In 2010, the School of Electrical Engineering & Telecommunications (EE&T) had a record breaking 400 research publications which contributed 24% of the total publications of the Faculty of Engineering. In 2011, EE&T made the highest contribution of publications across all 10 schools in the Faculty and 7 of our staff collectively secured $2.1 million in ARC Discovery and Linkage funding. $1 million in ARC LIEF funding was also secured that year.

These results are a testament to the calibre of academics at EE&T, their research expertise and international standing. Every day our staff play a major role in placing Australia at the forefront in our 5 research areas of expertise: power engineering, telecommunications, systems and control, microsystems, and signal processing.

For the first time, the School appointed a Director of Research, Professor David Taubman, who is responsible for the strategic direction of research in the School. This year, the School is compiling a Research Report to profile the research excellence of our staff and students and to celebrate our research achievements.

A key focus of the School is to foster the development of early career researchers and to grow our research groups so that they are closely aligned with national and international areas of interest. In the last three years, the School has made 4 early career appointments, all of whom are opening up new research opportunities in neuromorphic engineering, quantum systems control, power systems protection and systems dynamics. The School has also revitalised power engineering research at UNSW to keep pace with, and help drive international research and development in the area. To consolidate this, a senior appointment, Associate Professor John Fletcher, was made to further grow power electronics and renewable energy research.

The new Tyree Energy Technologies Building houses both the Australian Energy Research Institute (AERI) and the Centre for Energy and Environmental Markets. EE&T plays a key role in both of these cross-disciplinary research centres, which provide a platform for our researchers to engage with other faculties and institutes. I am pleased to report that the School has made two strategic senior appointments, Professor Vassilios Agelidis (Director of AERI) and Professor Gerald Sheblé (Ausgrid Chair), in the areas of sustainable energy solutions and electrical power economics.

The School also celebrated the success of Professor Andrew Dzurak and Dr. Andrea Morello who won the prestigious Eureka Prize for Scientific Research for their research in advancing the realisation of diamond-based quantum bits; work that also resulted in a publication in Nature magazine. This research is a huge scientific breakthrough and opens the paths to creating ultra-powerful computers in the future. Media events surrounding this breakthrough are ongoing.

The School is on a steadily rising trajectory in its research and has sustainable growth, as our academics continue to make research breakthroughs. With an increasing number of PhD and Masters students, the School is producing the next generation of innovative engineers who are set to make a valuable contribution both in research and in industry. We look forward to embarking on the research challenges and celebrating our successes along the way.

Professor Eliathamby Ambikairajah
Head of School of Electrical Engineering and Telecommunications
This research report is about our people, my colleagues, some of our important breakthroughs, and the open research challenges that we are pursuing. We have asked each of our academics to provide a brief research profile that emphasizes the relevance of their research field and their vision for the future. After reviewing these profiles, I am personally struck by the breadth of research interests and expertise that are located within our School.

We have also asked our academics to collectively contribute descriptions for a set of sample research projects, together with pointers to the much larger set of projects that are currently under investigation. Together, these research descriptions should leave you with a sense of the breadth and relevance of research taking place within the School, adding to the enormous and pervasive impact that the field of Electrical Engineering is having on the world we live in.

The School has a number of obvious areas of strength and concentration. Examples include power systems (machine and drive technologies, power electronics, stability, monitoring, control and associated economic systems); quantum computing (with new directions in quantum communications and control); materials and devices (including novel photonic materials and MEMS devices); and signal processing (covering fields as diverse as neural coding, forensics, speech, multimedia and biologically inspired signal processing).

However, areas of concentration only tell one part of the story. Our people work in a much wider range of areas, where many have very strong international reputations within their fields of expertise. The School boasts several Fellows of the most prestigious relevant research societies. Our staff profiles bespeak many prestigious awards for the publication of ground-breaking research and numerous distinguished presentation roles at large international conferences. EE&T also has the highest rate of research active staff members amongst any of the large engineering schools at UNSW. Approximately half of our academics have reached the position of Full or Associate Professor through a merit-based University wide promotions process; this number is high within the Faculty of Engineering and the University at large.

The School of EE&T at UNSW is an outstanding destination for research studies, for postdoctoral research work and for research collaboration. The School and University provide a rich multi-cultural environment, high quality research facilities and a wide range of funding opportunities.

Amongst several new initiatives, the School plans to offer a limited number of competitive internally funded postdoctoral fellowships over the next few years. The School is also mindful of the need to continuously maintain and strengthen the quality, the experience and the reputation of its PhD graduates. We are very pleased to announce the first EE&T student best paper award, generously sponsored by Canon Information Systems Research Australia (CISRA), full details of which appear under Awards and Accolades.
Organisational Chart

Head of School
Prof Eliathamby Ambikairajah

Director of Research
Prof David Taubman

- Energy Systems
- Microsystems
- Systems and Control
- Telecommunications (including Signal Processing and Photonics)
Head: Prof Faz Rahman
Prof Vassilios G. Agelidis
Prof John Fletcher
A/Prof Iain MacGill
A/Prof Toan Phung
Dr Rukmi Dutta
Dr Jayashri Ravishankar
Dr Daming Zhang

Head: Prof Chee Yee Kwok
Scientia Prof Andrew Dzurak
Prof Rodica Ramer
A/Prof Andrea Morello
Dr Torsten Lehman
Dr Aron Michael

Head: Prof Victor Solo
Prof Andrey Savkin
Dr David Clements
Dr Ray Eaton
Dr Branislav Hredzak
Dr Hendra Nurdin

Head: Prof David Taubman
Signal Processing:
Prof Eliathamby Ambikairajah
A/Prof Julien Epps
Dr Elias Aboutanios
Dr Vidhyasaharan Sethu
Dr Chamith Wijenayake

Photonics:
Prof Gang Ding Peng
Prof Francois Ladouceur
Dr Iain Skinner

Telecommunications:
Prof Aruna Seneviratne
Prof Jinhong Yuan
A/Prof Robert Malaney
A/Prof Vijay Sivaraman
A/Prof Wei Zhang
Dr Tim Moors
Professor Eliathamby Ambikairajah works in the field of digital signal processing and speech processing and has a particular expertise in speaker recognition and verification, as well as language identification. He has an interest in applying novel signal processing techniques to diverse areas such as medical science and diagnosis, tele-health, cochlear modelling, biometrics and speech enhancement. Some of the important elements of this field include forensic analysis, speaker diarisation, speaker modelling, robust language identification systems and emotion detection.

Applications for this research include security applications such as banking and share information retrieval, forensics, speaker recognition technology, translation services and other communications technologies, biomedical and tele-health technology designed for Australia’s ageing population. Overall, this field of research has huge benefits to the increasingly globalised world.

Professor Eliathamby Ambikairajah is a key contributor to research in language recognition. Over the last 7 years, he has graduated 11 PhD students in the field of speech processing. His work in language identification is so highly regarded on an international scale, that he was invited to write a tutorial entitled “Language Identification: A Tutorial” for publication in the special edition in the IEEE Circuits and Systems Magazine 2011. This is the first time a language recognition tutorial has been featured globally since 1993.

Highlights of his career include:
• repeated appointment as a short-term Invited Research Fellow at the British Telecom Laboratories, UK for 10 consecutive years (1989 - 1999);
• IEEE Young Research’s Best Paper Award 1981.

Professor Eliathamby Ambikairajah is a Chartered Engineer and is a Fellow of both Engineers Australia (FIEAust) and the Institution of Engineering and Technology (FIET).

Vision
With the rapid development of technology and the requirement for individuals to be connected in a globalised world, there is an increasing need for robust speech processing across every-day applications. Whether it is security, health or multi-lingual services, the field of signal processing is looking at vast growth in the future, particularly in the biomedical area. Although humans are still the most accurate language identification systems in the world, there are many benefits to be gained from making language identification an automatic machine based process. His vision is that language identification, speaker recognition and verification can be made robust by developing biologically inspired front-end-through specialised, deep recurrent neural networks, in the same way that humans do. In Australia’s multicultural and ageing society, the application of all of this technology on a daily basis will be a necessary part of life.

In the coming years, he will be working in the following areas:
• exemplar-based techniques for speech enhancement of noisy speech to provide robust speaker verification in security applications;
• developing tele-rehabilitation technologies to provide Australia’s ageing population with a better quality of life, including non-linear model/machine learning algorithms and developing a web enabled at-home tele-health system;
• Automated Sound Scene Analysis – to implement sound processing algorithms to classify acoustic scenes for hearing aids and cochlear implants The Signal Processing Application in Detecting Arc Faults and Determining Energy Losses in Distribution Networks”.

Professor Eliathamby Ambikairajah holds external appointments as Visiting Scientist to the Institute of Infocomms Research (A*STAR), Singapore and External Examiner to Taylors University College Malaysia.
Professor Vassilios G Agelidis is the Director of the Australian Energy Research Institute (AERI) and Professor of Power Engineering at the School of Electrical Engineering and Telecommunications. He is one of Australia’s leading authorities on electronic control of electrical systems, power electronic energy conversion, efficient electricity grid technologies and power engineering. He has done extensive research in the field of “smarter” electricity grid infrastructure and sustainable energy system integration incorporating solar photovoltaic, wind energy sources, batteries and fuel cells.

Applications for this research include renewable systems energy conversion, solar PV, fuel cell and wind generation system integration with electricity grids, electric vehicles and efficient energy conversion technologies.

**Highlights of his career include:**
- 2012: Smarter Planet Innovation Faculty Award, IBM
- 2010: Electrica Awards First Prize Winner €50,000: awarded by AREVA Transmission & Distribution, Paris, France. Electrica Awards was an international innovation contest organized by AREVA T&D, one of the top three global players in the transmission and distribution of electricity.
- 2009: IEEE PEDS 2009, Taiwan, ROC: Best Paper Award for the work entitled: Equalizing DC Capacitor Voltages in Multimodule HVDC Using SHE-PWM with Mr N. Florentzou.
- 2007: Endeavour Executive Award, Department of Education, Science and Technology, Australia to visit Seoul National University of Technology, Seoul, South Korea for three months.
- 2004: Advanced Research Fellowship, Engineering and Physical Sciences Research Council, United Kingdom.

Professor Agelidis is a senior member of the IEEE and an Associate Editor of the IEEE Transactions on Power Electronics.

**Vision**
To provide research leadership towards technologies that would help us transition to a more sustainable energy and electricity infrastructure and to contribute towards more efficient and cost effective energy conversion systems.

**In the coming years, he will be working in the following areas:**
- power electronics, grid-connected inverters and control;
- multilevel high-voltage high-power energy conversion systems;
- voltage-source converter based Flexible AC;
- transmission System and High-Voltage DC systems power transmission technologies;
- power electronics applications in distribution and transmission systems;
- renewable energy systems, wind energy, solar PV energy;
- AC and DC microgrids;
- solar PV large-scale grid integration;
- fuel cells grid-connected energy systems;
- hybrid energy storage systems and control;
- energy efficiency and sustainable energy solutions.
Dr Elias Aboutanios works in the field of signal processing. In particular his interest lies in the areas of adaptive and statistical signal processing with a focus on signal detection and parameter estimation.

Some of the important elements of this field are detecting and enhancing weak signals such as those from low power or distant transmitters, and estimation of the frequency, amplitude and phase of signals (especially sinusoids) in order to enable communications when the transmitter or receiver or both are moving, or when the carrier is not known a-priori.

Applications for this research include radar target detection and range and bearing estimation; GPS and other navigation systems; nuclear magnetic resonance spectroscopy and magnetic resonance imaging.

Dr Elias Aboutanios’ contributions to this field are a novel and powerful set of algorithms for estimating the parameters of complex exponentials in noise. This led to a patent and the algorithms have been applied in a wide range of problems from optical systems to wireless communications, to mechanical systems monitoring.

Highlights of his career include:
- recipient of a number of scholarships (Co-op Scholarship, Sydney Electricity Scholarship, and Australian Postgraduate Award);
- best paper award at the CISP-BMEI conference in 2010;
- a number of invited presentations at Conferences and Universities.

Vision
As we push our systems towards higher efficiencies and accuracy, we find ourselves working in lower signal to noise ratios. These systems can be improved partially through better hardware design. However, as the software and the signal processing part of the system are cheaper and more flexible, a large part of the burden is then placed on the signal processing algorithms. My vision for this field is to push the power of these algorithms and methods towards the theoretical limit of their performance.

In the coming years, he will be working in the following areas:
- GPS interference localization and mitigation;
- low concentration compound detection using Nuclear Magnetic Resonance Spectroscopy;
- improved signal processing algorithms for Magnetic Resonance Imaging;
- biologically inspired signal processing;
- improved time-frequency signal representations.

Through the development of the novel Design Proficiency subject, Dr Elias Aboutanios has been doing some research in education. He has interest in enhancing engineering education methods to the undergraduate students, as well as the promotion of engineering and in particular Electrical Engineering to high school kids.
Professor Andrew Dzurak is one of Australia’s leading experts in nanoelectronics and quantum computing technologies. He is the Director and founder of ANFF-NSW, the NSW node of the Australian National Fabrication Facility (ANFF – see www.anff.org.au). ANFF is a network of university-based laboratories that provide researchers and industry with access to state-of-the-art facilities for the fabrication of devices and nanostructures with application in sensors, medical devices, nanophotonics and nanoelectronics.

He received his PhD from the University of Cambridge in 1993, under the supervision of Professor Sir Michael Pepper, FRS. While in Cambridge he studied hot electron and ballistic transport in a range of semiconductor nanostructures, including the recently discovered quantum point contact and quantum dot systems. Professor Dzurak was awarded a Cambridge-Australia Scholarship from the Cambridge Commonwealth Trust to undertake his PhD, and he has since remained close to the Trust and Cambridge, having served on the Trust’s Australian scholar selection committee for five years.

He worked closely with Robert Clark to establish the Semiconductor Nanofabrication Facility at UNSW, and personally established Australia’s highest resolution electron-beam lithography capability. These facilities were subsequently expanded considerably by Prof Dzurak during 2006-12, establishing what is now the NSW node of ANFF.

In the late-1990s he began research in the area of silicon-based quantum computation, in particular the development of single-atom spin-based quantum bits (qubits) based on phosphorus donor atoms. This research led to the establishment of the Centre for Quantum Computer Technology. For more than a decade the centre has achieved major advances in the international effort to realize large-scale quantum information processing and was expanded in 2011 to become the ARC Centre of Excellence for Quantum Computation and Communication Technology. It maintains the world’s largest focused collaboration on silicon-based quantum computing and he is the Centre’s Work-Package Leader in this area, as well as the Lead Investigator for a major grant from the US National Security Agency and US Army Research Office in silicon quantum computing.

In 2011 he and his colleague Dr Andrea Morello were awarded the Australian Eureka Prize for Scientific Research for their demonstration of a “single electron reader” in silicon, as described by their paper the previous year – “Single-shot readout of an electron spin in silicon”, Nature 467, 687 (2010) – which has already received more than 80 citations in less than 2 years. This result built upon more than a decade of research, during which Andrew and his team have developed a range of single atom nanotechnologies that will be required for silicon quantum computing, and which also have relevance to today’s semiconductor industry.

In 2011 Prof Dzurak was appointed Scientia Professor at the University of New South Wales, the highest institutional accolade for research excellence at UNSW. He has also raised more than $80 Million in research funding for his work since joining the School. He is regularly invited to speak at international conferences in the area of nanotechnology and quantum information technologies, with over 30 invited and keynote presentations over the past decade.

Highlights of his career include:
• Eureka Prize for Scientific Research (2011);
• UNSW Scientia Professorship (2011);
• Chair, Nanofabrication Discipline Group, National Nanotechnology Research Strategy, for the Australian Academy of Science & DIISTRE (2011-12);
• Program Chair, ICONN 2010 - International Conference on Nanoscience & Nanotechnology, Sydney (2010);
• Member of Expert Working Group on Frontier Technologies – NCRIS Roadmap Review, for DIISR (2008);
• Finalist, Eureka Prize for Scientific Research (2006 & 2007);
• ARC Postdoctoral Research Fellowship, Australian Research Council (1996);
Publication and Citation Summary:
- Refereed Journal Publications: 84
- Conference Publications (Full Papers): 56
- Patent Families: 9
- Total Citations (ISI Web of Science): 1,699
- Career H-index = 21 (H = 19 since 2000)

Current Research & Vision:
Professor Dzurak leads a research team of more than 20 researchers and technical staff devoted to silicon-based quantum computing and nanotechnology. His core research continues to focus on the goal of demonstrating the key technologies for the realisation of scalable quantum computing based on single electron and nuclear spins in silicon. In 2012 Prof Dzurak and colleague Dr Andrea Morello demonstrated the first single-atom electron spin qubit in silicon. Using a silicon single electron transistor (Si-SET) to enable single-shot readout of an electron spin bound to an implanted P atom, they configured a device with an on-chip transmission line for the delivery of microwaves up to 50 GHz. Application of microwave pulses at the electron spin resonance frequency enables Rabi oscillations of the P donor electron spin, thus realising a 1-qubit gate. This work has been accepted to appear in Nature in 2012. The team also demonstrated the single-shot readout and control of a 31P nuclear spin qubit, with a remarkable gate fidelity of 98%. Underpinning this qubit scheme is an extremely high fidelity (> 99.6%) single-shot qubit readout. These results represent the realisation of a nuclear spin 1-qubit gate, as first envisaged by Bruce Kane more than a decade ago, and open the path to long-lived quantum memories based on single atoms.

