oscilloscope sampling is demonstrated despite the substantially lower input bandwidth of the oscilloscope thus the frequency response of the oscilloscope is essentially calibrated for.

Future Work

We intend to generalise the VNA to process multiple tones at once, like a non-linear VNA. Finally we want to create a transient NVNA to measure transient signals.

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7. Cancellation of Harmonic Content in Time of Flight Range Imaging.

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Amplitude modulated continuous wave (AMCW) time of flight range image acquisition is a fast and effective technique for acquiring a full image of distance values at full video frame rates. In AMCW range measurement, a light source and sensor are modulated at megahertz rates. The distance that the light travels, hence the distance to objects in the scene, is estimated from the change in phase of the light relative to the sensor. To estimate this phase change, the relative phase between the sensor and source are varied in steps, and for each step a measurement is taken, and the first order Fourier bin calculated.

Typically the light and sensor are modulated using square waveforms, in contrast the idealised situation calls for pure sine wave modulation. The difference between what is actual and ideal is due to the harmonic content of the square wave. The harmonic content alters measured phase and distance in an AMCW system, so is clearly a major and significant source of error.
Previous methods for the cancellation of phase error include calibration or alteration of the phase step regime [1–2]. These methods have significant drawbacks, for example a calibration might become invalid under varying operating conditions. Alteration of the phase step regime cancelled harmonics in a manner that is invariant to operating conditions, but also cancelled some of the desired signal which lead to a slight degradation of quality.

We identify a simple means to eliminate unwanted harmonic content. By altering the phase steps from the standard regime, one unwanted harmonic is eliminated during the phase estimated process. With square waves the third harmonic is the largest, and is the target of the harmonics cancellation. From an experiment we find a reduction in phase error from 0.33 (rad) peak to peak down to 0.07 (rad) peak to peak. The noise in the phase, however, only increased by 2% on average, a remarkably small trade off.

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8. Mobile Sensing for 3D Content Creation.

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This paper describes our experiences with the use of mobile sensing technology for 3D content creation. The term "mobile sensing" here refers to systems of rigidly coupled sensors whose pose can be determined at any time. Examples include airborne lidar and the Google™ street view van.

Our primary interest is in highly agile systems, such as hand-held systems or systems deployed on a quadcopter. We have developed a hand-held system which comprises a 6 degree-of-freedom optical pose sensor, a SICK LMS400 phase shift laser range scanner, and a AVT Stingray F145C texture camera. The optical pose sensor is based on a generalised camera assembly to obtain near omnidirectional viewing, and some stationary targets. The omnidirectional viewing helps provide accurate orientation estimates.

The applications of current interest include as-built surveying and photorealistic 3D content creation. Figure 1 shows an example acquisition for an as-built engineering application. Figure 2 shows an example of a texture mapped model for a gaming application.

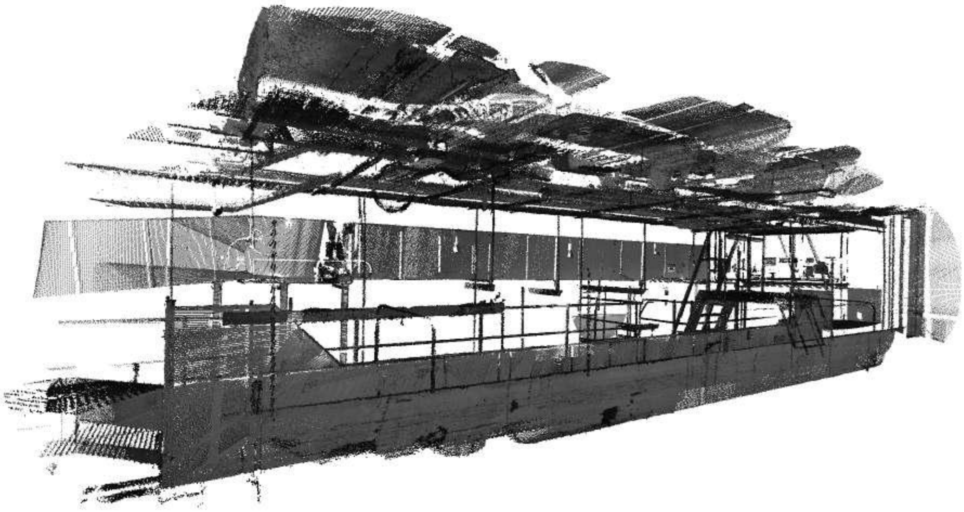

Figure 1: 3D Point cloud acquired from complex catwalk structure with multiple surface layers.

Mobile sensing has a number advantages. Because the sensors can be moved freely data can be acquired in highly cluttered environments. For example, the ceiling in Figure 1 was acquired through a small gap between some electrical ducting trays. In addition, sensors can be presented more favourably to objects or surfaces of interest giving better data. For example, a range scanner can be presented normal to a specular surface to recover data where signals might not be returned at an acute angle. Data can also be obtained from a variety of angles of incidence allowing estimation of additional surface information such as specularity and the BRDF. A system using many distributed features for positioning can be reasonably immune to vibration in the environment compared with placing a terrestrial laser scanner on a vibrating surface. This can be important for as-built applications in factories.

Figure 2: Texture mapped mesh of a beach scene.

A number of new low cost depth cameras and 3D sensors have arrived recently such as those based on the Primesense^{TM} technology. These devices have created great interest in new depth based SLAM algorithms (such as KinectFusion and its derivatives). These algorithms use a form of 3D self registration for positioning and can be regarded as mobile sensing systems. A problem with such algorithms is error accumulation over large regions and loss of tracking in regions of featureless geometry. Additionally new RGBD SLAM algorithms exploit registration between depth and colour. These techniques perform better because they can make use of both depth and texture features.

The main current limitation of our system is the laser range scanner. We plan to replace this with a new solid state 3D depth camera such as a PrimesenseTM device and introduce modern SLAM algorithms. This will provide the advantages of the RGBD SLAM algorithms while allowing accurate drift free acquisition over larger areas required for as-built surveying applications.