In the coming years, he will be working in the following areas:
- silicon-based quantum computing and information technologies;
- single-atom nanoelectronic device engineering;
- single electron devices for sensing and current metrology standards;
- new nanofabrication technologies for electronics, photonics and medical devices.
Dr Rukmi Dutta works in the field of design and control of permanent magnet machines, finite element analysis of electric machines and other devices and development of high performance electric drive system, design optimization of highly efficient generators but also have more general interest in the power electronics, renewable energy, distributed generation, smart grid technology and electromagnetics.

Some of the important elements of this field are design of the interior PM machine with wide field weakening and high power density, development of high performance controllers for electric drive systems, development of direct-drive PM generator systems for wind-energy, development of traction drive for the future generation electric vehicle, integration of wind and photovoltaics in the smart distribution network, etc.

Applications for this research include wind energy, electric and hybrid electric vehicles, distributed generation, etc.

Dr Rukmi Dutta’s contribution to this field covers design of novel interior permanent magnet machine with extended constant power speed range for application in electric vehicles. She has co-developed, with other researchers at UNSW, the first single-barrier IPM machine with very high field weakening range and the first fractional-slot interior permanent magnet machine.

Highlights of her career include:

- Best Paper award at ICPE (ECCE-Asia) 2011;
- invited tutorials in IEEE IAS and PEDS.

Affiliations and Memberships:

- member of the IEEE, IET, WIE;
- member in a number of technical committees of international conferences;
- reviewer in a number of IEEE transactions and other international journals.

Vision

Awareness of climate change in recent years makes us rethink how to use available energy resources efficiently and sustainably. Electric hybrid vehicles on our roads, PV-arrays on our roof-tops, wind-turbines are becoming a common sight. In these changing times, making available highly efficient, reliable and high power-density electrical motors for niche application such as pure electric vehicles and generators for renewable energy sources such as wind, wave, biomass, etc. is relevant more than ever. One of the key elements to fulfill this requirement of our time is the better understanding of the newly emerging technologies of this field such as IPM machine with concentrated winding, direct drive PM generators for wind-turbines and high performance controllers and drives for these systems.

In the coming years, she will be working in the following areas:

- design optimization of the fractional-slot, concentrated-winding interior permanent magnet synchronous machines for higher power density, efficiency and reliability;
- design optimizations of novel electric machines for specific areas of application, such as electric vehicle traction and wind power generation;
- development of suitable mathematical models and high performance controllers for these machines;
- integration of wind and PV in smart micro-grids;
- design optimization of the PM generator for the direct-drive wind-turbine.
Dr Ray Eaton works in the field of non-linear control system design, and more generally autonomous systems.

Some of the important elements of the field of non-linear control design include sliding-mode control, passivity-based control, and robust control in the presence of time-varying uncertainty. In the area of autonomous systems, the robust operation of unmanned ground and aerial vehicles is important, both independently and in a coordinated manner.

Applications for this research include precise and robust guidance of unmanned ground and aerial vehicles for the agriculture and defense industries.

Dr Ray Eaton is a member of the IEEE and the IET.

Vision
There is now an increasing need in the Australian agricultural industry to provide intelligent solutions which increase productivity and efficiency, particularly in light of a decreasing labour workforce. Automation and autonomous systems have a large and beneficial role to play into the future to bring about these solutions. He sees a farming environment involving coordinated teams of autonomous ground vehicles, each carrying out precision tasks in an efficient and highly productive way, all supervised by a centralised command centre.

In the coming years, he will be working in the following areas:
• advanced ground vehicle modelling;
• robust non-linear control of ground vehicles under the influence of significant slip and terrain uncertainty;
• coordinated control of teams of autonomous ground vehicles.
Dr Julien Epps works in the field of speech processing, in particular paralinguistic speech classification problems like recognition of emotion and mental state from speech, speaker recognition (validating a speaker’s claimed identity). In this area, a key problem is overcoming the significant variability in speech posed by the spoken content, speaker identity, different recording channels and other factors.

His contributions to this field have been at the level of proposing new features that can more effectively characterize speech and proposing new compensation, modeling and classification methods or adapting existing methods and demonstrating improvements on large speech data sets. Dr Julien Epps also has research interests in specific application areas of signal processing, including recognition of mental state from biomedical signals (GSR, EEG, eye activity) and genomic signal processing.

Applications for this research include systems that can automatically determine a person’s emotion, cognitive load (level of mental exertion), or mental state (e.g. depression, pre-suicidality). This is becoming increasingly important and feasible, as computing devices become constant companions for their users. Google Glass, the recently proposed eye-piece-mounted display device, is an excellent example of how close-talk speech and eye activity images could be acquired to continuously process behavioural signals in a passive manner, providing unprecedented fidelity of the user’s moment-to-moment mental state. In general, paralinguistic speech classification has applications in health (automatic detection of mental illness), remote security (identity verification over the telephone), surveillance (detection of identity or emotion in a caller), demanding work environments like command centres, surgery or call centres (continuous automatic assessment of mental load) and forensics (comparison of voice data).

Some of his contributions to this field, jointly with collaborators in EE&T, are:

- the development of spectral centroid features for paralinguistic speech classification applications, which have provided substantial improvements in accuracy for several different problems;
- the novel application of sparse regression methods to paralinguistic speech classification applications, yielding large improvements in speaker recognition and forensic voice comparison applications;
- establishing some of the key insights into speech produced under cognitive load;
- a new perspective and suite of methods for confirmatory period estimation in biological sequence data;
- a new information-theoretic method for comparing clusterings, which has seen rapid adoption by the machine learning research community;
- a new approach to extending the bandwidth of narrowband speech and compressing wideband speech at very low rates, proposed much earlier in my research career.

Highlights of his career include:

- program chair of the International Conference on Multimodal Interfaces in 2012;
- guest editor of the EURASIP Journal on Advances in Signal Processing (2011);
- most highly accessed paper in Biology Direct journal (May 2011);
- presented an invited tutorial at the APSIPA Conference (2010);
- senior participation in the I4U consortium submissions to the international NIST Speaker Recognition Evaluation, which was ranked among the top submissions from around 50 in 2008 and 2010.

Affiliations and Memberships:
IEEE, ACM, ISCA and ASSTA

Vision
Measurement and monitoring of human status has typically been the domain of biomedical engineering, and has depended on the automatic processing of signals from intrusive physiological sensors, however this is about to shift in emphasis in two important ways:

(i) increasingly the focus will be on the mental state of healthy humans, with a view to optimizing their lifestyle, work productivity and entire computing experience;
(ii) increasingly there will be a focus on non-intrusive signals such as speech and remote observation of eye and body activity. It is already clear that the human is the bottleneck in many human-computer partnerships, however in areas like human workload assessment for example, state of the art methods are subjective, manual and post-hoc.

In the future we can expect continuous automatic measurement of key indicators of mental state and function, like we have from Windows Task Manager in a PC, and new opportunities harness this to improve our experience of work and life.

**In the coming years, he will be working in the following areas:**
- paralinguistic speech classification, in particular methods for jointly modeling linguistic and non-linguistic information;
- affective and cognitive computing based on the processing of behavioural and selected physiological signals;
- recognition of depression and pre-suicidality from speech, and investigation of telephone triage speech data;
- genomic signal processing, in particular methods for exploratory period estimation of sequence data.

**External appointments**
Dr Julien Epps is 30% secondment to National ICT Australia (NICTA) as a Senior Researcher, and also serve as the Associate Director of Education for UNSW at NICTA.
Associate Professor John Fletcher works in the research area of electrical energy systems: generation, distribution and usage, and in particular, the use of power electronics in the control of all types of electrical energy systems and ancillary equipment.

Some of the important elements of this field are how we make power electronic equipment smaller and more reliable and how we can enhance their operation and control envelopes to increase the number of potential applications where they can be of benefit. Key challenges in electrical networks include the ability to provide power electronic solutions at medium and high-voltage (that is, 33kV to 1MV). At the distribution level, key challenges are enhancing reliability and cost, and managing the ubiquitous use of inverters in ‘smart’ grids. There are also a number of interesting niche applications for power electronics that we are working on. This includes using power electronics to develop nanosecond high-voltage pulses. Such pulses can be used in emerging imaging applications, for example, multi-pulsed X-ray diagnostics, in sterilization treatments, and an area where we are collaborating with UNSW Canberra on hypersonic engines. In hypersonic engines the high-voltage pulses are used to ‘pre-ionise’ Hydrogen gas making it easier to ignite in the hypersonic flow thus enhancing the utilization of the fuel in the engine making it more efficient. Other niche applications that he is worked on include cryogenic cooling of power semiconductors to enhance turn on and off speeds, and reduce power losses. This work was primed by a need in the next generation of superconducting magnets for fusion reactors.

Applications for this research include large-scale electrical networks and generation systems, electric vehicle technologies, aerospace and other mobile power system applications.

Some of his contributions to this field are:
- patented a new type of high-speed switched-reluctance machine;
- patented a loss-optimised pulse-width modulated technique which was commercialized by Dynex;
- developed, with Raytheon Systems, the first 400oC capable Silicon Carbide CMOS device;
- supported over 50 new products in the renewable/low-carbon sector as Director of a Technology Transfer network.

Highlights of his career include:
- directorship of a technology transfer network in renewable energy;
- commercialisation of a novel permanent magnet generator technology;
- industry collaborative R&D with a number of key industry partners: Rolls-Royce, Raytheon, BAE Systems, Proven Energy.

Affiliations and Memberships:
- Fellow of the IET;
- Member IEEE;
- Associate Editor IJE;
- Editorial Board IET Renewable Power Generation.

Vision
Applications of power electronics in the generation, delivery and utilization of electrical energy are rapidly increasing. Obvious examples in the home include the integration of PV-derived energy onto the electrical grid, and the technologies used in hybrid-electric vehicles. Power electronics underpins these products, and the future will see many more applications of power electronic technologies. Nonetheless, the future is by no means static, and there is potential for disruptive technologies to fundamentally push power electronic technologies in new directions including science at the forefront of materials development. Such advances include high-temperature materials, wide-band gap semiconductors, improved energy storage media, all of which have significant potential to alter the direction of power electronics research. At UNSW, we aim to keep abreast of these advances with, for example, our collaborations with the ANFF node at UNSW. In addition, there is also sector ‘pull’, for example, Government incentives and programs to de-carbonise the electrical network. This primes new markets and opportunities for power electronic technologies.
The future for power electronic technologies is excellent, and our vision for power electronics research at UNSW is to maintain ourselves at the forefront of global research into power electronic devices and their application.

In the coming years, he will be working in the following areas:

- power electronic technologies to help realize intelligent and smart energy networks;
- improved technologies for renewable energy generators, particularly wind and photovoltaic generation;
- novel, multi-phase drive systems and converter technologies;
- power electronic converters to generate high-energy, short-duration pulses for plasma generation in hypersonic scramjets.

Associate Professor John Fletcher is also the Member of DIISRs Frontier Technologies Expert Working Group 2011.
Dr Branislav Hredzak works in the field of Control systems and optimization for renewable energy systems, high precision mechatronic systems and reconfigurable systems.

Some of the important elements of this field are:

- Design of advanced, intelligent control systems for hybrid energy storage systems
- Development of advanced control methods for high precision dual-stage actuators
- Optimization of dynamic and reconfigurable placement of network-on-chip cores

Vision

The rapid increase in global energy consumption has accelerated the transition towards distributed generation employing renewable energy sources. Advanced control systems for energy storage are deemed to be an important part of renewable energy systems. Energy storage systems can store power for use at a later time and thus have the potential to extend and optimize the operation of distributed generation and thus allow for flexibility, improvement in efficiency, utilization, reliability and robustness of the grid.

In the coming years, he will be working in the following areas:

- Control systems and power converters for renewable energy systems
- Power management systems

Dr Branislav Hredzak is a member of the IEEE.
Professor Chee Yee Kwok works in the broad field of Micro-Electro-Mechanical Systems (MEMS). He started about 20 years ago with physical micro-sensors like accelerometers and flow sensors. His current MEMS research activities have a greater optical focus particularly in the area of MOEMS (Micro-Opto-Electrical-Mechanical Systems) where MEMS, as an enabling technology, is harnessed to provide high impact solutions. His other areas of active research are in advanced versatile large displacement micro-actuators and development of new processes for MEMS device fabrication.

Applications of this research are in MEMS based optical interconnect schemes for 3D integrated circuit stacks whereby a fully guided single mode optical bus is established in a vertical stack of integrated chips with capability for coarse wavelength division multiplexing. This scheme addresses the speed limitations of metal interconnects but does not replace the current metal TSV technology. The optical bus will form the basis for interfacing silicon photonics at the chip level to the polymer photonics on the PCB. In addition, the advanced versatile micro-actuators will provide the platform for a new generation of very low profile MEMS based drivers for micro-optics to facilitate optical zooming in cameras for mobile phones and tablets, constrained by their thin profile.

Over the years, he has made significant contributions in several areas of MEMS:
(i) development of the floating-gate flow sensor;
(ii) planar silica lens pair for low loss propagation in free space;
(iii) bi-stable actuators for optical switching;
(iv) versatile independently controlled micro-actuators capable of out-of-plane and in-plan actuation for micro-optics;
(v) development of a scheme to achieve guided optical communication between chips on different levels in a 3D stack. Prof Kwok shares co-inventor of two patents on optical interconnect for 3D integration and advanced micro-actuators for micro-optics, together with Dr Aron Michael.

Vision
MEMS (also known as Microsystems Technology) is an enabling technology cutting across many traditional disciplinary boundaries and has brought about the development of new devices and systems previously thought not possible. MEMS has its origins in semiconductor technology, where aggressive miniaturisation of device dimensions laid the foundation for the miniaturisation of sensors and actuators with integrated microelectronics, making it possible for the implementation of smart sensors and actuators. Today, this capability is employed in non-semiconductor materials and is opening many opportunities for technology paradigm shifts into other disciplines like medicine, bioscience, communications, transport, environmental monitoring, etc. MEMS will continue to rapidly evolve along two paths:
(i) new technology and device development in search for new applications; or (ii) existing problems in search for a MEMS solution. Advances in MEMS research and new applications will shape the basis for creating new technologies that will impact many areas including manufacturing, space exploration, security, defense, energy, transportation, robotics, medicine, biosciences, environmental monitoring, etc. Currently, about one MEMS patent is issued a day!
He envisages MEMS to play an ever increasing role in human lives – modern electronic devices, health and medicine, communication tools and transport systems, just to name a few.

Professor Kwok is a Senior Member of the IEEE. He has served on the Transducers Conference Executive Program committee and TPC. He was one of the founding members on the Steering Committee for the Asia Pacific Conference on Transducers. Professor Kwok is a regular reviewer of journal papers in this field.

In the near and medium term, Professor Kwok’s research work will be focused in three major areas:
(i) A completely guided single mode optical interconnect bus through 3D integrated circuit stacks, building on expertise developed in the past few years;
(ii) Advancing the development of low profile actuators for micro-optics to facilitate optical zooming capability in ‘thin profile’ mobile phones and tablets;
(iii) Development of MEMS based precision alignment technology for device stacking.
Associate Professor François Ladouceur works in the field of applied photonics with special emphasis on the development of new organic and inorganic materials. Central to photonics are the notions of emission, absorption, control and guidance of light. Photonics thus covers a wide range of concepts ranging from solid-state physics to quantum entanglement. In recent years the field has moved from the micrometer to the nanometer scale where structures so small as to form metamaterials are exhibiting novel properties.

Photonics is a branch of applied physics with a strong technology focus. Hence, photonics is based on physics, both classical (e.g. electromagnetic fields, interference, etc.) and quantum (e.g. photons, coherence) but also now links to biology (e.g optical biosensors) or information technologies (e.g. encoding, transmission).

Traditionally, photonics had a strong foothold in telecoms but is now increasingly applied to information processing in general, including display technologies, data storage, interrogation and sensing. Photonics can now be found in every household (Blu-rays/CDs), in planes (fly-by-wire, heads-up displays), and in cars (entertainment system cabling).

Some of his contributions to this field are:
In 2009, A/Prof Ladouceur’s research on non-linear optics was hailed as establishing a new-paradigm in guided wave optics by introducing the concept of light guiding light. It is indeed possible to use light to dynamically write structures that will guide light: hence the concept of rewritable, erasable and reconfigurable circuitry. A/Prof Ladouceur also introduced a radically new approach for the design of waveguide path design. This approach, based on adiabatic parameterised paths, has lead to significant improvements in both the size of integrated optics devices and in the ease of their design. This patented approach is now commonly used.