9. Fast electromagnetic imaging.

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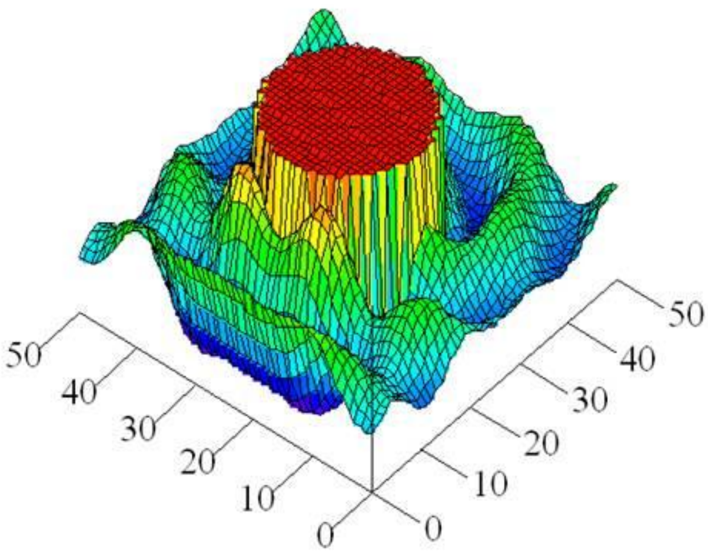
Non-linear inverse problems, such as inversion of electromagnetic plane waves scattered from objects, represent a difficult class of problem for two main reasons. First the forward problem, if nonlinear, is itself an inverse problem or, at best, a linearised problem or one that assumes linearity. Secondly, the inverse problem may be non-linear and hence necessitate a lengthy iterative reconstruction. In this paper we describe a method for circumventing both the above issues to provide a crude reconstruction from microwave scattering using an example of reconstruction of scattering from a dielectric cylinder. We first employ a Bessel/ Hankel function forward solution and then invert directly using Fourier diffraction along with a rapid 'phase filling' approach to partially compensate for the very limited data from the forward solution. This rapid inversion either stands alone for applications where exact size reconstruction is unnecessary, or may be used as the first step in an iterative inversion.



Scattered field from plane wave excitation of dielectric cylinder.

10. Opportunities for environmental sensors.

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Despite spectacular advances in science and communications, we still seem unable to respond effectively to the increasing damage we are doing to our environmental life-support systems. Perhaps this is because we are not receiving a sufficiently direct and personal sense of the changes in our biosphere, and consequently the warnings of experts are too easily deflected.

Could new environmental sensors that can communicate more personally, locally and immediately help to overcome our inertia? And what are the barriers to developing them? I hope to initiate a discussion that will draw on our various experiences.

11. Scaling Soil Moisture Profiles using Ray Tracing on GPR Data.

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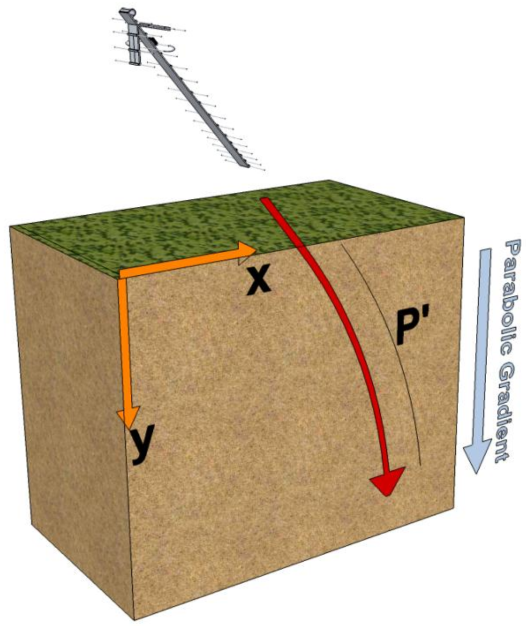
Ground Penetrating Radar (GPR) is used for a variety of purposes ranging from locating buried objects to determining geological structure and composition. In all applications the refractive index profile of the subsurface will determine the ray paths of the propagating wave. The percentage of free water in the subsurface material has a dominating influence over the refractive index profile and indeed determining the height distribution of this water is often the target of GPR measurements.

In this work we adapt Snell's law to provide measurements of the group path (P') and transverse displacement (x) of the signal caused by soils with moisture profiles that can be represented by a parabolic form. Since the resulting equations are analytic for this form, calculations are amenable to inverse manipulation so that the unknown subsurface profile can be reconstructed for a measured value of P'.



We calculate both the range/depth coordinates and group path values for two examples of moisture profiles and discuss their significance. We also sketch out the inverse technique of recovering the profile from GPR measured values of the group path.

12. Characterising noise on a TDR image sensor.

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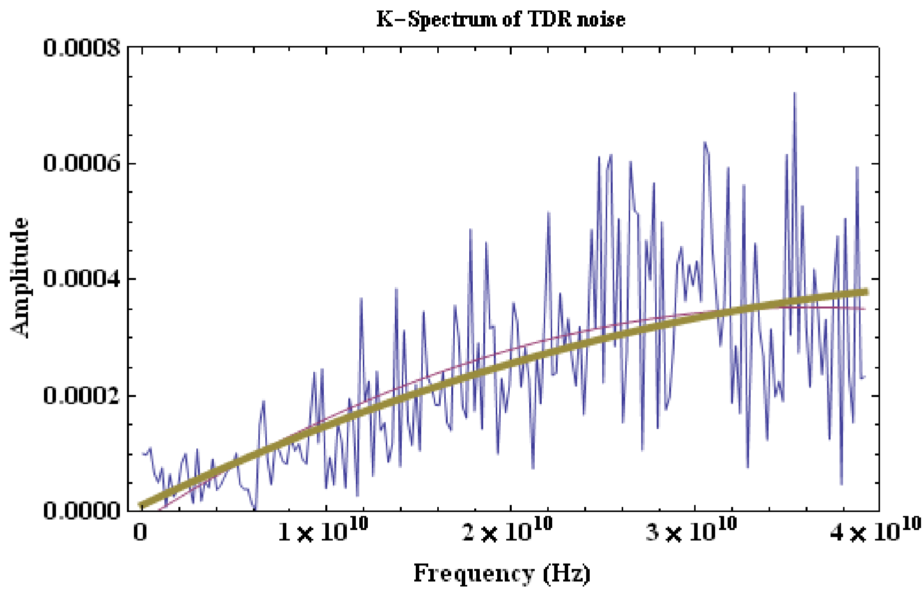
Time Domain Reflectometry (TDR) using parallel transmission lines can be used to non-invasively determine moisture content of a sample to a depth of several centimetres. Such a configuration can also be used to image structural detail within a sample using moisture as a surrogate (e.g. timber, soil). Since the signals returned by such a non-invasive system is very weak any included noise has the ability to overwhelm the sought response, especially when imaging small features.

In an attempt to reduce the influence of noise in this application we characterised the noise for the case where no sample is present and find that it has components that can be resolved in both frequency and space (space being along different points of the transmission line). The noise therefore behaves in a distinctly non-Gaussian manner for the TDR transmission.