Vision
The recent progress in photonics has been fueled by technological developments in general and by new materials in particular. Our abilities to pattern, modify and assemble material at the nano-scale is opening up new application fields and will revolutionise what are perceived as the current limitations of photonics. It is in the development of new materials and the tailoring of their properties to suit specific goals that the future of photonics is contained.

In the coming years, he will be working in the following areas:
• diamond-based UV-emitting devices for sterilization applications (industry supported research);
• multipoint voltage sensor for high-power electricity distribution;
• diamond integrated optics;
• artificial retina & skin based on organic micro-electronics.

External appointments
Special Study Leave (January to July 2006): Creation of Silanna Pty Ltd with an initial investment of €5 million Brisbane. Silanna now develops solid-state light emitting diodes for sterilization applications.
Dr Torsten Lehmann works in the area of microelectronic circuits and systems design. His research centres around the design of low-power CMOS analogue integrated circuits and interfacing electronic systems to the physical world, though he has a keen interest in all aspects of electronic circuits.

One of the key application areas of his research is in biomedical implants, such as cochlear implants, the bionic eye and chip-scale implants. Restoring sensory functions using implanted electronics requires design of a number of functions to interface with the body using implanted electronics with very small volume running at low power.

Another key application area of his research is in the continuing advancement of electronic systems in general: the characteristics of components in modern nano-meter CMOS processes require new circuit structures to perform common interface functions such as data conversion.

Dr Lehmann is a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE). He regularly acts as a scientific reviewer for international journals and conferences, and has been on the program committee on a number of international conferences, including the IEEE International Symposium on Circuits and Systems and the SPIE Conferences on Biomedical Applications of Micro-and Nanoengineering.

In the coming years he will be working in the following areas:

- chip-scale implantable circuits;
- circuits and systems for the bionic eye;
- control and observer circuits at cryogenic temperatures;
- amplifiers and data converters in nanometer CMOS;
- reconfigurable analogue circuits.
Associate Professor Iain MacGill
Energy Systems
Joint Director, CEEM

Associate Professor Iain MacGill works in the field of electricity industry sustainability, with a focus on clean energy technologies including renewables, their integration into the electricity industry, and the use of electricity market design, policies and regulations to drive more sustainable technology deployment.

Some of the important elements of this field are the engineering characteristics of cleaner electricity industry technologies and overall operation of the electricity industry, as well as the economic and commercial perspectives of electricity industry investment and planning.

Applications for this research include insights and tools for participants in the clean energy sector, electricity industry rule makers and market operators as well as energy policy makers.

Some of his contributions to this field are early work on sustainable energy technology assessment and electricity market design issues for renewable energy in the Australian context. More recently, Iain has contributed to work on designing environmentally related energy policy measures and developing expanded models of renewable energy deployment.

Highlights of his career include a John Yu Research fellowship at Cambridge University in 2003 and an Erasmus Research fellowship at IIT in Madrid in 2008, both in the area of electricity industry restructuring and sustainability. He was also a founding member and is now Joint Director (Engineering) of the University’s Centre for Energy and Environmental Markets (CEEM) which is a formal collaboration between the Faculty of Engineering and the Australian School of Business, that also brings together researchers from the Faculties of Science, Law and the Social Sciences. Iain’s research oriented consulting activities over the past decade include work on sustainable energy technologies, electricity industry restructuring and energy and climate policy.

Clients have included Governments (Federal, Victorian and NSW State Governments), energy industry players, electricity and energy technology industry associations, policy oriented Australian thinktanks and the NGO sector.

Affiliations and Memberships include his role as the Australian lead expert for Australian participation in the IEA PV Power Systems Task 14 on high penetration PV that involves some fifteen countries. He was also a member of the Australian Government’s Energy Technology Assessment (AETA) stakeholder reference group in 2011-12. A/Prof Iain is a Fellow of the Australian Institute of Energy and a member of the IEEE Power and Energy Society, and the International Association of Energy Economics (IAEE).

Vision
Electricity industries around the world including Australia are facing growing economic, environmental and energy security challenges. In particular, avoiding dangerous climate change would seem to require a transformation of the electricity industry towards cleaner energy over the next decade. Engineers have a vital role to play but their contribution can be enhanced through broader economic, commercial and social perspectives.

In the coming years, he will be working on facilitating this clean energy transformation within the electricity industry. Two key area of research will be modeling the technical, economic and commercial challenges and opportunities of high renewable energy penetration in the electricity industry, and for greater demand-side participation through distributed generation, energy efficiency and demand management.
Associate Professor Robert Malaney works in the field of communication systems, with interests ranging from location-based enhancements to wireless networks, coding theory, physical layer security, and quantum communications.

Some of the important elements of this field include use of location information to enhance routing and security; use of advanced coding theory so as to achieve optimal data throughput in a range of advanced wireless communication systems; use of coding theory to achieve maximal secrecy of information at the physical layer; use of quantum effects applied to classical coding theory so as to produce new quantum error correcting codes; and use of quantum effects to produce new applications that are impossible in classical communication systems.

Applications for this research that he is specifically investigating include use of location information to assist passenger and pedestrian safety in emerging intelligent transport systems that are currently being developed world-wide; and use of quantum mechanics that leads to ultra-secure communication and verification systems that are secured not by computational resources but rather by the laws of physics; and development of quantum error-correcting codes that can be applied to emerging quantum computers and quantum communication systems.

Some of his contributions to this field are:
• patented location acquisition schemes that optimize energy efficiency of smartphones, patented location verification systems for classical wireless networks, and patent quantum location verification systems which provide for unbreakable security in emerging quantum networks;
• New mechanisms for optimal routing in rapidly varying wireless communication environments that are anticipated to be deployed in emerging vehicular networks;
• development for the first time of an information;  
• theoretic framework for optimizing location verification in communication systems.

Highlights of his career include:
• eight patents held and five more filed in the area of classical and quantum communications;
• over 100 academic papers in areas spanning wired and wireless classical communications system, quantum communications systems and quantum physics with approximately 1500 citations to my work in the research literature;
• introduced the notion of quantum location verification into the academic literature leading to world-wide media attention.

A/Prof Robert Malaney is a member of the IEEE, a committee member and reviewer for IEEE international conferences. He is also a reviewer for many leading engineering and physics journals, and grant agencies.

Vision
Communication systems are now ubiquitous and form part of our daily lives. They also form an ever increasing part of our vital commerce, infrastructure, and defense systems. As such, the security of data that traverses these systems becomes ever more mission critical. In the coming years a vast effort will be made to further secure all our vital communication networks whilst still achieving useful functionality and purpose. This challenge will be particularly relevant to emerging mobile communications systems. Also, a key new development will be the integration of emerging ultra-secure quantum networks into our pre-existing classical networks. These issues raise many unsolved research questions and unsolved engineering implementation challenges.

In the coming years, he will be working in the following areas:
• security for emerging mobile communications systems at the physical layer;
• integration of quantum communication networks with classical communication networks;
• development of new applications that run over combined classical and quantum networks;
• development of quantum error correcting techniques and codes for quantum communication systems;
• the interplay between quantum error correction and quantum control techniques.
Dr Aron Michael works in the field of MEMS (Micro-Electro-Mechanical Systems) in general, and MOEMS (Micro-Opto-Electro-Mechanical Systems) in particular. Some of the important elements of this field that are of interest to him include development of new and novel micro/nano sensing and actuation mechanisms for micro-optics devices, new and novel micro/nano fabrication techniques for enabling new micro-structures, modeling and simulations of micro-structures, microelectronics for sensors and actuators, MEMS based optical switching and optical interconnect.

Applications for this research include miniaturized and high performance micro-optic devices for mobile handsets, security, medical, and automotive areas; MEMS based optical switching for high-speed telecommunication networks; MEMS based 3D-optical interconnect and cooling solutions for Tera-bit computation.

Some of his contributions to this field are:
(a) Development of a novel out-of-plane bi-stable micro-bridge actuator for planar silica waveguide optical switching; applications. This is one of the few bi-stable micro-actuators in the field.
(b) Analytical model which defines the bi-stability behaviors of multi-layered micro-bridges. This is the first model to establish bi-stability criteria for compressive micro-bridge actuators.
(c) Novel piezo-electrical actuation mechanism that provides independently controlled in-plane as well as out-of-plane movements. This mechanism, for example, can improve stroke displacement of a diaphragm by tenfold as compared to traditional approaches.

Dr Michael is a member of the IEEE and SPIE. He is a regular reviewer of papers considered for publication in the Journal of MEMS and the Journal of micro-engineering and micromechanics.

Vision
It has undoubtedly been established that miniaturization is a key feature for improving system performance and reducing cost. This is a driving force for the aggressive down-scaling that has been witnessed in Integrated Circuit (IC) technology. In addition to this aggressive IC miniaturization, however, miniaturization of sensors and actuators is critical to achieve overall system performance and cost reduction. MEMS is the key enabling technology for miniaturization of sensors and actuators. Despite some successful commercialization of MEMS products, there are still enormous challenges to be overcome to make MEMS more ubiquitous and facilitate miniaturization.

The challenges are not only fabrication but also the requirement of new micro/nano sensing and actuation paradigms. My vision is to harness the capability of MEMS miniaturization technology by introducing a new piezo-electric based sensing/actuation mechanism. The mechanism will be a fundamental architecture that enables new MEMS design and re-designing of the existing MEMS system with significant performance improvement and reduction in size.

In the coming years, he will be working in the following areas:
- developing a novel piezo-electric actuators/sensors;
- investigating an advanced out-of-plane and in-plane actuation/sensing mechanism based on the novel developed piezo-actuator/sensor;
- investigating novel ways of an integrating micro-lens, micro-mirror and micro-actuation/sensing mechanism to develop high-performance miniaturized micro-optical devices;
- developing a new approach for on-chip integration of a scanning probe microscope to enable fast and miniaturized systems;
- MEMS based optical interconnect 3D integration.
Dr Tim Moors works in the field of telecommunication networks, emphasizing Internet Protocol based networks.

Some of the important elements of this field that he works on are enhancing the reliability of communication networks, and better supporting video communication, both in terms of network infrastructure and in terms of systems that make video conferencing/chat more like face-to-face communication.

Vision
Now that the Internet is almost pervasive, people are becoming increasingly dependent on it and so increasingly concerned about reliability. Consequently, research and development to enhance the reliability of Internet services is becoming increasingly important, especially when this can be done as an extension that is used by only those users who are particularly sensitive to service dependability. The maturity of the Internet has also led to massive bandwidth being widely available which will enable widespread video communication. While video phones have existed since the 1960s and yet have failed to become widely adopted, recent advances in bandwidth and high definition video capture and display have overcome opposition due to image verisimilitude leading to high quality telepresence systems, and (more interestingly) there is great scope to make the technology less intrusive (e.g. using computer vision so that cameras track people, rather than people having to position themselves in front of cameras) and so more widely adopted. A third exciting area is that of mobile smartphones which are critical in human communication because of their deeply personal nature and their integration of sensors (e.g. location and video). This will lead to innovative applications that have been impossible on conventional computers.

In the coming years, he will be working in the following areas:

- network reliability;
- video communication and smartphones;
- following through with research to take it further than piles of papers, and instead transfer new technologies to the marketplace so that inventions become innovations.

Dr Tim Moors is also a member of the IEEE.
Dr Andrea Morello works in the field of spin-based quantum computing and nanoelectronics. His research interests revolve around the goal of constructing a quantum computer, where information is encoded in the quantum state of individual electron spins bound to single dopant atoms in silicon nanostructures. The research is broad and multidisciplinary, spanning areas from foundations of quantum mechanics and decoherence, complex dynamics of spin systems, design and nanofabrication of single-atom devices in silicon, microwave engineering, and the development and application of advanced experimental techniques for the observation and manipulation of quantum systems at ultra-low temperatures and high magnetic fields.

Applications for this research include the simulation of complex quantum systems, fast database search, and breakthrough cryptography methods. Our choice of physical platform for the quantum computer – single dopant atoms in silicon nanostructures – has the important consequence that we work at the border between quantum technologies and the extreme end of classical CMOS nanoelectronics, with numerous chances for cross-fertilization.

Some of his contributions to this field are the first experimental demonstration of single-shot readout of an individual electron spin in silicon, and the full quantum control of the electron as a quantum bit, i.e. the ability to write and retrieve and arbitrary quantum state. In earlier years, Dr Morello made seminal contributions to the study of large spin systems and how their behavior crosses over from quantum to classical.

**Highlights of his career include:**
- designed, patented and demonstrated the first device to read out in real time the spin state of a single electron in silicon [A. Morello et al., Nature (2010)];
- demonstrated the first single-atom quantum bit in silicon;
- winner of the Eureka Prize for Scientific Research in 2011;
- more than 20 invited talks and colloquia in the last 5 years.

**Affiliations and Memberships:**
- Program Manager in the ARC Centre of Excellence for Quantum Computation and Communication Technology.
- Member of the American Physical Society and the Australian Nanotechnology Network.
- Contributor to the International Technology Roadmap for Semiconductors.

**Vision**
Quantum technologies are going to revolutionize the way nanoelectronic devices are designed and operated. The convergence of extreme miniaturization in electronic devices with the development of functional platforms to exploit the exponential amount of information contained by quantum systems, will offer exciting opportunities for research and education. Dr Andrea Morello seeks to maintain a world leadership in this field, and to encourage its dissemination through modern and exciting lecture courses and research projects. His mid-term vision is to develop all the conceptual and technological steps to demonstrate a functional few-bit quantum computer. Such a prototype will already represent a striking revolution in the way silicon chips are operated, and we expect it will lead to profound rethinking of the role of quantum mechanics in modern technology.

**In the coming years, he will be working in the following areas:**
- design, construction and development of single-atom electron and nuclear quantum bits in silicon;
- demonstration of two-bit quantum logic gates for quantum computation;
- development of techniques for the transport of quantum information encoded in the spin state of single electrons;
- coupling photons to atoms and spins in solid state;
- study of the fundamental limitations to quantum coherence in spin systems.
Dr Hendra Nurdin works in the field of quantum systems and control theory but has broader interests in the general area of systems and control theory.

Some of the important elements of this field are its interdisciplinary nature and the interplay of sophisticated concepts and tools drawn from control theory, theoretical physics, and mathematical physics. Researchers are required to acquire the necessary knowledge from these fields as well as knowledge from relevant sub-fields such as quantum optics.

Vision
Recent years have seen various breakthroughs in the fabrication of functional experimental quantum devices and demonstrations of control on experimental quantum systems. Although complex large-scale quantum technologies, such as quantum computers with many qubits (quantum bits), remain extremely challenging to realize and will likely remain so in the foreseeable future, continuing experimental advances and successful implementation of control strategies will likely lead in the nearer term to the realization of smaller scale quantum technologies in the areas of quantum communications, quantum metrology (precision measurement), and quantum simulators, that exploit exquisite quantum control for their functions. These emerging applications will drive the next development of quantum control paradigms and theories tailored to these specific application domains.

In the coming years, he will be working in the following areas:
- model reduction of open Markov quantum systems;
- control for quantum communication networks;
- filtering and control of open quantum systems driven by highly non-classical quantum fields.

Dr Hendra is a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE).
Professor Gang Ding Peng works in the field of photonics and optical communications, including optical fibre and waveguide devices, silica and polymer optical fibres, optical fibre sensors and nonlinear optics.

The photonic field has a number of important elements which include:
1. Special silica optical fibres and devices;
2. Application-specific polymer optical fibres and devices
3. Optical fibre sensors;
4. Planar photonic and waveguide devices;
5. Optical fibre communication systems, WDM systems, office and home networks;
6. Photonic signal processing techniques.

Applications for this research include optical fibre sensors, and high capacity telecommunications.

Professor Peng is the key contributor to the development of many novel application-specific silica and polymer optical fibres and photonic devices. Both theoretical modelling and experimental fabrication of optical fibre tapers, couplers, and twin-and multi-core coupling fibres as well as the development of both modified Gaussian and generalised Gaussian approximation methods. Photosensitive polymer optical fibres (POFs) and gratings, including first invention of POF gratings and their fabrication facilities in UNSW, which still keeps the world record for the highest transmission and broadest tuning range, fabrication of the most photosensitive and also lowest loss POF among the handful POFs currently available from commercial and research sources around the world, the first proposal of single-mode POFs and gratings for sensing, etc.

**Highlights of his career include:**
- Science and Technology Achievement Award (Second Prize), from the National Education Council, China, 1987
- Young Lecturer Achievement Award, Jiao Tong University, 1988
- Australian National University Postdoctoral Fellowship, 1988
- Queen Elizabeth II Fellowship from Australian Research Council, 1992
- Australian Academy of Science --Scientific Visiting Fellowship (to US, Canada and Mexico), 2000
- Anthony Mason Fellowship --Scientific Visiting Fellowship (to China), 2001
- Visiting Professor, Osaka University, 2004
- Guest Professor in 4 Universities in China
- Distinguished Overseas Expert Taishan Scholar, Shandong Academy of Sciences, 2010

**Affiliations and Memberships:**
- Professor in School of Electrical Engineering & Telecommunications, UNSW
- Fellow and life member of Optical Society of America
- Life member of SPIE

**Vision**
Photonics is a key enabling technology. The 21st century will be the century of the photon – much as the 20th century was the century of the electron. Following the paradigm of the rapid evolution of electronics that followed the invention of the transistor in the late 1940’s, over the coming decades photonics will impact most areas of our lives, revolutionize societies and industries around the globe.

Photonics will enable:
- The development of the future internet infrastructure with multi-terabit capacity, which can dramatically reduce global energy consumption of our future telecommunications systems.
- Photonic sensing will contribute to a greener environment by advanced pollution detection, and enable higher levels of security and safety through the use of sophisticated surveillance technology and detection of dangerous goods. Additionally, the closely linked disruptive Organic and Large Area Electronics technologies will enable radical new approaches to Healthcare, moving from the current, cost-intensive treatment after onset of a disease, to the detection and prevention of the disease at the earliest possible stage.
In the coming years, he will be working in the following areas:

- development of new specialty fiber to broaden capacity of new transmission paradigms such as developing few-mode fibers to employ both WDM and mode-division multiplexing techniques, development of Bi/Er co-doped fiber for ultra broadband luminescence, etc;
- development of new functional fiber sensors for different fields, such as the auto industry, mining industry, civil engineering, etc;
- development of new polymer optical fibers and gratings with high photosensitivity and stability and the application of polymer optical fiber for the biosensing, complicated strain and temperature sensing.

Professor Peng is also a guest professor in Tianjin University, Beijing University of Post and Telecommunication.
Dr Toan Phung works in the field of high-voltage engineering and power system equipment. Some of the important elements in this field include high-voltage generation/testing/measurement techniques, materials for dielectric and electrical insulation, effects of electric/thermal/mechanical stresses on power system components or equipment, diagnostic methods to monitor and assess their conditions, electromagnetic transients in power systems.

Applications for this research include power system equipment design (generators, transformers, cables and overhead transmission lines, switchgear), development of intelligent robust on-line condition monitoring for substations and other strategic components of high-voltage electricity grids.

Some of his contributions to this field are practical research/development in the field of partial discharge measurement and characterisation, application of signal processing methods to on-line condition monitoring, application of computation techniques (data mining, artificial intelligence) in power equipment diagnostics. Much of his work involves collaboration between the university and Australian power utilities.

**Highlights of his career include:**

- developed, patented and commercialised the CDA3 in the early nineties - one of the first computer-based partial discharge measurement and analysis systems (jointly with A/Prof Ron James);
- contributor to CIGRÈ Publication 226 - Knowledge Rules for Partial Discharge Diagnosis in Service;
- Technical Program Chair of the 2008 Australasian Universities Power Engineering Conference (AUPEC).

Dr Toan Phung is a Senior Member of the Institute of Electrical and Electronic Engineers (IEEE), a member of the IEEE Dielectrics and Electrical Insulation Society, and a member of the International Council on Large Electrical Systems (CIGRÈ) Australian Panel D1 – Materials and Emerging Technologies for Power Systems.

He is convener of the Australian ATP-EMTP (Alternative Transient Program) Users Group.

**Vision**

There has been long, on-going, and close interaction between the UNSW High Voltage group and power utilities throughout Australia on high-voltage testing and diagnostics. It is important to align our research activities to maintain and expand such collaboration. The electricity grids are going through significant transformation in all areas from generation to transmission, distribution and utilization. Such changes to the operating environments will present new problems to the grid infrastructure. As an example, the impact of high penetration of distributed renewable energy into the electricity grid presents new challenges to the reliable operation of the cabling systems, in particular the increased risk of high-frequency switching transients, and overvoltages on the cable insulation. Thus, there will be a need for developing new condition monitoring techniques to apply to the changing environments of the electricity networks.

**In the coming years, he will be working in the following areas:**

- development of novel diagnostic techniques for insulation assessment, e.g. ultra-high frequency detection of partial discharges, dielectric spectroscopy, frequency response analysis;
- smart-grid enabling substation monitoring systems with embedded intelligence to provide on-line and quasi-continuous monitoring of power flow, power quality, losses/efficiency and networks transients;
- development and characterization of new dielectric materials, e.g. polymer nanocomposites, biodegradable insulating liquids;
- high-voltage direct-current transmission systems;
- applications using high-voltage, high-frequency, high-power electronics.
Professor Faz Rahman works in the field of design of permanent magnet machines, power electronic converter circuits and control techniques for high performance sensorless electric drive systems. Recent research efforts were directed into the design of the interior PM machine with wide field weakening and high power density, bi-directional power converters with high efficiency and sensorless direct control of the interior PM machine with high performance from zero to the maximum field weakening speed range.

Some of the important elements of this field include the analysis of dynamics of various types of electrical machines, design of controllers, and state and parameter estimators for control of these machines over a wide speed range. The elimination of mechanical sensors to improve the reliability and cost of electric drive systems is also an important aspect of this field of research.

Applications for this research include suitable machines for the automotive traction drive in electric and hybrid electric vehicles where high performance, wide field weakening speed range and high power density are important. Sensorless control of these drives down to zero speed and gearless operation obtained through high field weakening range is also important in such applications. Application of the gearless interior permanent magnet machines in wind generator systems is also emerging.

Professor Rahman led the development of the first sensorless direct torque controller of IPM machines operating over a large field weakening range and down to zero speed with high performance. He also co-developed, with other researchers at UNSW, the first single-barrier IPM machine with very high field weakening range and the first fractional-slot interior permanent magnet machine.

Highlights of his career include:
• two IEEE Best Paper awards;
• outstanding Paper award at the ICEMS 2010;
• keynote speakers in ICPESA 2004 and IECI 2010;
• IEEE Third Millennium Award in 2000;  

• several invited tutorials in IEEE IAS, IPEC, PEDS, IPEMC and other international conferences;

Affiliations and Memberships:
Professor Faz Rahman is a senior member of the IEEE, a member of the IET and an Associate Editor of the journal on Electromotion. He has also served on the Advisory Panel of many international conferences.

Vision
New types of electric machines, power converters and controllers for electric drive systems will play a significant role in the emerging fields of electric traction, variable speed drives, wind power generation and many other areas of energy generation and utilization. Machines and converter systems with high power density, and control systems delivering high-performance and reliable operation of the machines will transform many of these areas. Developments in these areas are highly inter-related, often embodying new developments in magnetic materials, power semiconductors, embedded electronics and control theories. Key elements of these developments will rely on deep understanding of each of these diverse technologies, modeling and implementation of these systems.

In the coming years, he will be working in the following areas:
• design of the fractional-slot, concentrated-winding interior permanent magnet synchronous machines in order to achieve higher power density and reliability than existing machines;
• design optimizations for specific areas of application, such as electric vehicle traction and wind power generation;
• development of suitable mathematical models and sensorless controllers for these machines;
• development of efficient and reliable power converters for application in vehicles and wind power systems;
• refinement of torque, flux and state observers for robust sensorless operation of electric drives; interaction of machine design with self-sensing.
Professor Rodica Ramer works in the area of high frequency engineering covering various aspects of microwave devices and materials. This work includes electrical design, simulation, fabrication and measurements. Some of the most recent topics are related to reconfigurable Radio Frequency Micro-Electro-Mechanical Systems (RF MEMS) for wireless communication systems. Micro-Electro-Mechanical Systems technology has the potential to replace many Radio Frequency components used in today’s mobile and communications systems. RF MEMS not only offer substantial reduction in size, weight, power consumption and cost, but also promise superior performance compared to other current technologies.

Applications for this research include:
- telecommunications infrastructure for microwave communications, WLAN and WPAN;
- automotive collision avoidance radar;
- high value applications for military radio, satellite systems.

Professor Rodica Ramer contributed to the development of novel RF MEMS switches, integrated reconfigurable switch matrices, MEMS based switchable filters and antennas.

Highlights of her career include:
- development of a large range of microwave devices in different technologies: waveguide, microstrip, CPW – two patents;
- development of large range of microwave materials – patent.

Professor Rodica Ramer is a Fellow of the MIT Electromagnetics Academy, a Senior Member of the IEEE MTT-S, AP-S, Comms. – S, a Member of the European Microwave Association (EuMA) and a Member of COST.

Vision
In recent decade, the utilization of the unlicensed 60 GHz spectrum and the light licensed E-band spectrum became significant for point-to-point wireless systems. Research activities oriented toward the development of multi-gigabit transmission systems that could probably overtake the optical fiber counterparts, became worldwide intensive. Millimeter-wave systems not only provide wide bandwidth but their passive device footprints could also be made considerably smaller. In the millimeter-wave spectrum, RF MEMS based devices exhibit desirable characteristics for development of possible millimeter-wave applications.

In addition, modern communication systems require RF/microwave multifunction operation environment which demands extra functionality from its passive and active devices. Small sized, highly selective, with wide tuning range and low loss microwave components are critical. Tunable and reconfigurable devices would support multiple wireless functions using common hardware, thus decreasing and simplifying the overall system complexity and potentially improving its performance and functionality.

In the coming years, she will be working in the following areas:
- new RF MEMS devices;
- MEMs based multimode, multiband millimeter range filters;
- MEMS based reconfigurable antennas in the millimeter ranges;
- packaging, assembling, 3D integration;
- reliability for RF MEMS applications;
- new microsystem designs.
Dr Jayashri Ravishankar is an early career researcher working in the field of power system dynamics specifically in the area of modelling, analysis and control of grid connected renewable energy systems. Some of the important elements in this field include small signal and transient stability analysis, power quality issues, application of flexible ac transmission system (FACTS) controllers, controller tuning and coordination, artificial intelligence techniques and application of power electronic components.

Applications for this research include analysis of distribution systems, micro-grid, smart grids, fault-ride through of generators used for renewable power generation and reactive power compensation. She is also focussing on smart sensors for partial discharge detection.

Some of her contributions to this field are related to the performance enhancement of grid connected wind energy conversion systems by way of identifying the instability mechanisms and assessing methods for stability improvement.

Dr Jayashri Ravishankar joined UNSW in January 2010 on the sponsorship of the Australian Power Institute (API). She is a member of the Institute of Electrical and Electronic Engineers (IEEE). She has supervised to completion more than 10 Masters theses and is currently supervising two PhD candidates in the area of micro-grids, joint-supervising one PhD candidate in the area of partial discharge detection and co-supervising two students in the area of large scale wind/solar energy integration.

**Vision**

In recent years, the increase of power penetration from renewable energy sources especially in the distribution network, has spurred investigations, to understand their behavior as well as to predict their impact on the power grid. This requires development of appropriate models.

Also, assessment of steady state performance of electrical networks with distributed generation is not as simple as with conventional generation and can be planned from a probabilistic point of view only, as the renewable sources are intermittent in nature. The fast growth of these new resources, has led to concern about the impact of these sources on the dynamics of electric power systems. Thus, the dynamic analysis of the system becomes important as the electricity grid goes through significant transformation. Added to these, the emergence of micro grids to the electricity network is anticipated, as a possible path way of achieving clean energy generation. Micro grids are distributed generation systems that are designed to operate as self-contained local electrical power grids often incorporating on-site renewable energy sources.

In the coming years, she will be working in the following areas:

- integration issues of large scale wind energy into weak grids with various types of generators;
- steady state and dynamic analysis of power systems involving renewable sources, micro grids and smart grids;
- modelling, analysis and control of renewable energy based micro grids;
- controller design for system stability enhancement, fault ride through and maximum power point tracking;
- use of artificial intelligence techniques for controller tuning;
- storage options in power systems;
- power quality issues in hybrid and renewable power systems;
- design and control of hybrid wind-PV systems;
- multi-terminal DC systems for wind farm integration;
- impact of plug-in electric vehicle loading on distribution system operations.
Professor Andrey V. Savkin held a postdoctoral position in the Department of Electrical Engineering, Australia Defense Force Academy, Canberra. From 1994 to 1996, he was a Research Fellow with the Department of Electrical and Electronic Engineering and the Cooperative Research Centre for Sensor Signal and Information Processing at the University of Melbourne, Australia. Since 1996, he has been a Senior Lecturer, and then an Associate Professor with the Department of Electrical and Electronic Engineering at the University of Wester Australia, Perth. In 2000, he became a Professor with the School of Electrical Engineering and Telecommunications, The University of New South Wales, Sydney.

Professor Savkin works in the area of Systems and Control. His current research interests include:

- robust control and filtering;
- networked and hybrid control systems;
- robotics;
- application of control and signal processing in medicine and biomedical engineering;
- control and deployment of mobile wireless sensor networks;
- control of wind power systems.

Professor Savkin has authored/co-authored 5 research monographs and numerous journal and conference papers. He has successfully supervised to completion 14 PhD students. Prof. Savkin has served as an Editor/Associate Editor/Guest Editor for several international journals and conferences. Currently, he is an Associate Editor for Automatica, Mathematical Problems of Engineering, and the Program Chair for the 2012 Australian Control Conference.
Professor Aruna Seneviratne works in the field of mobile computing systems. In particular, his current work focuses on developing ways of optimising the performance of mobile computing systems and preserving the privacy of the users using new content distribution mechanisms and quantifying information privacy.

This research will have beneficial for any application or service that require rich content to be delivered to mobile devices such as smart phones at tablets. These include, on-demand TV, games, and advertisement systems.

Professor Seneviratne is a internationally recognised leader in the field. He acts an expert of European Union Research projects (Framework 7) and is regularly invited speaker at numerous networking conferences. Also he has strong collaborative research links with leading multinational companies such as Ericsson, and international research institutions and Universities. He also currently leads the Networks Research group at NICTA, Australia’s Center of Excellence in ICT research.

**Highlights of his career include:**

- Fellowships at British Telecom and Telecom Australia (Telstra) Research Laboratories.
- Visiting Professorships at INRIA (France), University of Pierre Marie Curie and Swedish Institute of Computer Science.
- IEE Most out standing student.

**Vision**

One of the biggest needs of our Information Society is the discovery and dissemination of the relevant information on time to the users. With the advances in computing capabilities of devices and the rapid deployment of broadband wireless and fixed networks, the amount of information that is being generated and the services that are being provided is growing exponentially. Users are beginning to have access to unprecedented amounts of information and services.

The challenge is to provide seamless and cost effective, timely access to information and the services – ubiquitous access to information. Mobile devices will play an ever-increasing role in both generating as well as consuming information.

The provision of access at the “mobile edge” compound the problem because of the scarcity of resources such as radio spectrum (bandwidth), energy (battery), the disparity between the resource availability in fixed networks and at the mobile edge and the dynamic nature and interaction with its physical surroundings. Thus it is necessary to design and deploy mechanisms that will enable the provision of seamless access to information and enhanced services across mobile and fixed networks.

In the coming years, he will be working on improving the quality of experience of the users when accessing information and services, especially at the mobile edge, by developing methods that will enable the users of mobile systems to access the information they need seamlessly, and designers of mobile system to develop services quickly and cost effectively, by developing new theories, models and mechanisms for

- providing the necessary connectivity to discover, access, and disseminate information from anywhere at any time and;
- preserving the privacy of the users.
Associate Professor Vijay Sivaraman
Telecommunications
Postgraduate Research Coordinator

Associate Professor Vijay Sivaraman works in the field of data communication networks, with interests ranging from core Internet switching to body-area networking and collaborative sensor networking.

Some of the important elements of this field include architectures for scalable, reliable and energy-efficient data transport, algorithms for optimizing network performance and quality, and protocols for user mobility, security and privacy.

Applications for this research that he is specifically investigating include reducing Carbon footprint of the Internet, continuous healthcare monitoring via wearable devices, and real-time monitoring of urban air pollution.

Some of his contributions to this field are:
(a) patented architectures for improving energy efficiency of Internet routers, which are being deployed in commercial equipment;
(b) new mechanisms for low-energy communication and automatic security configuration in body-worn devices, which have influenced the design of commercial wearable platforms for healthcare monitoring; and
(c) demonstration of novel smart-phone applications for environmental monitoring.

Highlights of his career include:
• two patents held and two more filed in the area of Internet router architectures;
• over 80 academic papers in areas spanning Internet architectures, body-area networks, and security, with over 1200 citations to his work in the research literature;
• led the development of key aspects of an award-winning carrier-class Internet switch/router at a silicon-valley start-up.

Affiliations and Memberships:
Associate Professor Vijay is a member of the IEEE, committee chair of an IEEE international conference, program committee member of major conferences in the networking area such as ACM Sigcomm and IEEE Infocom.