Such spatial and frequency dependence is an ideal candidate for wavelet filtering and we investigate this application. Such filtering gives qualitative improvement on the signal condition and has the ability to decrease the amount of smoothing over those portions of feature edges necessary for pattern classification applications. We discuss the merits of this filtering procedure and the practical advantages of applying it to fast algorithms.

13. Low cost autonomous 3-D monitoring systems for hydraulic engineering environments and applications.

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The details of developing autonomous 3-D motion monitoring systems based on commercial off-the-shelf (COTS) motion sensors for hydraulic environments are discussed. Possible areas of application are river bed sediment transport monitoring and monitoring the agitation and other physical parameters inside milk vats with a mechanized agitator. Simplified calculations of inertial navigation systems (INSs) such as Euler angle method, MATLAB programs for further processing, power management systems for autonomous operation including the possibility of inductive power transfer (IPT) and use of micro electromechanical systems (MEMS) technology are discussed. Experimental results for proof of concept systems are highlighted.

14. Optically Sensing Fruit Firmness.

Philip Rowe[1,2], Rainer Künnemeyer[2], Andrew McGlone[1], and Sadhana Talele[2]
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In New Zealand the fruit industry has grown from just $481 million dollars in 1985 to $3.5 billion dollars in 2011 (Fresh Facts, 2011). With this increase comes a growing expectation of fruit quality. To satisfy this need, fruit grading systems have been developed to measure attributes such as weight, colour, diameter, shape, density and taste by companies such as Compac Sorting Equipment Ltd and Taste Technologies Ltd.

Firmness remains difficult to measure at high speed (10 fruit per second, for example). Common measurements include the penetrometer, force deformation, impact, and vibration (Garcia-Ramos, 2005). The disadvantages of these techniques are that they are either destructive or involve contact with the fruit which is difficult at high speed and can even cause damage. More recently there are a number of techniques that try to make the measurement optically. These include near infrared reflectance spectroscopy, NIR transmission, laser backscattering, time resolved spectroscopy (Garcia-Ramos, 2005). They present significant advantages as they are non-contact, non-destructive and can allow for high speed measurement.

This research looks at developing a laser backscatter based imaging system that can measure firmness at high speed. Three four discrete lasers (690, 850, 904, and 980nm) are used to illuminate apple samples. A high performance CMOS camera then acquires images of the illuminated samples. The images are analysed and an intensity profile is extracted. Figure 1 (left) shows an image captured using the system with static samples, and on the right is the intensity profile. These profiles are analysed and firmness parameters are extracted which can be used to develop firmness prediction models.

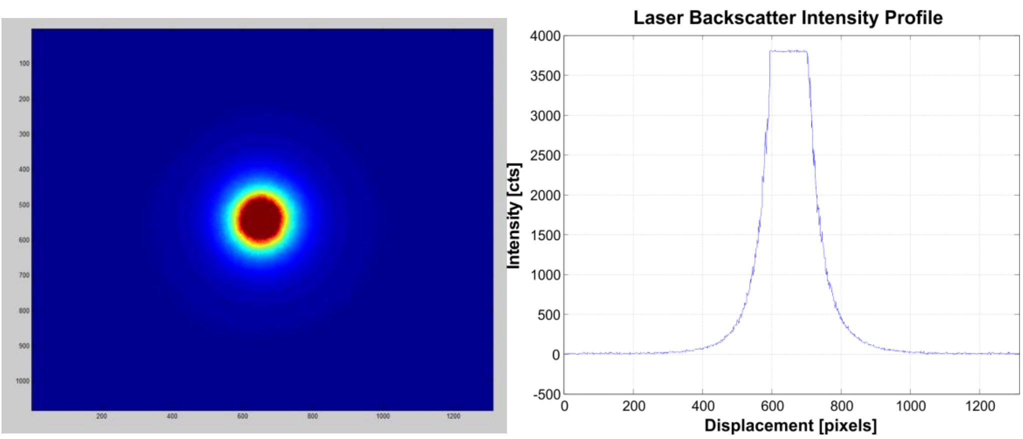

Figure 1: Laser backscatter image from 690nm laser incident on an apricot (left). Extracted intensity profile from backscatter image (right).

15. Light Emitting Diode (LED) spectrometer based on optimised discrete wavelengths selection method.

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Development of LEDs based Near Infrared (NIR) spectrometer is presented. The device is currently being developed for in-field fruit quality assessment. The optimised wavelength combination is important to the development of new types of inexpensive and/or portable NIR technology. The use of discrete bandwidth devices, such as LED light sources and filter-based sensors, requires pre-selection of a small number of discrete wavelengths. In this research, a set of kiwifruit spectra was obtained using a portable NIR device (NIRVANA, Integrated Spectronics, Australia) that uses a wide spectrum spectrometer (MMS-1, Zeiss) operating over the range 300 to 1150 nm with resolution of about 3.3 nm. The dataset consists of 834 absorbance spectra and corresponding fruit dry matter (DM) measurements, an important maturity indicator for kiwifruit. These data have been used in other studies to develop models for predicting kiwifruit dry matter across a range of different genotype.

Optimised wavelength selections were made using spectral data from the 650 to 1050 nm range and interpolated to a set 10 nm resolution. Multiple Linear Regression models were generated using up to 7 wavelengths. The models were optimised within a calibration and validation regime using the root mean square error of prediction (RMSEP) as the primary metric. The Partial Least Square (PLS) method was also applied to the dataset to provide a bench-mark. The result shows that six wavelengths have been identified as an optimum number to predict kiwifruit dry matter. The sensitivity of the discrete wavelength has been analyzed by introducing perturbation to each wavelength from 1 nm to 5 nm range. The new DM prediction was obtained from perturbed data set where the Standard Error Prediction (SEP) has been used as the primary metric. The result shows that the SEP of predicted kiwifruit DM will increase with increase of perturbed wavelength.