Vision
As the Internet grows in data capacity, becomes more ubiquitous, and is increasingly accessed via embedded and mobile devices, several new challenges emerge:
(a) The energy footprint of the Internet is growing rapidly, and the energy density of switching equipment is becoming a bottleneck in scaling capacity. New research is needed that can manage this energy growth in the short, medium and long time-scales, by employing ideas ranging from optical switching and electronic integration to dynamic energy management and renewable sources.
(b) Miniaturization is yielding networked consumer electronics products with unprecedented capabilities in areas such as health monitoring and environmental monitoring. This leads to research opportunities in areas such as new applications (that perform large-scale data collection and analytics), as well as device capabilities (improved battery-life, secure access, etc.).
(c) Rapid growth in personal network devices (such as smartphones and pads) and online services (social networking, searching) is creating new concerns about user privacy, and research is needed in methods to protect privacy without compromising the business model of the Internet primarily driven by advertising.

In the coming years, he will be working in the following areas:
(a) energy-efficient core network design using hybrid optical and electronic switching capabilities;
(b) dynamically optimizing Internet switch/router architectures for energy efficiency;
(c) mechanisms for securing body-worn medical monitoring devices without requiring user configuration;
(d) techniques for protecting user privacy by obfuscating individual data while protecting aggregate statistics; and
(e) design and deployment of participatory sensor networks for monitoring air pollution.

External appointments:
Visiting scientist at the CSIRO ICT Centre, and contributed researcher to the Networking and pervasive Computing group at NICTA.
Dr Iain Skinner specialises in the field of engineering education and photonics.

Some of the important elements in engineering education are:

- syllabus design and professional requirements;
- teaching methodologies;
- integration of technology with learning;
- student diversity and attributes;
- design of assessment activities.

Applications of this research include education of engineers, specifically how and what material is presented to students, and how their respective achievements are assessed.

**Some of his contributions are:**

- identification of effective ways to improve students’ communication skills;
- identification of better ways for students to understand professional responsibilities.

**Affiliations & memberships:**

Australian Association of Engineering Education

**Vision**

Dr Skinner sees the study of engineering education becoming better respected as it delivers ideas which prove valuable to those charged with engineers’ education.

**In the coming years, he will be working in the following areas:**

- How do students actually learn something?
- How best to present ideas to students?
- What can sensibly be expected of students?
- This will be anchored in both technical material (electromagnetism) and professional characteristics (ethics).
Professor Victor Solo’s work is spread across a number of disciplines including control, signal processing, neuroimaging, neural coding, econometrics and statistics.

He has spent about half of his academic career in the USA most recently (2004-2006) as a tenured Professor of Electrical Engineering and Computer Science at the University of Michigan, Ann Arbor. He has also been a visiting Professor of Radiology at Harvard Medical School (1998-2004).

Professor Solo is a Fellow of the IEEE. He has been an Associate Editor of significant IEEE, Econometrics and Statistics journals. Currently he is on the editorial boards of the IEEE Signal Processing Magazine and the IEEE Journal of Selected Topics in Signal Processing.

He has organized numerous workshops. At the 2011 Human Brain Mapping meeting, with colleagues from Oxford, Warwick, Columbia and Emory Universities he ran a workshop on brain connectivity which attracted well over 1000 attendees.

He has been a member of the ARC College of experts. In 2011 he was part of a review panel for the Austrian Science Foundation of a multi-million dollar Mathematics Centre.

He has been an invited visitor to many institutions. In April 2011 he was an invited visitor to the Program for Economic Research at Columbia University, New York, USA. This is a significant week long invitation usually only accorded to distinguished Economists.

Research Themes

Some current and planned activities in a few of the areas mentioned above are now sketched. The foremost technology behind current Neuroimaging is functional Magnetic Resonance Imaging (fMRI). This revolutionary modality was developed in the early 1990s and enables the brain to be observed non-invasively while it is active. Current research emphasis is on developing advanced statistical signal processing methods for studying dynamic brain connectivity. Another challenging topic is to develop advanced methods to gain superior temporal and spatial resolution by ‘bolting together’ different imaging modalities such as fMRI and magneto-encephalography (MEG).

Driven by applications in computer vision, attitude estimation and robotics another theme involves developing statistical signal processing, system identification and control techniques for random processes evolving in Riemannian manifolds.

Neural Coding involves recording of neuronal spike trains from electrodes implanted in the brains of awake animals. The overall aim is to understand how the brain represents and processes information using spike trains. It seems that much coordinated brain activity relies on some kind of synchrony. Which means that groups of neurons must fire together. But current statistical signal processing models for spike train activity preclude this possibility. A new program aims to provide statistical signal processing tools to address this bottleneck issue.
Professor David Taubman works in the field of multimedia compression and communication, but also has more general interests in image and signal processing. Some of the important elements in this field include image compression, robust communication of compressed media over error-prone channels, and interactive communication of regions, resolutions and frames of interest using efficient scalable coding techniques. Multi-view and 3D media are also becoming increasingly important.

Applications for this research include entertainment (e.g. digital cinema); free view-point video; surveillance (especially for large format devices that are emerging); mobile media browsing; and medical imaging.

Professor David Taubman is the key technology contributor to the JPEG2000 suite of ISO standards for image compression and interactive image communication. He also discovered the motion compensated lifting transform, as an important framework for scalable coding of video and other media. His other contributions involve developing an important class of algorithms for reliable communication of scalable media over lossy networks and new paradigms for motion and depth representation and compression. His research has impacted numerous products and commercial services worldwide.

Highlights of his career include:

- two IEEE Senior Best Paper awards plus one IEEE Best Conference Paper award;
- plenary speaker at the largest international image processing conference (ICIP 2006);
- research overview presenter at the IEEE International Conference on Multimedia and Expo (ICME 2012);
- primary technology contributor to two major international standards (IS15444-1 and IS15444-9);
- developer of the Kakadu software toolkit for JPEG2000 based compression and interactive media browsing that is licensed by hundreds of companies worldwide.

Professor David Taubman is a Senior Member of the IEEE, has served two terms as Associate Editor for the IEEE Transactions on Image Processing and is a constitutional Member of the Australian Standards Committee IT-1-29.

Vision

In recent times we are witnessing the emergence of new media types, such as multiview video (including 3D TV), media produced by depth imaging devices, and ultra high resolution surveillance content (stretching to Giga pixels per frame). Rather than taking fundamentally different approaches to image and video compression and communications, as is done today, his vision for the future is one that involves a small number of unifying paradigms supporting highly scalable and highly interactive communications that are efficient and robust.

Key elements of this will be a better understanding of how to represent motion and geometry, together with data transformations that interact with these representations.

In the coming years, he will be working in the following areas:

- advanced motion modelling techniques;
- techniques for recovering object boundaries from overlapping smooth motion models with noisy frame data;
- scalable compression techniques for geometry of object boundaries;
- compression and communication techniques for 3.5 and 2.5 dimensional media (video + depth, image + depth);
- interactive communication of video governed by perceptual models.
Professor Jinhong Yuan works in the field of communication systems, with a main focus on mobile and wireless communications, and interests ranging from digital modulation, coding, multiple-input/multiple-output (MIMO) techniques, space-time processing and coding, turbo coding, iterative receiver techniques, wireless physical layer security, and quantum error control coding, wireless network coding, cooperative and cognitive wireless networks. His research activities include analysis and performance evaluation of mobile cellular communications, design of optimum transmission schemes and related receiver algorithms for wireless communications with the main objective of improving the efficiency, reliability and coverage of mobile and wireless communication systems.

Some of the important elements of this field are how to explore the tough wireless channel conditions, such as multipath propagation, channel variation, interference, frequency and time selective fading, conventionally viewed as pitfalls for communications system design, to improve the spectral efficiency and power efficiency of wireless transmissions, reduce the transmission power, increase transmission reliability and improve coverage. Some examples are: use of modern coding techniques and iterative processing (Turbo codes or LDPC codes) to achieve optimal data throughput in a range of advanced wireless communication systems; use of space-time coding and MIMO techniques to explore the channel variation and fading to boost the data transmission rate and reliability; exploring the broadcast nature of wireless communications and allowing mobile terminal users to share their antennas for transmission so as to reduce transmission power and improve coverage; use of coding theory to achieve maximal secrecy of information at the physical layer; use of quantum effects applied to classical coding theory so as to produce new quantum error correcting codes.

Applications for this research include future wireless LAN, cellular mobile broadcasting networks, and other multihop wireless networks. Development of quantum error-correcting codes can be applied to emerging quantum computers and quantum communication systems.

Professor Jinhong Yuan and his research team are the key contributors in designing optimal space-time trellis codes for 2, 3 and 4 transmit antennas in terms of diversity gain and coding gain. These codes have been widely used in the research community as benchmarks to compare new codes in this area. Related contributions include his unified code design criteria on fading channels, and an important space-time coding book in the area. Another contribution in this area is his novel MIMO adaptive transmission signalling scheme, which can adaptively select transmit antennas and the corresponding pragmatic space-time trellis codes to provide robust performance for wireless transmission.

His contributions to turbo codes and iterative receiver designs for digital communications, including the design of novel code matched interleavers for turbo codes that can significantly improve the code performance in the whole SNR range, new performance bounds for turbo codes over Rician fading channels, which have been used and adopted by numerous research groups to design and evaluate performance of turbo and serial concatenated codes on fading channels.

**Highlights of his career include:**

2 major research books, 2 book chapters, 1 editorial paper, over 200 scientific research papers in premier international journals and conferences, and over 20 industrial reports. Most of these publications appear in top (A+ or A) journals and conferences.

The total citations of his publications are over 2700.

He is the co-inventor of one patent on MIMO systems and two patents on low-density-parity-check (LDPC) codes.

He co-authored three Best Paper Awards and one Best Poster Award, including:

- a Best Paper Award of IEEE Wireless Communications and Networking Conference (WCNC), Cancun, Mexico in 2011;
- a Best Paper Award of IEEE International Symposium on Wireless Communications Systems (ISWCS), Trondheim, Norway in 2007;
• a Best paper award of International conference on wireless broadband and ultra wideband communications, Sept. 2007, Sydney, Australia.

Affiliations and Memberships
• IEEE Senior Member;
• IEEE NSW Chair of joint Communications/Signal Processing/Ocean Engineering Chapter;
• Editor for European Transactions on Telecommunications 2011-now;
• Guest Editor for EURASIP Journal on Wireless Communications and Networking, 2008;
• Editor for ETRI Journal, South Korean, Oct. 2006-Sept. 2009;
• General Chair of Australian Communications Theory Workshop 2009, Sydney;
• Chair of Communications Theory Symposium of The 13th IEEE international conference on communication technology (ICCT);
• Program Chair of Information and Coding Theory of the 7th International Conference on Communications and Networking in China (ChinaCOM 2012).

Vision
A main trend in future communications is to extend rich Internet contents and services to wireless/mobile users. To facilitate a wide variety of new services, such as mobile Internet, mobile broadcasting, or next generation Wireless LAN, wireless communications have to deal with tough challenges due to limited spectrum resources, and bandwidth-hungry and power-hungry features of the aforementioned services. New technologies to efficiently use spectrum and power while supporting high data rate transmission over hostile wireless channels will be required. It is expected that network coding, as an emerging technique to design future communications networks, is very promising to have a considerable impact on the theory of networks. It has the potential to exploit the broadcast nature of wireless transmission and to turn the wireless multiple user interference into the benefit in increasing the wireless network throughput and reliability. However, the challenge is how the theory will shape the practical designs of future networks.

In the coming years, he will be working in the following areas:
1. wireless network coding to boost the network end-to-end throughput;
2. wireless physical layer security;
3. quantum error control coding.

External appointments
He has been a Visiting Associate Professor at City University of Hong Kong from Jan-July 2006 and a Visiting Researcher at Institute of Network Coding at the Chinese University of Hong Kong from Sept 2011-Feb 2012.

He has been a regular visitor at ICT Centre, CSIRO since 2004.

He has also been a Visiting Professor at Beijing Institute of Technology since 2010.
Dr Wei Zhang works in the field of wireless communications with an emphasis on communications theory.

Some of the important elements of this field are space-time modulation and coding for multi-antenna systems, cooperative communications, cognitive radio, and multiuser information theory.

Applications for this research include wireless LAN, cellular networks, vehicular networks, and cognitive radio networks.

Dr Wei Zhang’s contributions to this field include designing high-rate space-time codes and space-frequency codes for broadband wireless systems. He also proposed robust cooperative spectrum sensing algorithms for cognitive radio networks. His other contributions involve development of effective interference alignment techniques to achieve high capacity of interference channels.

Highlights of his career include:
- two IEEE best paper awards;
- IEEE Communications Society Outstanding Young Researcher Award.

Affiliations and Memberships:
- Senior Member of the IEEE;
- Editor of IEEE Transactions on Wireless Communications;
- Editor of IEEE Journal on Selected Areas in Communications (Cognitive Radio Series).

Vision
For most emerging wireless networks such as cellular networks or wireless LAN, where multiple users are served by a number of base stations or access points at the same time and the signals from many undesired or interfering transmitters are added to the desired transmitter’s signal at a receiver, interference is the main performance-limiting factor and mitigation of the interference power becomes critical. Interference alignment is a novel idea that has recently emerged out of the capacity analysis of interference networks.

In the coming years, he will be working in the following areas:
- advanced interference alignment and cancellation techniques;
- precoding techniques for interference channels;
- low complexity receiver design for multiuser networks.
Dr Daming Zhang obtained his bachelor and master degrees from Huazhong University of Science and Technology, Wuhan, China, in 1993 and 1996 respectively. He obtained his PhD degree from Nanyang Technological University, Singapore in 2000. He worked in Guoce Corporation, China from 1996 to 1997 as a design engineer of power system protection. From 1999 to 2003, he was with the Institute of High Performance Computing, Singapore to carry out research on energy conversion in electric and magnetic devices. He then was with the division of power engineering in Nanyang Technological University, Singapore from May 2003 to December 2011 as an assistant professor. He has been with the school of Electrical engineering and Telecommunications, University of New South Wales as a lecturer since January 2012.

Research interests:

- Power system protection: 1) non-linear modelling of current transformers and voltage transformers using the Jiles-Atherton model; 2) Islanding detection and protection in renewable energy systems.
- Condition monitoring: application of wavelet transform to de-noise partial discharge signals.
- Harmonics and conducted EMI in power converters: 1) Application of non-linear magnetics to harmonics and conducted EMI in power electronics converters and their mitigation; 2) Design of passive and active filters.
- Computation of electric and magnetic fields in power engineering using finite element methods and moment methods, especially for transformers and electric machines.

Vision

- Digital protection strengthened by standardized communication protocols will make substation protection an intelligent system. Today a mixture of traditional protection schemes and highly intelligent and automatic protection schemes coexist.
- Upgrading the traditional schemes demands a good understanding of them and knowledge of intelligent electronic devices and telecommunication based substation automation. To meet such challenges, a team formed by researchers with different backgrounds in power system protection, signal processing, control and telecommunication is essential. Such a team can provide good protection design for many applications including renewable energy related distribution generation protection.
- Research on harmonics and conducted EMI in power converters and their mitigation becomes more and more important since power converters are used widely in power systems, some of which convert and condition renewable energy to the existing grid. For such research, one important issue is to optimize the overall system design to meet standard harmonic and conducted EMI requirements without incurring higher system cost and without sacrificing system overall efficiency. Such research demands an in-depth knowledge of the devices’ comprehensive properties, such as non-linearity of magnetic components, wide-band circuit switching devices etc.

Research work in the coming year:

- Develop non-linear models for current and voltage transformers; duplicate the primary side current of current transformer under severe fault conditions; develop non-linear model that suits high pulse transformer modelling; develop a digital protection system platform for both research and teaching; solve electric and magnetic fields by finite element methods with incorporation of the B-H curve of the magnetic materials.
Research Projects
APPLICATION OF NON-LINEAR MAGNETICS TO MODELLING OF CURRENT TRANSFORMER AND STUDY ON HARMONICS AND CONDUCTED EMI IN POWER CONVERTERS

Power system protection relies on accurate response from current and voltage transformers as these are the primary inputs to relays. Under severe fault conditions in a power system, the current transformer can become saturated. It then fails to duplicate the primary side current and could cause malfunction of the relay in the protection system. Some research efforts have been reported that reproduce such fault currents accurately. There has also been an attempt at using the Jiles-Atherton algorithm to model the current transformer (CT) and obtain its secondary response. Nevertheless using the Jiles-Atherton model to reproduce the primary side current of the current transformer has not been reported. Furthermore the Jiles-Atherton model adopted by earlier researchers does not take into account the fact that when the flux density exceeds a certain value above the knee point, all magnetizations are reversible. This will be taken into account in our research.

The Jiles-Atherton and Preisach models are two popular mathematical methods of simulating both the linear and non-linear performance of magnetic cores. The advantage of the Jiles-Atherton model is that it can be described by several simple first-order equations, which can be readily incorporated into other equations describing the overall circuit. We will carry out research on how to utilize Jiles-Atherton model to reproduce the primary current under saturated conditions, and will detail the processing necessary for implementation in a digital relay.