16. TDR moisture sensing in bread.

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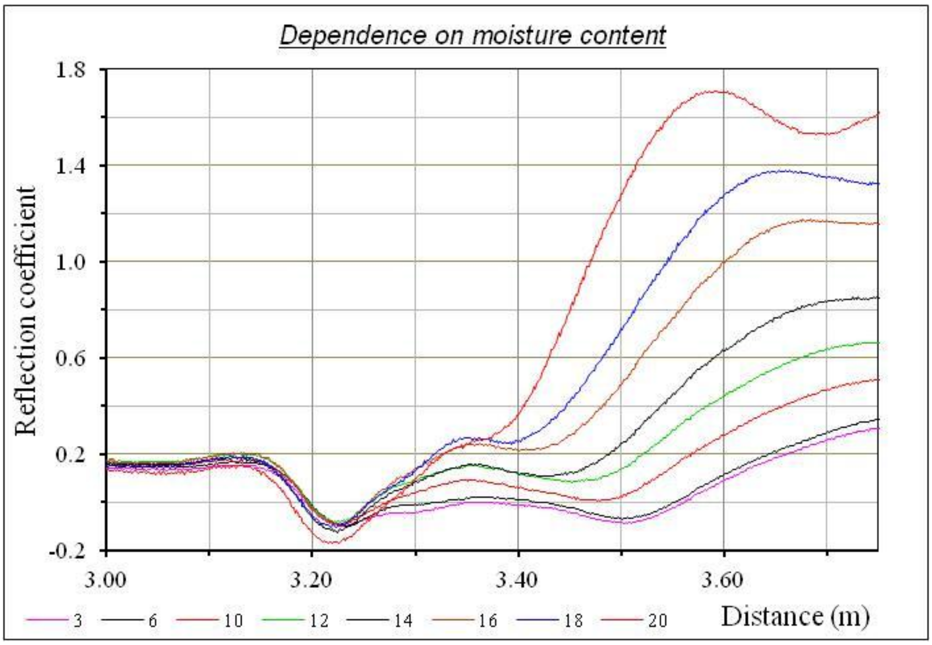
We describe a preliminary experiment to measure the moisture content dependence of the time domain reflectance (TDR) spectra of a bread loaf.

The average moisture content of a fresh loaf varies considerably depending on the recipe, the moisture content of the flour and other constituents, and on production conditions. The complex permittivity of bread depends on its moisture content (Liu et al. 2009). However, within a fresh loaf the moisture content is very uneven (e.g. from 11% in the crust to more than 60% in the centre, Bhatt et al. 2009). This creates particular difficulties for permittivity measurement methods that require sub-sampling of loaves, and to methods which are sensitive to uneven moisture distributions. The TDR method employed here samples a large fraction of the loaf, and responds to bulk permittivity and thus has a low sensitivity to moisture distribution.

The figure demonstrates the strong dependence of TDR waveforms on bulk moisture content in initially fresh bread as drying progresses, and the potential for determining bulk moisture content. Although the intention of this work was to measure the moisture content and determine parameters of a dielectric model for fresh bread, typically 60% moisture content by weight (dry basis), the experiment was extended to quite dry bread which led to some mould growth and void development during the drying process. The presentation describes details of the experimental protocol and methods which could be used to constrain deterioration when drying bread.



17. Towards tissue recognition using dispersion in optical coherence tomography.

Norman Lippok[1,2], Stuart Murdoch[1], Stéphane Coen[1], Poul Nielsen[2,3], and Frédérique Vanholsbeeck[1]
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Optical coherence tomography (OCT) is a non-invasive imaging technique based on low coherence interferometry that provides high resolution 3D images of small samples with a depth range of a few mm in turbid media [1]. Typically the depth resolution is inversely proportional to the light source bandwidth and can be as good as 1 µm in recent experiments. OCT has adapted methods that offer tissue differentiation and functional information such as elastography [2] and speckle contrast [3]. Most other OCT-based methods that provide material differentiation are related to the electric susceptibility of a medium. Absorption has been used to differentiate lipid from water [4] and polarization sensitive OCT use the tissue birefringence, i.e. the angular dependence of the refractive index, as a contrast agent [5].

Chromatic dispersion, i.e. the frequency dependence of the refractive index, is seen as detrimental in OCT as dispersion imbalance between the two arms of the interferometer degrades the resolution of the OCT setup. We have been working on different techniques, both hardware and software, to compensate for dispersion imbalance and to restore the system resolution to the theoretical prediction [6]. In some cases, the numerical techniques present the advantage of being able to measure the sample dispersion. Recently we have been working on using chromatic dispersion for material differentiation.

Using a tri-band swept source configuration, we can identify water and lipid at a sample thickness of 40 µm and 90 µm, respectively. Our preliminary results reveal exciting prospects for medium identification or differentiation at a resolution suitable for OCT. This is possible even without dispersion calculation, by only evaluating the sign and magnitude of the walk-off. The successful encoding of lipid on such scales could have profound consequences for clinical applications and may aid the detection of lipid filled plaques in coronary arteries prior to rupture.

OCT images suffer from speckle that reduces the contrast and the visibility. While speckle is seen as a source of noise, it has also been recognise as a carrier of information [7,8]. Based on our recent work on dispersion compensation using the Fractional Fourier transform [6,9], we have devised a new technique that allows for simultaneous speckle reduction and dispersion compensation. This method is based on fractional Fourier transforms of a single A-scan and demonstrated on biological samples using a center wavelength at 840nm and 1300nm, respectively. A 1.54-fold reduction in speckle contrast was achieved with negligible axial resolution broadening.

During the talk, we will present the basics of OCT and discuss the different techniques we have implemented to obtain images with a better contrast and to aim at tissue differentiation.

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18. **Printable Plasmonic Sensors for Low-Cost Alcohol Vapour Detection.**

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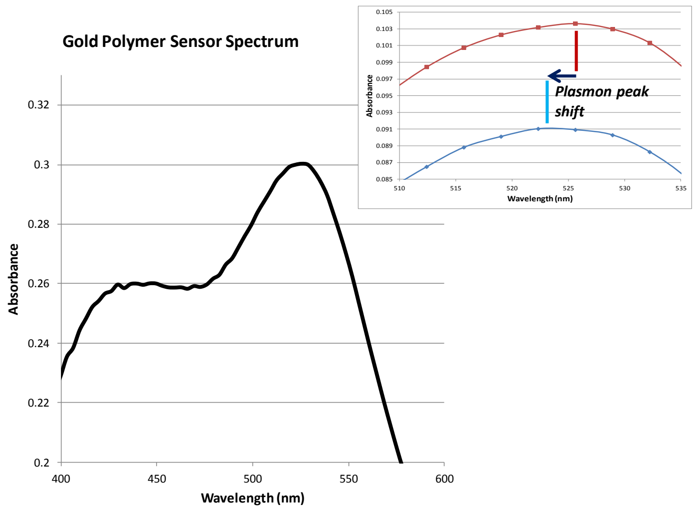
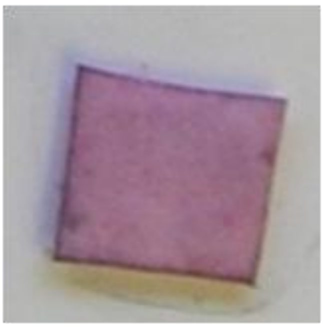
A great variety of different transduction technologies are available to detect organic vapours sensitively but there is a pressing need for disposable low-cost sensors capable of responding to concentrations of critical industrial organic volatiles as they fluctuate in real time. Printing of gas-responsive polymer layers onto low-cost paper substrates offers a means of mass-producing large numbers of colorimetric gas sensors that can be read by portable spectrophotometers.