This is the first part of the research topic. The second part of the research is as follows. Electromagnetic interference and compatibility (EMI/EMC) is an important issue when designing power electronic circuits. It determines whether such circuits can perform effectively to fulfill their basic functions. IEEE, IEC and other standards specify strictly the limit of each harmonic component that a circuit can emit into power mains, since some EMI or harmonic components emitting from one power electronic circuit can mal-function other electric appliances sharing the same power mains through conducted emission or being placed close to it via radiation. Thus it is necessary for us to accurately model and measure EMI in the power electronic circuits.
To accurately model a power electronic circuit for the purpose of EMI study, unavoidably accurate modeling of each component, including inductors, transformers, capacitors, resistors, diodes and switch etc is a first fundamental step before a thorough circuit level modeling can be implemented.

Building an efficient and accurate model for the study of hysteresis of magnetic core used to construct an inductor or transformer is the most challenging among modeling all individual components. In the linearized modeling, the hysteresis and magnetic core losses are not considered. In order to model the dynamic response and transient phenomena of EMI, such as inrush current, sub-harmonic, and chaotic response, the accurate hysteresis modeling of magnetic cores is indispensable. In power converter circuits there are two basic types of magnetic cores used, one being silicon-iron cores, mainly used in power frequency energy manipulating, and the other being Mn-Zn ferrite cores, mainly used in kHz through MHz converting circuits. So far there are two widely adopted models for studying the hysteretic phenomena of magnetic cores, namely Preisach and Jiles-Atherton (J-A) models.

In this project researcher will have the following tasks to fulfill

- Develop accurate modelling technique based on both J-A model and Preisach model for transformers and inductors.
- Design EMI filter using both passive and active switching technique, which include modelling and hardware implementation.
- Optimization of the system considering switching loss, overall system efficiency, harmonic generation, cost and compactness etc.
CONTROL SYSTEMS FOR HYBRID ENERGY STORAGE SYSTEMS

Photovoltaic and wind power plants require both long-term and short-term energy storage. The long-term energy storage needs to (i) supply the energy to the load when there is inadequate solar irradiation for longer periods of time and (ii) to store the excess energy when the energy supplied by the PV plant exceeds the energy required by the load for longer periods of time. On the other hand, the short-term energy storage has to buffer the short-term energy differences such as to compensate for the short-term solar irradiation prediction inaccuracies and disturbances such as a partial shadowing of the PV plant.

Typically, batteries or fuel cells are used as the long-term energy storage systems. However, the lifetime of the batteries and the fuel cells can be significantly reduced if they are required to buffer fast varying power or large bursts of power. On the other hand, the ultracapacitors have low energy density but high power density, have high life cycle and high efficiency, and thus are able to buffer large bursts of power. Therefore, hybrid energy storage systems combining the benefits of both the batteries/fuel cells and the ultracapacitors are attractive as an energy storage system for the photovoltaic and wind plants.

The aim of this project is to develop novel advanced, intelligent control systems and power converter topologies in order to ensure that the hybrid energy systems is fully utilized while maintaining its operation within predefined operational limits in order to guarantee the energy supply/storage quality and maximum lifetime of each energy source.
DESIGN OPTIMIZATION OF THE FRACTIONAL-SLOT CONCENTRATED WINDING INTERIOR PERMANENT MAGNET MACHINE WITH A WIDE CONSTANT-POWER SPEED RANGE FOR ELECTRIC VEHICLE AND WIND ENERGY APPLICATIONS

Electrical machines are a critical component in wind generators and electrical vehicles. Enhancing their operating envelopes is a key discriminating factor. Our recent studies have demonstrated that the fractional-slot, concentrated-winding interior permanent magnet machine is a preferred choice for many high-performance, variable-speed drive applications including electric/hybrid vehicles and wind generators. The fractional-slot machine has a higher power density, is more fault-tolerant and is easy to manufacture compared to conventional distributed winding machines. The aim of this project is to optimize the design of the fractional-slot machine for wide constant power speed range, assuming application in wind turbines and electric vehicles.

The research performed in this project has led to the successful construction of a prototype machine achieving a wide 7:1 constant power-speed ratio. Distributed winding machines capable of achieving equivalent values of constant power-speed ratio have complex rotors and hence significantly increased manufacturing issues and cost. Our proposed design was subjected to the same size constraint as two previously constructed 550W distributed winding interior permanent magnet machines. With this constraint, the advantage of shorter end winding length was exploited and the active length of the machine increased. This resulted in a significant increase in output power to 800W throughout the constant power-speed range. A detailed study on losses performed in this work showed that despite the increased harmonic content generated by concentrated winding, the frequency-related losses can be minimized through appropriate design methods, and greater than 80% efficiency can be achieved throughout the operating range of the machine for this relatively small-scale machine.

Based on confidence gained from the experimental verification of the concentrated-wound machine, a scalability study was performed and designs up to 30kW were proposed. A study on efficiency optimization was also performed and the prototype machine redesigned and simulated with 93% efficiency. This fundamental research has established a strong basis for future work on concentrated-wound machines in automotive traction drives and has also proven that this machine type is suitable for high performance industrial applications requiring high efficiency over a very wide speed range.

The project has been funded through an ARC Discovery Grant.

Research Field:
Energy system technologies

Participants:
> Dr Rukmi Dutta
> Prof Faz Rahman
> Dr Branislav Hredzak
> Prof John Fletcher
> Prof Vassilios Agelidis
> Dr Mihai Ciobotaru
> Dr Baburaj Karanyil
> Nguyen Dai Quang
> Merlin Chai
> Kazi Ahsan Ahmed
> Jae Yoon Kim
> Dan Xiao
> Ali Masood
> Tan Cheng

Other Projects:
- Design, optimization and modeling of fractional-slot, concentrated-wound interior permanent magnet machines
- Sensorless direct torque and flux control of machines at very low speed, including zero speed
- Multi-phase matrix conversion techniques
- Medium-voltage integration technologies for photovoltaic and wind energy devices
- Multi-level and multi-phase inverter topologies
- ‘Thin’ power electronic topologies to minimize local energy storage requirements
- Impacts of power electronic control within microgrids
IMPROVEMENTS IN DIGITAL RELAY TECHNOLOGIES TO COMPENSATE FOR TRANSFORMER NON-LINEARITY

Modern power systems are changing shape. New generation technologies, which includes sources of distributed generation such as wind and photovoltaics, and the adoption of more intelligent electrical grids are altering the way power flows in distribution networks. This project aims to assess some of the technical issues related to protecting these new power system paradigms during faults. It requires developing an understanding of how power electronic inverters react to disturbances on the grid, and how we can model their characteristics to allow coordination of protection devices. Then, we need to assess and develop guidelines for protective device settings. In addition to addressing these issues we are also developing methods that can more accurately assess the state of the network during faults, for example, enhancing current transformer technologies and compensation techniques for non-linear operation of these devices during faults. By doing this, digital relays are better equipped to make decisions on protective actions, thereby providing a secure but safe supply of electrical energy.

Power system protection relies on accurate response from current and voltage transformers as these are the primary inputs to relays. Under severe fault conditions in a power system, the current transformer can become saturated. We are performing research on utilising the Jiles-Atherton model to reproduce the primary current under saturated conditions, and the processing necessary for implementation in a digital relay. Such a compensation technique allows the digital relay to make a better-informed decision as to the state of the network. We are researching and developing digital techniques that allow us to embed the compensation technique in existing relay products, thereby enhancing their performance, without altering the hardware in the relay.

Research Field: Advanced power systems protection schemes

Participants:
> Dr Daming Zhang
> A/Prof Toan Phung
> Prof John Fletcher
> Prof Gerald Sheblé
> Meng Jiang
> Tan Cheng
> Rashmil Danayake

Other Projects:
• Compensation of current transformer hysteresis using Jiles-Atherton models
• Protection of meshed HVDC networks for large-scale wind farm integration
• Novel fault-tolerant power electronic topologies for large-scale photovoltaic connection
Electrical faults in distribution networks are a common occurrence which produce large currents and, if not acted on quickly by the protection system, can cause extensive damage to equipment or components of the network. They can potentially result in lengthy supply interruption, costly repairs, loss of revenue to the asset owners (electricity distributors), and possible litigation from affected customers. Thus, it is important to be able to detect and quickly respond to the occurrence of an electrical fault.

At present, high impedance faults on distribution networks still present the most persistent and challenging problem to protection engineers. This is because this fault type does not produce a fault current large enough to be detectable by conventional protection devices such as over-current relays, reclosers or fuses. Prolonged arcing and flashing at the point of contact due to HIF presents a serious safety risk and the potential to start fires.

The overarching goal of this project is to develop a monitoring system which is able to accurately and reliably detect high impedance faults. This system will be aimed for on-line deployment by electricity distributors for monitoring their medium-voltage distribution networks. Furthermore, the hardware and signal processing techniques developed for the high-impedance fault detection system can be utilised to provide accurate and detailed on-line and quasi-continuous monitoring of losses in the distribution networks. Power electronics and compact fluorescents generate significant harmonic content in the grid, both in the voltage and current waveforms. The harmonics increase substantially the energy losses in items such as transformers and feeders. Monitoring of the total losses in the system will allow the determination of optimal line and cable selection and configuration, and optimal voltage settings of transformer on-load tap changers in zone substations to achieve lowest losses. Such monitoring will also provide utilities with the ability to provide accurate loss information to the Australian Energy Regulator. At the moment the data provided is based on estimations rather than measurement and does not include the impact of harmonics. The proposed system will be implemented in an embedded platform and can be integrated into Intelligent Electronic Devices (IED) used for metering, protection and control of feeders. Thus it will serve as an integral and important component of a Smart Grid.

The project is funded through an ARC Linkage Grant (2012-2014). The industry partner is the Australian Strategic Technology Program (ASTP) which is currently composed of 9 electricity transmission and distribution utilities, including most of the largest utilities in Australia.
MODELLING THE TECHNICAL, COMMERCIAL AND ECONOMIC IMPACTS OF HIGH RENEWABLE ENERGY PENETRATIONS IN THE GRID

There is growing interest in the challenges and opportunities of integrating very high levels of renewable energy into the electricity industry. There are important technical, economic and commercial perspectives to be considered, and a number of interdisciplinary projects are underway at UNSW in this area. One project funded by the Australian Solar Institute is exploring the impacts of high PV penetrations on the grid. Work to date has included analysis of distributed PV operation, solar forecasting and two case studies undertaken with Australian network service providers on Australian electricity grids with high levels of PV. This work is contributing to an International Energy Agency PV Power Systems Task that brings together researchers from more than fifteen countries exploring the impacts of high PV penetrations.

Another project being led Dr Merlind Kay of SPREE is on solar forecasting within the Australian National Electricity Market to facilitate the integration of large solar generation penetrations. This is also being funded by the Australian Solar Institute. EE&T is leading the work on integrating such forecasts into electricity industry operation and investment.

Most recently UNSW and the University of Melbourne have jointly been awarded funding from the Australian Renewable Energy Agency to develop, model and cost different low-carbon future electricity industry scenarios for Australia. A primary focus of this modelling is simulating the operation of different renewable technologies located across Eastern Australia, and exploring lowest cost opportunities to greatly reduce Australian electricity industry emissions.

Research Field:
Facilitating renewable energy integration within the Australian National Electricity Market

Participants:
> A/Prof Iain MacGill and A/Prof John Fletcher (EE&T academics)
> Dr Peerapat Vithayasrichareon and Dr Robert Passey (Research Associates in EE&T)
> Ben Elliston, Sebastian Olivia and Simon Heslop (PhD students in EE&T)
> Dr Regina Betz and Dr Paul Twomey (ASB)
> Dr Anna Bruce and Dr Merlind Kay (SPREE academics)
> A/Prof. Mark Diesendorf (Institute for Environmental Studies, Faculty of Science).
> Other participants in this work include the Australian PV Association, the University of Melbourne and the University of South Australia.
OPTIMAL BIDDING STRATEGIES FOR MULTIPLE MARKETS UNDER INCOMPLETE INFORMATION

Project is to simulate multiple markets ranging from energy to ancillary services and contingent contracts. Goal is to identify techniques to model trader behavior in each market. Simulation enables inexpensive learning and a means to study the impact of market rules. The simulations show the best strategy for the set of given conditions. The components of a market are a place for buyers and sellers to negotiate price and quantity under a set of negotiation rules and enforcement of those rules. An auction is the mechanism to implement the rules for negotiation and procedures for resolving disputes in the negotiation process. There are two types of auctions: one sided and two sided. A one sided market is composed either of buyers or sellers bidding to a single seller or buyer respectively.

The traditional economic dispatch optimization is a one sided auction where all of the suppliers bid to produce at the stated incremental price. The benchmark for such auctions is either the binary search or the gradient search mechanism. Each mechanism starts with an initial guess at the incremental price and announces that price. Each generator then responds with a bid to generate a specified quantity of real power. The central auction mechanism adds all of the bids to determine if there is just the right amount of real power. If there is too much real power, then the incremental price is reduced. If there is too little real power then the incremental price is increased. This process is repeated until the amount of real power is within an acceptable bound of the forecasted demand for the period.

The decision analysis mechanism of each bidder is modeled as a corporation with a forecasting department, production department, and strategy department. These processes are modeled as a discrete event system simulation. The structure of the processes and the parameters for each process has to be learned by trial and error using the successes at bidding as the performance index. This project examined particle swarm optimization, evolutionary particle swarm optimization and the Petrov-Roth-Erv Learning algorithm using Monte Carlo simulation to identify these components.

The particle swarm optimization starts with a set of trial solutions, explores the advantage of the social sharing of information, and then updates the solution. The velocity of the update is based on the random mix of the previously best position and the current global best position. The new solution is then evaluated and added to the memory of past solutions. Evolutionary particle swarm optimization (EPSO) is a combination of evolutionary algorithms with particle swarm optimization. EPSO allows the weights to evolve to a near-optimal value. Each individual (particle) is characterized by object parameters and strategic parameters. The process to generate new particles includes the evolutionary process of replication, mutation, reproduction, evaluation, selection and elimination.

The original Roth-Erv algorithm is a simple model that is able to predict, as well as, explain observed behavior on games where other players play a crucial role. The contest is defined by a set of rules, between individuals with conflicting objectives. Examples of successful replication include fish markets, farm markets, employment negotiations, and intercompany contracts to name a few. This model assumes that each player has a finite number of strategies (possible actions) with a probability distribution that identifies the probability of each strategy being selected. At each iteration, a player plays a randomly chosen strategy based on the current probability distribution, the auctioneer decides which strategies were
accepted, then each player updates his probability distribution based on the reward obtained. The two psychological principles for this algorithm include the law of effect and the power law of practice. The law of effect states that choices that led to good outcomes in the past are more likely to be chosen in the future. The power law of practice is that learning curves tend to be initially steep and then decrease as the information is not as dramatic based on the history of past solutions. Additional assumptions include experimentation and recency. Experimentation states that choices that are similar to successful choices tend to be employed more often as well. Recency effect states that recent experience plays a larger role than past experience. The Petrov-Roth-Erv algorithm is a modification of the update function based on the observations of non-selected strategy use and avoidance of degeneracy. The observation is that if a strategy succeeds, then the algorithm should explore more likely strategies, with the closer ones being more explored. The PRE algorithm was applied to multiple markets. Monte Carlo was applied to the RE and PRE algorithms assuming that each player has a finite number of strategies and a probability distribution that identifies the probability of each strategy being selected. A player selects a strategy randomly based on the initial probability distribution, the auctioneer decides which strategies are accepted by the market rules, and then assigns the contracts to each player to evaluate the profit obtained. After a certain number of iterations is achieved then each player updates the probability distribution that associates to each strategy the probability of being successful.

Other Projects:

- Real option valuation of renewable energy resources as portfolio choice
- Adaptive agent solution of financial decision strategies for maximum profit
- Genetic algorithm solution of the unit commitment scheduling problem
- Dynamic solution of auction mechanisms using discrete event simulation simulations
- Operation of renewable resources with various energy storage devices including flywheels, batteries, hydrogen and methane fuel cells, micro-turbines, hydro systems, and pumped hydro storage
- Finite element analysis of real options and electromagnetic fields for wind generator design
- Genetic algorithm solution of patient healthcare treatments procedures
ADVANCED MEMS MECHANISM FOR HIGH PERFORMANCE MICRO-OPTICS SYSTEM

High optical zoom, auto-focus, faster operational speed, lower power consumption and operating voltage are the most desired performance characteristics of miniaturized optical systems. In optical systems, such as the camera, there exists a tradeoff between size and performance. Performance features such as autofocus and enhanced optical zooming are easily achievable for large optical systems like digital cameras, available today in the market. However, incorporation of such features at a miniaturized level remains a challenging issue as a result of serious limitations with the existing paradigms.

The existing technology based on the assembly of discrete fixed shape lens and mechanical components have reached its limitations. As a result, commercially available miniaturized systems employ either a single fixed lens with no auto-focus or optical zoom feature, or small Voice Coil Motor (VCM) to move trains lenses to provide limited auto-focus feature with very limited optical zoom if any. In addition to their limited opportunity to further miniaturization, the VCM consumes significant amount of power with limited operational speed, which is not appealing for high quality video recording.

In an attempt to overcome the existing limitations, various approaches involving focal length tunable lens have been proposed. However, these approaches also suffer from serious drawbacks, which include (a) limited optical zooming capability (b) not amenable to further miniaturization (c) slow operational speed, which makes them unattractive for high quality video recording (d) requires large operating voltage or substantial power.

The aim of this project is to develop a novel approach to provide a significant breakthrough to existing limitations and serious drawbacks. Particularly, a low profile micro-actuator with large displacement capability is desperately needed for today’s generation of ‘thin profile’ mobile phones. The new approach will not only allow the incorporation of auto-focusing and enhanced zooming capabilities but also enable fast ultra-small optical system with minimal power consumption.

In addition to applications for ultra-small camera modules, the project will have a wide range of medical, security, defense and automotive applications.

The approach of this project is based on an IP filed by Dr Aron Michael and Prof Chee Yee Kwok. The project will involve design, ANSYS simulation, micro-fabrication, mechanical and optical characterization. It will also cover complete camera system development incorporating the IP.

Other Projects:
- Towards miniaturized AFM: employing silicon photonics and piezo-electric actuation.
- MEMS based optical interconnect.
- MEMS based cooling for high-performance micro-processors.
- MEMS optical switching.

Research Field:
MEMS

Participants:
> Prof Chee Yee Kwok
> Dr Aron Michael
> Prof Rodica Ramer
> Ping He
> Jingbo Wang
CIRCUITS IN NANO SCALE CMOS

Integrated circuits technologies are continuing to scale down according to Moore’s law, enabling ever increased functionality at lower power of digital systems. The leap in functionality seen in mobile phones and other portable electronic systems in recent years have largely been driven by such scaling. The scaling comes with a down side—however: down-scaled transistors exhibit increased leakage, reduced gain and operational voltage, and large component variability; issues that impact very negatively on traditional integrated circuit structures.

Many essential functions of electronic devices rely on traditional integrated circuit structures; for example high-precision analogue-to-digital converters, and communications circuits. As older integrated circuit technologies are phased out, or increased system integration is required, such functions will have to be implemented in new down-scaled technologies.

This project addresses circuit design issues arising from these undesirable transistor properties found in modern CMOS technologies (below the 65nm technology node). Two key areas are targeted: the design of ultra high speed logic circuits operating in excess of 30GHz, and the design of alternate analogue structures which can give good performance while components are suffering from severe mismatch poor transistor characteristics and reduced supply voltage. In both areas new circuit topologies are investigated to achieve standard digital and analogue functions.

By investigating new circuit topologies for key electronic functions, the project has the potential to benefit a very large number of future electronic devices.

This research is partly supported by an ARC Linkage grant with Perceptia Devices.

Participants:
> Dr Tara Hamilton
> A/Prof Torsten Lehmann
> Julian Jenkis
> Libin George
> Andrew Nicholson
> Nonie Politi
> Astria Irfansyah

Other projects:
- Cryogenic CMOS Circuits
- Neuromorphic Engineering
- Chip-scale Biomedical Implants
- Bionic Eye
SINGLE-ATOM QUANTUM BITS

The size of the transistors employed in modern computer chips is shrinking to unprecedented levels: in the latest 22 nm node, the transistor channel is only a few hundred atoms across, and contains a similarly small number of dopant atoms. At this level, the behaviour of electronic devices is only approximately described by classical physics – quantum effects can easily become predominant – and the exact location of the dopants starts to play a role.

Instead of fighting quantum mechanics, our project aims at fully exploiting its amazing features to create a “quantum computer” that works in a radically new way. The binary information is not encoded in the on/off state of a classical transistor, but it is encoded in one of the possible “states” of a “quantum bit” (qubit). Because of some fundamental properties of quantum mechanical systems, such as superposition and entanglement, a quantum computer can encode and process an exponentially larger amount of information as compared to a classical one. This can be exploited to vastly reduce the computational complexity of certain calculations.

Research field:
Microelectronics – quantum computing with single atoms in silicon

Participants:
> A/Prof Andrea Morello
> Scientia Prof Andrew Dzurak
> Dr Juha Muhonen
> Dr Arne Laucht
> Dr Fay Hudson
> Jarryd Pla
> Juan Pablo Dehollain
> Fahd Mohiyaddin
> Rachpon Kalra
> Henry Yang
In this project we design, fabricate and operate nanometre-scale electronic devices where individual dopant atoms (for instance Phosphorus) are accurately planed in the vicinity of special transistors. The dopant atom binds an individual electron, which carries an intrinsic magnetic moment (spin). The spin constitutes a qubit, where the two logic states are “up” or “down”. However, a quantum superposition of the two is also allowed! The nearby transistor - sensitive to the displacement of a single charge - is used to read out the state of the qubit, and a sophisticated microwave setup is used to encode the quantum information.

By integrating the quantum properties of single atoms with the exceptional technological maturity of silicon nanoelectronics, we work towards demonstrating a fully scalable quantum computer, where individual dopant atoms interact with each other and with external electric and magnetic fields. Near-term goals will revolve around the demonstration of a 2-qubit logic gate, and the ability to transport quantum information across the chip.

Other projects:
- Cryogenic Quantum information processing with electron spins confined in silicon quantum dots
- Electrically-detect optical spectroscopy of single dopant atoms
- Advanced modelling of nanoscale quantum electronic devices
- Quantum dot change pump for a new metrology standard of electrical currents
Within the mining, defence, and agriculture industries, the machinery used are large, and their dynamics cannot be ignored for the purpose of controller design. The vehicles are mechanically complex, especially in the case of articulated (connected in series) vehicles, and hence mathematical modelling and control of the complete dynamics is very difficult. In addition, the surfaces the vehicles operate on are very different to urban transportation surfaces such as sealed roads or rail tracks. The wheel/surface interaction is not only different from the urban scenarios but also varies significantly from place to place. This causes the off-road vehicles to undergo significant lateral and longitudinal slip.

The aims of this project are to firstly develop new control methodologies to control off-road vehicles and their trailed sections to track a path with high accuracy and secondly, implement the developed controllers on a practical system to validate the controller performance. More specifically, the project will see the development of novel modelling and non-linear control techniques to reject external disturbances and compensate for lateral and longitudinal slip. The resulting solutions will allow high speed operations and high accuracy operations at low speeds.

With an autonomous agricultural tractor and active agricultural trailing implement already built and in operation in a real farming environment, the research opens up many opportunities in the area of practical precise vehicle guidance in challenging environments.
Model Reduction of Open Markov Quantum Systems

Proposed quantum technologies, a class of technologies that are based on the laws of quantum mechanics and implemented by quantum systems, promise to significantly surpass the capabilities of state of the art non-quantum technologies in the areas of computing, communication, and precision measurements. Some of these technologies will perform these tasks in radical new ways by exploiting quantum information rather than classical (non-quantum) information, while others aim to exploit quantum features to carry out classical information processing much more efficiently with quantum systems, such as implementing classical information processing using ultra-low power quantum devices.

One of the challenges of working with quantum systems that are of interest for quantum technology is that they are often dynamical systems described by complex mathematical models. Even relatively small quantum systems may need to be described by many variables, making the design, analysis, and simulation of large scale quantum systems on digital computers extremely challenging. Complex systems are of course also common in the classical world. In the context of systems and control theory for classical dynamical systems, systematic methods have been developed to obtain simplified dynamical models for various classes of state-space dynamical systems, where the dynamics of the simplified models approximate the dynamics of the full dynamical models. The process of finding simplified dynamical models is known as model reduction. Some popular approaches to model reduction of state-space systems include the balanced truncation and proper orthogonal decomposition (POD) approaches.

In the quantum context, there have recently been substantial developments of efficient methods for simulating certain classes of quantum systems, such as the so-called density matrix renormalization group (DMRG) methods. However, these methods do not attempt to reduce the complexity of the mathematical model of the quantum system to be simulated. Thus, suitable model reduction methods tailored to quantum systems can potentially be coupled with efficient quantum simulation techniques to further increase the size of complex quantum systems that can be simulated and analyzed. A class of open quantum systems (quantum systems that are not isolated from their environment but interact with them) that are of importance in quantum technology development are open Markov quantum systems. Whenever they are valid, open Markov quantum systems make attractive mathematical models because of their relative simplicity, and are widely employed in the fields of quantum optics, cavity and circuit QED, nanomechanical systems, etc. to much success. They are the quantum analogue of a distinguished class of systems that have been extensively studied in classical systems and control theory; that is, the class of classical Markov systems represented by state-space differential equations.

This project aims to investigate adaptations of model reduction techniques for classical Markov systems to open Markov quantum systems that take into account the special structure of open Markov quantum systems. This structure needs to be preserved in the model reduction process to ensure that the simplified model also represents a genuine open Markov quantum system.

Other Projects:
- Control for quantum communication networks.
- Filtering and control of open quantum systems driven by highly non-classical quantum fields.
The foremost technology behind current Neuroimaging is functional Magnetic Resonance Imaging (fMRI). This revolutionary modality was developed in the early 1990s and enables the brain to be observed non-invasively while it is active.

Sophisticated statistical signal processing is used to produce a sequence of images showing regions of brain activation. Current interest involves recognition of brain patterns and brain analysis of functional connectivity structure. Other work involves multimodal analysis which attempts to use other modalities such as Magneto-encephalography (MEG) to improve spatio-temporal resolution. This is important because brain processing takes place on a wide range of temporal and spatial scales and the various modalities only capture some of these. Thus MEG offers fine (milli-second) temporal resolution not possessed by fMRI; while fMRI has a good spatial resolution (mm) that MEG lacks. A more recent activity involves mapping of the brain's response to Transcranial Magnetic Stimulation (TMS) something that has hitherto proved hard to do.

Neural Coding involves recording of neuronal spike trains from electrodes implanted in the brains of awake animals. The overall aim is to read the 'neural code'. That is to understand how the brain represents and processes information using spike trains. Research has most recently concentrated on developing advanced statistical signal processing tools to facilitate the extraction of information from the recorded spike trains.

Project Publications and Workshops

Research work has been published in the major venues.

Journals:
- Neuroimage, Human Brain Mapping,
- IEEE Transactions on Medical Imaging,
- Neural computation.

Conferences:
IEEE International Symposium on Biomedical Imaging (ISBI); Human Brain Mapping (HBM) (the main international conference on neuroimaging); A number of competitive workshops (attended by 400-1200 scientists) have been run at HBM jointly with colleagues from Oxford, Warwick, Columbia and Emory Universities.

NEUROIMAGING AND NEURAL CODING

Project Members:
> Project Leader: Prof Victor Solo.
Current PhD student: Mr B. Cassidy.
Recent Postdoctoral Fellow: Dr A. Pasha.

> Collaborator (& co-supervisor): Prof C. Rae,
Neuroscience Research Australia (NEURA), UNSW.

> Institutional Collaboration: Martinos Center for Biomedical Imaging, Harvard Medical School, Boston, USA.

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Neuroscience Research Australia (NEURA), UNSW.

> Institutional Collaboration: Martinos Center for Biomedical Imaging, Harvard Medical School, Boston, USA.
Collision free navigation of a mobile robot in cluttered environments is a fundamental problem of robotics. Existing navigation approaches can be generally classified as global or local (reactive). Global path planning algorithms use a complete model of the environment and attempt to obtain the best possible solution.

Local or reactive navigation algorithms use on board sensors to locally observe small fragments of an unknown environment at each time. Many existing in robotics reactive navigation algorithms are heuristic and do not have any mathematically rigorous justification.

The aim of this project is to develop effective reactive navigation strategies with mathematically rigorous proofs of their performance. We have developed a number of very promising reactive algorithms of robot navigation including some biologically inspired algorithms.

In particular, we will concentrate on the problem of robot navigation among numerous moving obstacles.

The projects include a number of industrial applications such as navigation of unmanned helicopters in urban environments, automatic navigation of intelligent wheelchairs with severely disabled people, and navigation of autonomous robotic hospital beds for neurosurgery patients.

The project is partly funded through an ARC Discovery Grant.

Other Projects:
- Control of implantable blood pumps for heart failure patients;
- Modelling and Control of heart rate during exercise;
- Control of physiological variables during kidney dialysis;
- Control of mobile sensor networks
- Modelling, forecasting and control of wind power systems.
The explosion in optical fibre research worldwide demands increasing resources and facilities, especially for the specialty silica optical fibre. To retain leadership in this field, a primary consideration is the construction of next generation fibre facility. This facility, located at The University of New South Wales, is the latest state-of-the-art silica fibre fabrication facility, built on the combined experience of optical fibre research based across NSW.

It is supported by Australian Research Council and nine Australian University partners including:
- The University of New South Wales (UNSW)
- The University of Sydney
- The University of Melbourne
- Macquarie University
- Victoria University of Technology
- Wollongong University
- Swinburne University of Technology
- The University of Newcastle
- The University of Southern Queensland

The facility underpins key cross-disciplinary and interdisciplinary photonics research spanning chemistry, physics and engineering across Australia and globally. It is dedicated to the production of research grade silica fibres and enhancing the pioneering work in Australian optical fibre research, pioneered at UNSW, over many decades. It includes on-site MCVD fabrication, the tallest research intensive draw tower in the Southern Hemisphere, and extensive characterisation equipment including a new perform analyser and a fibre component analyzer.

Through its partners, a comprehensive and complete characterisation process for all optical fibres and fibre components exists.

This project is partly funded through two Australian Research Council (ARC) LIEF grants.

Research Field:
Photonics: Fabrication and application of specialty silica and polymer optical fibers and their devices

Participants:
> Prof Gang-Ding Peng
> Yanhua Luo
> Dr Ginu Rajan
> Prof Jianzhong Zhang
> Muhammad Yusof Mohd Noor
> Zinat Mahol Sathi
> Amir Hassan Zarean
> Niran Azadpeyma
Distributed sensors are becoming an integral part of our interconnected world: from wireless sensor arrays to embedded photonics structural sensors, from spacecraft fuselage to seismic studies, their application fields are steadily growing. This growth affords many opportunities, some of which are well suited to photonics sensors especially under harsh environmental conditions; for instance in the presence of high-electromagnetic fields (turbines, high-power lines) or flammable atmospheres (mining, gas/oil distribution).

Photonics sensors offer the possibility of multiplexing using optical fibres, leveraging staggering investments made over decades in the field of optical telecommunications: simple multiplexing schemes, such as wavelength-division multiplexing (WDM) or time-division multiplexing (TDM can efficiently be implemented to interrogate and/or control distributed sensors over large areas; standard single-mode optical fibres can be used to provide secure and robust physical connection at low cost; readily available and affordable broadband sources can be exploited.

Based on recent advancements in nano-materials, nano-fabrication and new methods of liquid crystal alignment, this project aims at developing fully integrated polarisation-based sensors, which lend themselves to multiplexing and scalable fabrication. Their implementation takes the form of a sensor head, (see figure), which uses liquid crystal plate coupled to a standard single mode optical fibre via a nano-wire grid polarizer where a novel non-contact photo-alignment technique allows precise liquid crystal alignment with respect to the nano-structure.

This voltage-sensing reflective cell offers continuous hysteresis-free optical phase shift and remarkable linearity of the reflectance response. The cell can also operate using unpolarised broadband illumination and consequently can be multiplexed using standard single-mode fibres, avoiding the need for polarisation maintaining fibres.

Moreover, the sensor operates at low driving voltages, i.e. from 0 to 3 V, enabling the device for a wide range of applications.

This project is partly funded through an ARC Linkage grant (LP100200532, $270k) in collaboration with Smart Digital Optics Pty Ltd.

Figure caption: Sensor head. The device is a layered structure comprised between two glass substrates. An optical fibre is glued to the front glass substrate to inject light through the following layers: the front gold electrode, on which a nano-wire grid polariser is etched, a photo-alignment layer, a liquid crystal plate of thickness 5 μm, a second alignment layer, the back gold electrode which also acts as a broad band mirror and reflects light back into the fibre.

Other Projects:
• Diamond-based UV-emitting devices for sterilization application (industry supported research)
• Multipoint voltage sensor for high-power electricity distribution
• Diamond integrated optics
• Artificial retina & skin based on organic micro-electronics.
ENHANCED SIGNAL PROCESSING METHODS FOR NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

NMR is a powerful technique that permits the characterization of the structure of chemical compounds. Alternatively, it allows compounds in a solution to be detected and their concentrations to be estimated. An important application of NMR is the detection of impurities in a sample for quality control and human safety assurance.

NMR involves obtaining a time domain signal that is modeled as a sum of decaying exponentials whose parameters are to be estimated. The challenge in NMR arises due to the large number of components that exist in any practical sample. These components therefore overlap and strong signal mask weaker ones. This makes the detection and estimation of low concentration impurities in a sample a particularly difficult task.