In this project, gold nanoparticles are encapsulated into a responsive silica-based sol-gel-derived polymer to form a hybrid material where the individual nanoparticles are prevented from aggregating by steric spacing and appropriate tailoring of the polymer electrochemistry. This hybrid polymer is formed on porous paper substrates by spin-coating, producing a thin layer that is permeable to the target organic volatiles. As the volatile penetrates the polymer nanostructure, the inter-particle distance between the gold nanoparticles is increased and the plasmon absorbance peak of the nanoparticles is blue-shifted. This response is reversible, thus allowing the sensors to be re-used for multiple individual exposures or alternatively used as a near-real-time monitor for organic volatile concentration.

The sensors have been tested for methanol and ethanol vapours and gave plasmon peak shift responses of between 0.1 and 1.5 nm which were detected using a spectrophotometer. It is envisaged that a hand-held optical reader device could be used to evaluate sensor responses in future. The sensors achieved detection limits of 160 ppm for methanol and 100 ppm for ethanol, making them suitable for use in industrial control applications. Work is ongoing to improve the detection sensitivity further and to evaluate the chemical mechanism of the gas detection response.





19. Characterisation of SnO_2 and ZnO Nanostructures.

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Current applications of nanotechnology include gas sensing and characterisation of materials and fluids at different stages of chemical processes. This paper presents the nano-characterisation of thin films prepared from tin (iv) oxide and zinc oxide for the optimal determination of trace hydrocarbons gases in geo-environmental fluids. Different concentrations of tin (iv) oxide and zinc oxide nanoparticles were combined, and used to prepare particle mixtures. The metal oxide nanoparticles were deposited by radio frequency magnetron sputtering at different conditions onto SiO_2 substrate to obtain thin films. Depending on the concentration of the combining metal oxides and the durations of plasma deposition, the as-grown layers of the thin films exhibited variable surface morphology. Critical analysis of the surface and particle characteristics of thin films was investigated using Scanning Electron Microscopy (SEM). The direct surface representation of the material was determined by tapping mode Atomic Force Microscopy (AFM). This study has provided valuable insight into the growth optimisation of the thin film structure for optimal volatile gas sensing process.

20. Applying SARIMA Time Series to Forecast Sleeping Activity for Wellness Model of Elderly Monitoring in Smart Home.

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The life expectancy of older individuals is increasing, and this tendency will continue. The older individuals are interested in satisfying lives by living independent, but the self-regulating way of life include with risks. In particular, the everyday house actions such as primary features like preparing day meal or food, bathing, walking, sleeping, watching TV etc., is a key sign in identifying the performance of older individuals house actions. Intelligent, robust, low-cost, versatile and real-time house actions tracking program is very much required to record the primary house actions and respond immediately when there is a change in the frequent action of an older individual.

There is a huge need for an electronic system with smart process for tracking primary Activities of Daily Living (ADL) actions of older individuals living alone so that healthcare can be taken at the best by showing the physical fitness in terms of quantitative well-being to care taker. To have better operational understanding on the sensing data analysis through time sequence, in this paper, we have elucidated time series technique with sleeping activity scenario based on the bed sensing usage action for forecasting elderly sleeping tendency. The same set of processes can be applied to various primary daily activities performed by an elderly, and the corresponding indices can guide the performance in terms of quantitative wellness and thus appropriate care can be provided before unforeseen event can happen.

The overall system structure of wellness determination contains two important areas i) Signal Network with Zigbee modules and ii) Intelligent home monitoring program to gather sensing signal information and execute information for behavioural changes of an elderly.

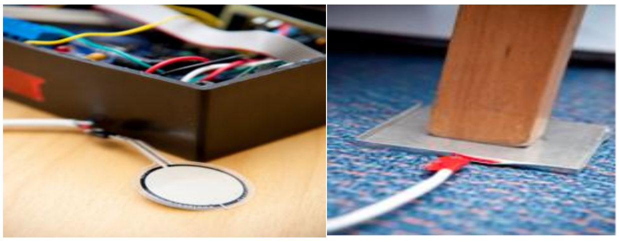

Figure1: Wireless sensing units monitoring a subject bed usage.

Along with the Wireless Sensor Network (WSN), a laptop computer was setup with Zigbee component acting as coordinator to gather sensor signal data. WSN consists of sensing units both electrical and non-electrical. As we are exemplifying sleeping activity in this paper, corresponding fabricated sensing unit using force sensor is shown in Fig. 1 to monitor bed usage.

Trend and prediction of time series is computed by using Auto Regression Integrating Moving Average (SARIMA) model.

From the Fig. 3, it was observed that the time series is not stationary, hence Seasonal-ARIMA with Autocorrelation (ACF) and Partial Autocorrelation (PACF) functions of the time series are considered for trend analysis. Forecasting the usage duration of objects in smart home by time series modeling can precisely predict how long a particular appliance can be used by the elderly. This model was helpful in reducing the number of false alarms to be generated.

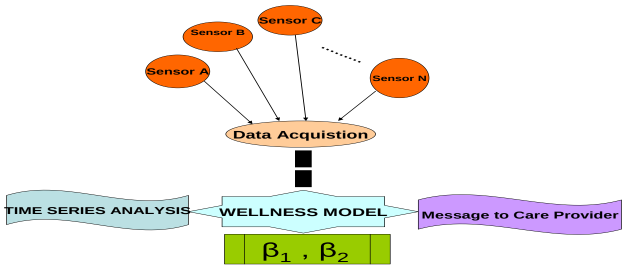

Figure 2: Functional description of Wellness Computation Functions

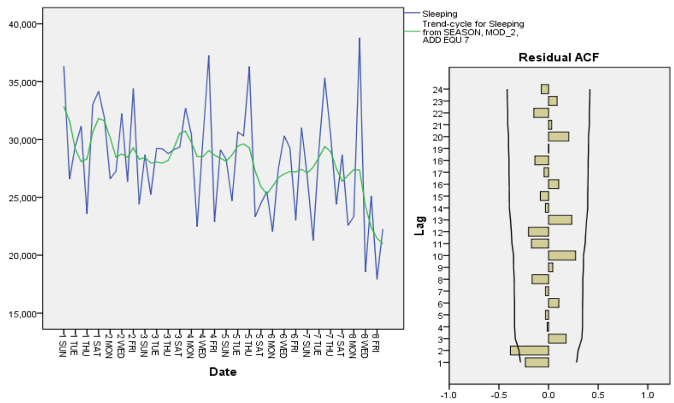

Figure 3: Bed sensing sequence and Trend based on the forecasting model of sleeping activity of subject1 elderly

21. An Analysis of the New Affordable DepthSense Range Imaging Sensor.

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A new player, SoftKinetic, has recently appeared in the 3D full-field range imaging camera market with their DepthSense camera range priced in the US$250-300 bracket. The sensor is targeted at the consumer market and for gesture recognition, presumably, for applications such as gaming on computers. Given the substantial price advantage (over an order of magnitude) over the competition it is an interesting question as to the quality of the sensor.

We analyse the SoftKinetic DepthSense 325 range imaging camera for precision and accuracy in ranging out to 3 m. It is specified as suitable for 0 to 1.2 m operation however because the active illumination is modulated at 50 MHz it should be capable of unambiguous ranging out to 3 m.

Two flat planar targets are imaged; first a grey board is imaged from 0 m out to 1.5 m and, second, a retroreflective target is imaged from 1.2 m out to 3 m. The retroreflective target was needed for imaging out past 1.5 m so that sufficient light is received to make the range calculation, however it could not be used for imaging at distances less than 1.2 m due to excessive specular reflection. Straight-forward image processing is used to identify the target and calculate the range and the root mean square variation in ranging to the target.

It is found that inaccuracies in ranging of up to 2 cm occur to the grey board when imaging over 0 m to 1.5 m and the precision in ranging degrades from just below 1 cm at 0 m to almost 10 cm at 1.5 m. Similar inaccuracies occur with the retroreflective target but the precision is always under 1 cm even out to 3 m due to the strong signal return received from the target.

These results indicate a rather good accuracy due to harmonic contamination in comparison to other much more expensive technology. They also indicate that it is possible to unambiguously range out to 3 m using high reflectivity targets for specialised applications.

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22. Designing Smart Grids Using Wireless Sensors & Actuator Networks.

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The efficient use of electrical energy is vital in today's world; this is due to the growing energy demands and the limited availability of renewable energies. Power networks constantly undergoing changes due largely to facilitate ever increasing power usage. During recent years, Smart Grids have emerged to deal with these challenges by identifying the energy usage patterns and thereby improving usage efficiency. As a future power system, the smart grid pursues continuous monitoring, pervasive communication, self-healing reliability, and timely reaction to meet the growing demand for sustainable and clean electric energy [1]. This study presents a framework to design a smart wireless sensor and actuator network (WSAN). This system monitors and efficiently manages power consumption and helps distributing peak load in a smart grid environment.

Sensors in wireless sensor and actuator network are low-cost, low power consuming devices with limited sensing, computational, and communication capabilities. Whereas, the actuators in this kind of network are resource rich nodes with better computational, and wireless communication capabilities. In WSANs, the sensor monitors by capturing the current status of the target devices, while the actuators are operated by the control logic. In smart grid perspective, the WSAN's will play a key role hosting various energy demands and energy management applications [2]. Our system is targeted to a residential/household environment. By analysing the data from the sensors that are connected to various electrical devices in a home, a series of control activities are initiated and are executed by the actuators. These control activities can be either turning on or turning off various electrical devices connected to the power supply that are being monitored. Figure 1 shows our proposed model of WSAN to be implemented in a residential environment. Firstly, a load profile of the building was calculated based on the power consumption as shown in figure 2. Further analysis of these load profiles by using appropriate algorithms may lead us to accurately pin point the electric devices that are required to be either turn on or off. This will ultimately reduce the peak loads on the grid and thereby improve the power usage, efficiency of the power grid.

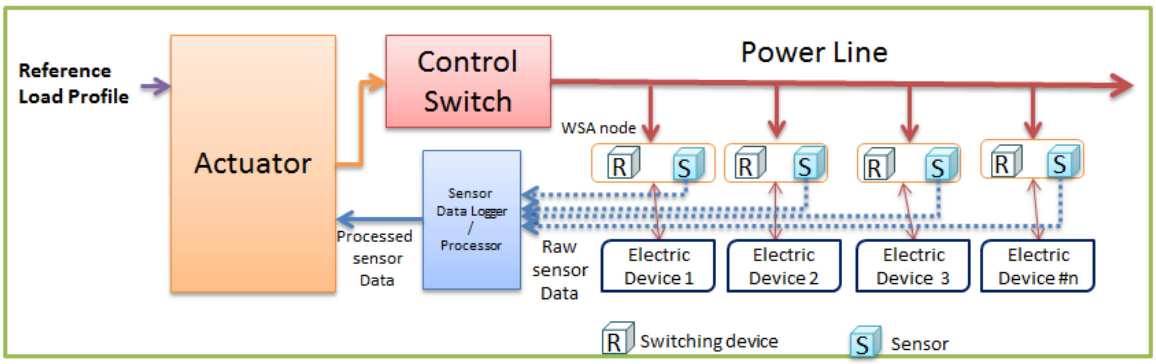

Figure 1: Wireless sensor & Actuator Network Model

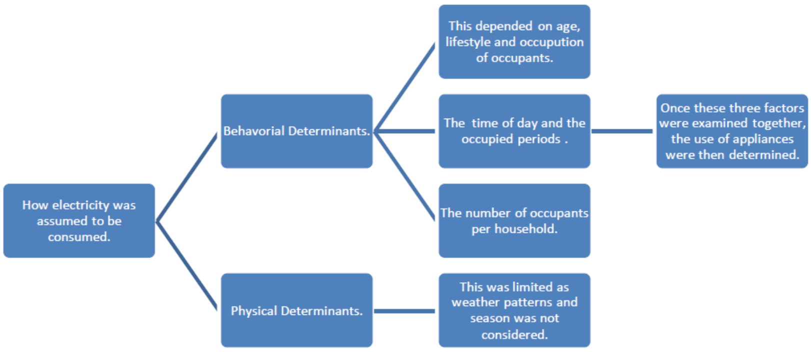

Figure 2: Flow chart to determine energy consumption

So far six different energy load profiles of typical house types have been generated as shown in figure 3 and 4. Each profile represents the total daily energy consumption of hot water, lighting and electrical appliances. The profiles have been individually created for each scenario (household) depending on the type of occupants and their lifestyles. Building the load profile and predicting energy consumption plays an important role in this research. Accurate load profiling and forecasting methods can help actuators in the network to work more efficiently. This can help the whole wireless system to take decisions more intelligently and accurately.

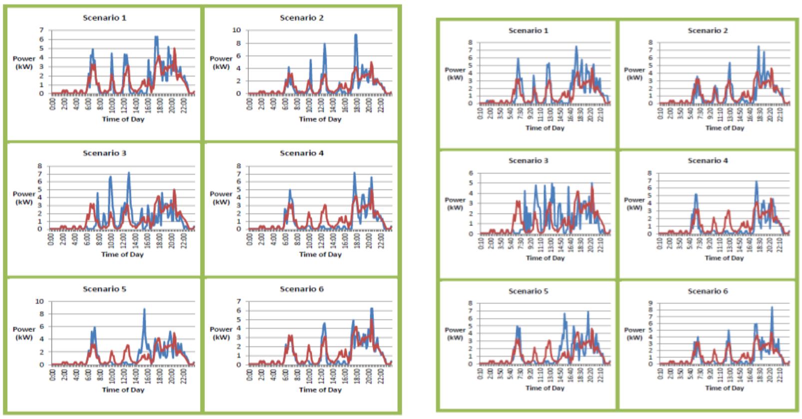

Figure 3: Total power consumed per household; left: 10 August 2012, right: 17 August 2012

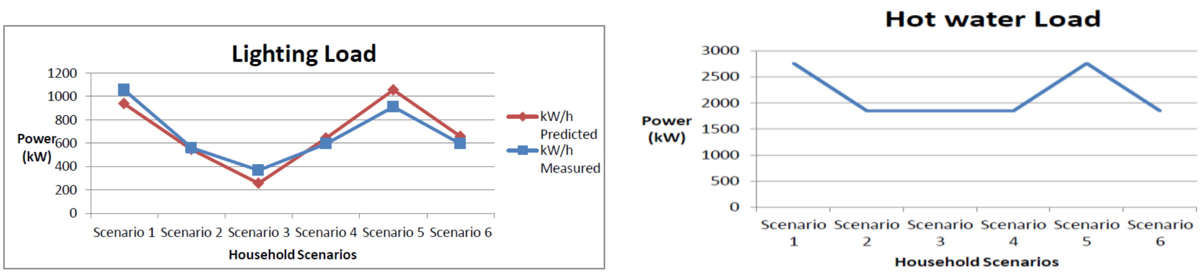

Figure 4: Load graphs

[1] V. C. Gungor, B. Lu, and G. P. Hancke, “Opportunities and challenges of wireless sensor networks in smart grid,” IEEE Trans-actions on Industrial Electronics, vol. 57, no. 10, pp. 3557–3564, 2010.

[2] M. Erol-Kantarci and H. T. Mouah, “Wireless sensor networks for cost-efficient residential energy management in the smart grid,” IEEE Transactions on Smart Grid, vol. 2, no. 2, pp. 314–325, 2011.

23. The Use of Vissim Real Time in Data Acquisition, Analysis and Feedback.

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In current research into an electromagnetic automotive suspension, a real time data processing system was required. This system was to use inputs from one or more accelerometers and a Linear Variable Displacement Transducer. These inputs are required to be processed in real time and the output used to control a magnetic field to produce a variable damping effect.

A standard hardware/software based approach would be to use a National Instruments package such as CompactRIO, which supplies data to Labview. This approach has been widely adopted by both industry and academia. However, while very powerful it is expensive and requires several pieces of dedicated supporting hardware. The high cost means it is normally unaffordable by small engineering companies. A less costly solution is to use a data acquisition board (DAQ) supplying a signal that is then processed by VisSim Real-Time software package. VisSim can operate effectively on most modern PC's and is a block diagram based simulation and control software with a range of add-on software such as Real-Time which enables the user to integrate the sensor inputs directly with the hardware of the control system. This approach is also known as 'hardware-in-the-loop'. VisSim is well known for its user friendly block diagram interface and ease of installation which allows time constrained small companies to become productive in a short time.

VisSim Real-Time allows sophisticated real time conditioning and processing of sensor signals. Sensor signals are input to VisSim Real-Time through relatively low cost, commercially available DAQ systems. A wide range of built in tools are available to condition and process the sensor signals, including filters, dead-band, Boolean, etc. This approach can eliminate the need for external electronic circuits for signal processing.

During the development phase of a mechatronic type project, rapid improvement of the signal processing and control system is possible as it only takes a few seconds to change filters, integrators, etc., by manipulating parameters in the blocks and then re-running the system. The simulations and hardware control can be run at the same time allowing direct comparison between the expected and actual results. Furthermore, data can be collected from both simulations and experiments simultaneously for later review or post processing. The key to the success of real time systems is the processing speed of modern computers. However, even with the fast processing speed of modern computers, care still has to be taken with the complexity of the signal processing and control algorithms to ensure they actually run in real time. Once the final system has been developed using VisSim Real-Time it can be embedded in a computer chip for use in real world and commercial applications.

24. A physically-based dielectric model for moisture sensors.

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The use of dielectric properties as an indirect measure of volumetric moisture content (θ_v) is widely accepted across a range of disciplines such as the natural sciences (e.g. soil), food engineering (e.g. fish, food powders), timber processing (on-line measurement of medium density fibreboard), and agriculture (barley within a silo). Dielectric models are used with electronic methods of measuring the permittivity of a material, to translate measured dielectric properties (usually the real or complex relative permittivity ε_r) to θ_v of the composite material.

We describe aspects of a dielectric model for use with granular materials such as soil and basecourse, working from basic physical parameters such as particle size distribution and specific surface area that may be obtained through measurement or estimated from published data. Results for coarse-grained soil demonstrate good agreement with published data.

Dielectric mixing models quantify the influence of physical properties on ε_r of a material, and may take the form of $\varepsilon_r(\theta_v, other\ parameters)$ or $\theta_v(\varepsilon_r, other\ parameters)$. Much of the research activity in this field is directed towards using the dielectric properties of soil as a function of θ_v. While the physical size and shape dominates the dielectric response to water, particularly at low water content, there are many similarities in response with cellulose or protein-based materials, so many of the principles described here are transferable across such materials. This arises from (i) the large disparity between ε_r of water (~80) and that of most other materials where ε_r is typically in the range 3-5, and (ii) the orders of magnitude variation in the surface area between different materials to which water may bond and hence points to specific surface area as a useful dominant parameter in a dielectric model.

Many dielectric mixing models apply to a restricted range of parameters, particularly the particle shape and size distribution within the composite material that we may relate to specific surface area. These physical parameters also strongly affect the frequency dependency. We show the basis for how these influences may be accounted for by Debye relaxation descriptors and hence provide the basis for a physically based dielectric model for granular materials.

25. Electrochemical Capacitive Sensing of Alcohol in Human Breath.

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Ethanol has been consumed by humans of different cultural backgrounds in the form of alcoholic drinks since the prehistoric times, for various reasons. Sudden large intake can build up in the bloodstream faster than it can be metabolized by the liver causing intoxication and impaired human responses. Alcohol impaired driving is one of the largest causes of serious road crashes in New Zealand.

The development of gas sensors has become popular in detecting alcohol in human breath, due to the increase of alcohol-related accidents. As a result, several breathalyzers have been developed and commercialised to help detect an individual's alcohol concentration in their breath by blowing into the device via a pipe or a mouthpiece but this creates health concerns among people regarding communicable diseases. Distance alcohol detection devices provided a solution to these concerns but these cannot detect beyond 4 cm and these lack accuracy and selectivity. Above all, these devices provide qualitative instead of quantitative results which cannot be used to figure out blood alcohol concentration (BAC) of the subject. The distance alcohol devices that are capable of giving good estimation of BAC cannot read beyond 1.3 cm.

A new approach of electrochemical capacitive sensing is used in this research in order to overcome these constraints. This technique is capable of detecting alcohol in human breath up to 20 cm and is selective to the ethanol molecules. Electrochemical Impedance spectroscopy is applied in conjunction with the planar interdigital capacitive sensor to achieve the objective of distance detection of alcohol in human breath simulated in laboratory environment using bubble train experimental setup. The silicon substrate based interdigital capacitive sensor is fabricated using MEMS fabrication technique involving photo lithography and etching steps already in-practice in semiconductor industry. The sensor's selectivity to alcohol is achieved using Stannum oxide coating on the sensing area. Experiments were carried out for alcohol concentrations as low as 0.014 mg/L to 0.114 mg/L gas (human breath) with detection distance of 10, 15 and 20 cm at room temperature. The experimental outcomes provide sufficient indication to favour the development of a low cost detection system for rapid quantification of alcohol in human breath potentially useable as distance breathalyser or a car interlock system that checks BAC of the driver before heading on a trip.

26. Wireless sensor network for microclimate monitoring.

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No abstract available.

Standby

Abstracts have been provided for the following presentations, but they have not been included in the program schedule due to time constraints. Contact the authors directly if you would like further information.

Modal testing for quality assessment of produce.

Separating Scatter and Absorption.

LIBS for precision agriculture.

27. Modal testing for quality assessment of produce.

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Modal testing is a technique where the natural, vibrational (modal) frequencies of an object under test are determined and compared to a reference. The technique is particularly useful in quality assurance applications where a potentially faulty test object is compared to the perfect response of a reference.

Often an impact hammer is used to provide impulse excitations that result in all modes of vibration being excited with equal energy. In general a basic understanding of structural dynamics is necessary for successful modal testing. Nevertheless this method has been successfully employed to find faults in many mechanical components produced on production lines.

Modal testing can be applied to produce, like fruit, vegetable, eggs, etc., to evaluate the overall stiffness or vibrational response of the object. Modal testing can be used to assess the overall stiffness of fruit which can be related to ripeness, and can be used to differentiate cracked eggs from intact eggs.

We have investigated a non-contact approach for both stimulus and detection, where chicken eggs are excited by acoustic waves, and their frequency response is measured using a phase locked self-mixing diode laser interferometer. The optical vibrometer allows reasonably high spatial resolution, high precision measurements and does not add mass loading to the sample. An advantage of using sound rather than a conventional shaker or impact hammer is that the acoustic waves can be modulated as desired. In addition, the speaker does not require any moving part and its alignment process is trivial. Our experiment shows white noise excitation produces a significantly different vibration spectrum for the intact part of an eggshell compared to spectra recorded on or near the cracked part of the shell.

28. Separating Scatter and Absorption.

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Visible and near infrared spectroscopy has been successfully applied to predict the composition or quality of various materials. Some of these are highly turbid, where the total measured attenuation is affected by absorption as well as light scatter. Pre-processing techniques, like multiplicative scatter correction, are widely used to minimize the effects of scatter on the calibration of the spectra. However, biological material, for example fruit or human tissue, can be very heterogeneous with substantial variations in composition as well as scatter coefficient. The variation in scatter can be far greater than that caused by absorption. In this case it can be desirable to separate absorption and scattering and measure both coefficients independently - more so as the scattering coefficient itself might hold valuable information about the sample.

We review intensity modulated as well as continuous wave spectroscopy techniques which we have used, coupled with diffusion theory, to separate absorption and scattering effects. The techniques were applied in the laboratory to determine temperature of blood (Martinsen et al., 2008) and Intralipid (Cletus et al., 2010), which is a tissue simulating phantom extensively used in biomedical research. Using frequency domain techniques we were able to determine the temperature of Intralipid from the absorption coefficient of water. We found that changes in the absorption coefficient could be used to estimate temperature to within ±1°C using a full spectrum, multivariate approach while the frequency domain method, which does not require calibration training, gives ±4 °C.

The frequency domain technique can be extended to diffuse optical tomography where the variation of the absorption and scattering coefficient inside a turbid medium is determined. We are developing a non-contact measurement system based on range-imaging cameras (Hassan et al., 2010) and are able to detect objects immersed in Intralipid.

In another project we are applying continuous wave techniques to the assessment of fruit properties on-line a high speed fruit grader. The diffuse image of a laser spot on the fruit is recorded and analyzed by fitting a diffusion model (Qin and Lu, 2007) to the radial decay of the intensity. The curve fitting algorithm returns absorption and scattering coefficients of the medium. The goal is to predict quality parameters, like firmness or bruising, at high speed. Initial results indicate that we are able to determine optical properties, but correlation of the scattering coefficient with fruit properties is poor.

Cletus, B., R. Künnemeyer, P. Martinsen, and A. McGlone (2010) J. Biomed. Opt. 15: 017003:1-6.
Hassan, A., R. Künnemeyer, A. Dorrington, and A. Payne (2010) ENZCON 2010, 17th Electronics New Zealand Conference, Hamilton, New Zealand.
Martinsen, P., J.-L. Charlier, T. Willcox, G. Warman, A. McGlone, and R. Künnemeyer (2008) J. Biomed. Opt. 13: 034016:1-7.

29. LIBS for precision agriculture.

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Laser Induced Breakdown Spectroscopy (LIBS) uses bursts of energy from a laser to generate a plasma at the surface of a material. The laser illuminated material dissociates into constituent ions and atoms. Each emits light at characteristic wavelengths, allowing the proportion of different elements to be analyzed. LIBS has been successfully employed in the laboratory and on mobile platforms, like the Mars rover where it gave accurate information on the composition of the materials investigated.

LIBS technology can be applied in a number of ways and can potentially be used to assess the nutritional status of growing fruits, or could be used in a vineyard to detect the disease organism Botrytis for targeted spray application. Our aim is to develop a LIBS instrument to provide real-time measurement of plant nutrition status for precision application of fertilizer.

We will discuss the challenges to develop an instrument that is accurate and usable in the field under normal operations.

Registered participants

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