Our goal in this research is to develop powerful signal processing methods that enhance the power of NMR in extracting these parameters without requiring very long experiment times. This will have direct implications for drug safety, agrochemicals, and other areas where the characterization of impurities is important, such as the determination of the (geographical) source of a chemical sample. The research will also have wider applicability in areas such as the determination of the structure of new chemical compounds, metabolomics, and magnetic resonance imaging.
INVESTIGATION OF A SCALABLE HIERARCHICAL LANGUAGE IDENTIFICATION FRAMEWORK

With little training, humans are able to identify a language within seconds of hearing an utterance and perhaps more importantly even if they cannot identify the language, they can often make subjective judgements based on similarities to other languages.

Machine based approaches to language identification are however very different, typically treating all languages equally and consequently ignoring any information about families of languages or similarity between languages.

This project aims to investigate if such information can be exploited to both improve the performance of machines and to make the system scalable so that it can be expanded at a later stage to incorporate new languages without having to modify the fundamental structure.

A new scalable framework for language identification will be developed based on hierarchical tree structures that are capable of dealing with a large number of languages. Applications include automatic routing of phone customers or emergency callers to specialists who speak the appropriate language or if that is not possible, a similar language.

Project Aims
• To develop a new framework for language identification based on hierarchical tree structures that is capable of dealing with a large number of languages; by considering language clusters of decreasing sizes as the tree is traversed from root to leaves, with individual languages considered only at the leaves.
• To investigate a suitable metric for similarity (or equivalently dissimilarity) between languages that takes into account acoustic, prosodic and phonotactic information.
• To jointly model acoustic, prosodic and phonotactic information at each level of the hierarchical structure to optimally distinguish between language clusters at that level.
• To investigate how the proposed hierarchical structure is able to identify a set of closely related language hypotheses, even if a single language is not identified.
• To gain insights into language clustering of the world’s languages, for state-of-the-art spoken language identification technology to take a leap forward.

Spectro-temporal energy distribution of a speech segment

Research field:
Speech Processing – Language Identification

Participants:
> Prof Eliathamby Ambikairajah
> A/Prof Julien Epps
> Dr Vidhyasaharan Sethu
> Dr Tharmarajah Thiruvaran
> Dr Haizhou Li

Other Projects
• “Exemplar-based Sparse Discrimination for Robust Speaker Recognition/Speaker Verification”
• “Exercise and Tele-rehabilitation for Australia’s Ageing Population”
• “Cochlear Implant Signal Processing – Smart Channel Selection and Automated Sound Scene Analysis”
• The Signal Processing Application in Detecting Arc Faults and Determining Energy Losses in Distribution Networks”
PARALINGUISTIC SPEECH CLASSIFICATION

Humans are able to express, process, and interpret non-linguistic information, such as emotion, conveyed by speech automatically and effortlessly in the course of any normal conversation, however for machines this is a key outstanding problem remaining to be addressed by the speech research community. Whereas systems that deal with the problems of speech, speaker and emotion recognition in isolation exist, typically they don’t make use of the interdependence between these different types of information. This project aims to investigate the type and extent of the interdependence and exploit it to improve the speech-based recognition rates for emotions and other mental states (e.g. depression or suicidality) currently achieved by machines.

The aims of the project are to:

- develop a joint model of linguistic and paralinguistic information such that their interdependence is exploited in both linguistic and paralinguistic pattern recognition tasks.
- investigate the use of linguistic models to reliably extract high level features representative of paralinguistic speech information.
- examine how the new joint model can be exploited to improve the accuracy of speech recognisers, speaker recognition systems and in particular systems for the recognition of emotion and mental state from speech.

Progress in the major areas of speech research has typically been contingent on the existence of models that have been demonstrated to capture the fundamental aspects of speech production and perception. In the recognition of paralinguistic speech attributes, notable models include the widely used mel frequency cepstral coefficient representation of the short-term speech spectrum, the Gaussian mixture model representation of the acoustic space (still the mainstay of speaker recognition systems) and model transformations by various methods (e.g. normalisation, nuisance attribute projection, factor analysis) for removing variability that is assumed to be independent of the speech attribute of interest. Essentially the time has arrived for a new modelling approach: one that explicitly captures and exploits interdependencies between speech attributes.

This project directly sets out the key investigations that underpin an interdependent or joint model of linguistic and paralinguistic speech for recognition applications.

This project is the first to propose and evaluate a system with a flexible and scalable framework for joint recognition of linguistic and paralinguistic information. The flexibility and scalability refers to the fact that the type and number of paralinguistic speech attributes modelled can be changed and/or increased within the framework. Completion of the investigations will yield a new design paradigm for paralinguistic recognition systems. There is therefore an opportunity for the research team to make some of the key contributions to this field of engineering.

The project addresses from a recognition perspective a fundamental question in speech science and technology: how are linguistic and paralinguistic speech
attributes related? The project will investigate the existence of linguistic patterns that are dependent on paralinguistic information at three levels, namely, the phonetic, the word and the language model levels. Insights from this investigation include the extent and form of the interdependence between linguistic and paralinguistic information, whether linguistic structures (at all three levels) that are characteristic of paralinguistic information exist and how knowledge of these structure can be exploited. This project allows previous work to be significantly extended to study phonetic and speaker variability in an emotion recognition system simultaneously rather than in isolation. To give just a single example, this allows the investigators to analyse the relative contributions of each phoneme towards emotion recognition on a per-speaker basis.

On a more abstract level, these investigations address the question implicitly posed by the original aims: Are the linguistic and paralinguistic information in speech interdependent? This question is highly significant since current linguistic and paralinguistic recognition systems use normalisation techniques extensively to remove variability associated with information that are not the target of the system. These systems make an inherent assumption that the information being normalised is independent of the target information. The investigations in this project directly address this and could potentially show this assumption is weak or incorrect, and hence form the basis for a new generation of recognition systems. On the other hand, even if the assumption is shown to be correct, this project will be the first detailed, recognition-based validation of this integral assumption.

In a world where increasingly the agent at the other end of human interactions is a machine (e.g. call centres, Internet, voice over IP commerce), it is critical that the machine can intelligently understand human expression and human cognitive states. Emotion recognition in this implicitly means also other types of paralinguistic information, including mental state. In extreme cases, for example angry telephone customers or pre-suicidal crisis centre callers, there are significant human benefits in machines being able to automatically route calls to specialist human operators, efficiently on a very large scale. Automated detection of cognitive load (also being developed by the investigators), stress or other unique non-linguistic cues from telephone calls may also prove helpful to agencies dealing with the search for pre-terrorism activities or organised crime in large volumes of digital information.

The project is mainly funded through an ARC Discovery Grant, and partly by National ICT Australia.
SCALABLE COMPRESSION OF MOTION FIELDS

Efficient scalable compression schemes are highly desirable for many applications such as internet video, surveillance and mobile video communications. A scalable video stream is one that has been compressed once but can be decompressed in many different ways, to suit the frame rate, frame size and communication bandwidth required by the rendering application. This is done by extracting suitable subsets from the compressed representation. From a different perspective, efficient scalable compressed bit-streams should be incrementally refinable, meaning that higher quality, frame sizes or frame rates can be obtained by adding successively more bits to an initial low quality representation.

Motion modeling plays a central role in all modern video compression systems. For scalable compression schemes, the motion information that is embedded within the compressed bit-stream must also be successively refinable. The dominant approach, found in all video compression standards, has been hierarchical block-based translational motion. However, these models create numerous artificial block boundaries that have no physical meaning and hence very poor successive refinement attributes.

The aim of this project is to develop new approaches to the joint scalable representation of motion and boundary geometry, which possesses the same incremental refinability that can be found in well-known highly scalable image compression schemes such as JPEG2000. We have developed very promising representations for the motion discontinuities that occur at boundaries of objects with different motion.
These are successively refinable in both quality and spatial resolution, allowing boundaries to be progressively refined through the addition of bits to the compressed representation. We are also developing highly scalable transforms for the motion information itself that adapt to the scalable boundary information.

This project opens up many exciting new directions and possibilities for scalable compression of video and other media types, including depth imagery. These directions present opportunities for other researchers to join the project in the future.

The project is partly funded through an ARC Discovery Grant.

Other Projects
- Compression and communication of single and multi-view video based on overlapping motion hint fields
- 3D active surface modelling of small structures in CT
- Efficient scalable compression of depth maps and elevation data
- Multithreaded processing paradigms for JPEG2000
- Intelligent client/server systems for efficient interactive
- Communication of imagery and video
SECURITY MECHANISMS FOR BODY-WORN HEALTH MONITORING DEVICES

A growing trend in age-related disabilities and chronic medical conditions (diabetes, heart disease, etc.) is putting a huge strain on national health expenditures and welfare spending worldwide. A promising solution that dramatically reduces healthcare costs is to shift the task of patient monitoring and diagnosis from the hospital to the home. This paradigm is enabled by the development of small, unobtrusive wearable sensors that can record a patient’s vital signs (heart rate, blood glucose, ECG, etc.) in real-time and wirelessly transmit readings to a mobile phone or gateway device, from which the medical data can be sent over the Internet and interact remotely with caregivers over a much faster and more reliable always-on connection.

The patient’s personal medical data collected by these wearable sensors needs to be adequately secured: data privacy is a serious concern for the patient, whereas authenticity of the data is critical from the caregiver’s point of view. Traditional computer security mechanisms are too resource intensive for miniaturized sensor devices as they possess limited power, memory, and computation capabilities.

In this project, we develop novel solutions that address the security concerns of Internet-enabled wireless healthcare devices (as elaborated in the new IEEE 802.15.4 standard). The first aspect of this project deals with deriving the security key to encrypt the medical data, and our method is based random but reciprocal nature of the wireless channel between two communicating parties, which allows for generation of shared secret bits that are infeasible for an eavesdropper to deduce. We are developed the theoretical basis for this secret sharing technique, and our experimental validation of this idea in several realistic deployment scenarios is showing good promise. Our approach opens up exciting new directions whereby the system replenishes its security automatically and users are obviated from configuring security parameters for their medical devices.

The second aspect of this project is developing low-complexity ways by which the integrity of the medical data generated by the body-worn device can be guaranteed. Traditional public-key cryptographic techniques are too complex to operate on light-weight wearable devices. Our approach combines block signatures to amortize the authentication costs with network coding to provide loss resilience. Both aspects of the project offer new directions that need to be explored for realization of mass deployment of body-worn health monitoring devices in the near future.
Emerging mobile wireless networks are currently being designed to support a wide range of newly proposed applications. It could be argued that the application of wireless communication systems to emerging intelligent transportation systems has generated the most excitement and interest in the past few years. Almost all developed nations are now moving to implement and regulate some form of vehicular ad hoc networks (VANETs) into their future road-safety systems. The main idea here is that cars will coordinate critical information between themselves in order to greatly enhance passenger and pedestrian safety. Improved traffic coordination and reduced carbon pollution are secondary aims of such systems. However in the rapidly changing radio environment of a VANET link failures will dominate the error control features of the communication system. Such link failures require a direct response from the routing protocols, leading to a potentially excessive increase in the routing overhead and degradation in network scalability. However, in all modern wireless communication systems location information will be ubiquitous - an outcome already well established in vehicular networks. In this project we will further research the performance and capabilities of our recently proposed hybrid location-based routing protocol which is specifically designed to address the issue of frequent link breakages. Our new protocol combines features of reactive routing with location-based geographic routing, in such a manner so as to efficiently use all the location information available. The protocol is designed to gracefully exit to reactive routing as the location information degrades. Our protocol is scalable and has an optimal overhead even in the presence of high location errors. It provides an enhanced, yet pragmatic, location-enabled solution that can be deployed in all VANET type environments. The focus of our ongoing research in this area is to carry out detailed prototyping in the setting of live vehicular networks, and to carry out further theoretical analysis of the system’s performance and optimality when supplementary information, such as a real-time traffic motion model, is made available. Extension of our protocol to include the location information as a security enhancer, and deployment of our protocol in other emerging wireless communication systems, will also form part of our ongoing research in this rapidly developing area.
Quantum communications is emerging as one of the key new communication technologies of the 21st century, with large-scale deployments now at the production stage, and successful experimental tests reported in regard to full-scale global (via satellite) quantum communications. Quantum communications is an exciting and rapidly emerging field of study which crosses the domains of both physicists and engineers. In the past five years great technical progress has been made in the deployment of quantum communications on scales of 100km. Commercial deployments of quantum communication systems for cryptography applications have also recently appeared on the market. Even larger quantum communication systems are being pursued in the US, Japan, and a global quantum network via satellites is now being actively pursued by a large European consortium of researchers and industrial partners. City-wide quantum communication systems are now deployed in several major cities, the most recent being a 50km wide deployment in Tokyo.

However, it is only in the past few years that a focus on the techniques required for larger multihop quantum systems have appeared. Such multihop quantum systems are anticipated to be emerging into a full operational phase over the next decade or so. They will be deployed over future fibre-based and wireless-based communication systems. Such systems will consist of a merging of classical and non-classical communication technology. The classical communications will consist of data, management-overhead, protocol-overhead, and information related to quantum operations such as teleportation. The non-classical communication will be related to the transfer of quantum state information which is in the form of qubits or higher dimensional quantum systems.

A critical component of emerging quantum networks will be the quantum error correction codes. This is particularly the case in a multihop environment given the number of quantum operations that will occur and the number of de-cohering channels encountered. However, there currently is a dearth of efficient quantum code designs aimed specifically at this emerging multihop quantum network environment. In this project we will plan to leverage our own previous experience in several key areas, all of which are related to our proposed development of novel quantum error correcting codes operating over emerging multihop quantum communication networks. These areas are: Classical error correcting Low-Density Parity-Check (LDPC) codes; protocol optimisation studies in large-scale communication networks; decoherence of quantum information over noisy quantum channels; application of quantum error codes to new location verification protocols; and application of classical LDPC codes to unknown quantum channels.
COGNITIVE AND COOPERATIVE COMMUNICATIONS

Cognitive radio is an exciting emerging technology, which has the potential of dealing with the stringent requirement and scarcity of the radio spectrum. Such revolutionary and transforming technology represents a paradigm shift in the design of wireless systems as it will allow the agile and efficient utilization of the radio spectrum by offering distributed terminals or radio cells the ability of radio sensing, self-adaptation, and dynamic spectrum sharing. Cooperative communications and networking is another new communication technology paradigm which allows distributed terminals in a wireless network to collaborate through some distributed transmission or signal processing so as to realize a new form of space diversity to combat the detrimental effects of fading channels.

One of the most important challenges for cognitive radio systems is to identify the presence of primary (licensed) users over a wide range of spectrum at a particular time and specific geographic location. While cooperative spectrum sensing has been recently studied to improve the detection capability of the primary users, there are still many open problems in spectrum sensing, such as the quickest detection of primary users, the sensing-throughput-overhead tradeoff, the sensing with accurate modeling of primary user traffic, etc. Another important aspect for cognitive radio system design is to allow dynamic spectrum access of cognitive users to the primary channels. Cooperative transmission is envisioned to bring new direction and dimension to dramatically improve the spectrum utilization. However, due to the dynamic nature of the spectrum and limited transmit power, spectrum sharing between cognitive users and primary users should be carefully designed so that the spectrum utilization can be maximized while the interference is under control.

The objective of this proposal is to propose bandwidth efficient cooperative spectrum sensing and spectrum sharing in cognitive radio networks. The ultimate aim is to dramatically improve the network’s spectrum efficiency, power efficiency and reliability, without interfering with other incumbent devices in the same frequency bands. The project is partly funded through an ARC Discovery Grant.
Network coding is an emerging technique to design future communications networks. It is first proposed to address the problem of the network multicast capacity of wireline networks. Since then, network coding has attracted a significant interest, as it promises to have a considerable impact on both the theory and practical design of multiple terminal communications networks. In contrast to classical routing approach where only the packets that validate a routing criterion are forwarded without further processing, network coding allows intermediate nodes in a network to not only forward but also process the incoming information flows by performing a “coding” operation. The coding operation takes two or more received packets to form a new network-coded packet and broadcast it to the destinations. By doing so, network coding is able to increase the transmission rate/throughput, reduce the delay and achieve the minimum-cut maximum-flow capacity for multicast in a wireline network, which is the maximum amount of information that can be pushed through a network between a sender and multiple receivers.

Most of the existing work on network coding assumes error free transmission and wireline networks, like Internet. For wireless networks, however, transmission errors occur due to the channel noise and interference. Many distinguished features of wireless channels, such as broadcast nature, multi-user interference, and hostile channel condition, have to be considered to develop the relevant theory and its design. In practical wireless communication systems, error free transmission requires a powerful channel coding and effective automatic repeat request (ARQ) schemes.

Moreover, in networks, channel errors might propagate from one node to another. Therefore, channel coding and network coding usually cannot be separated without loss of optimality. The project will aiming at developing the theory and the design of novel and practical coding techniques cross physical layer and networks layers for wireless communications. It is expected that the novel designs can dramatically improve the network’s spectrum efficiency, power efficiency and reliability. It is highly desirable that the proposed novel and practical cross-layer coding theory and techniques can enable a breakthrough in deploying the forthcoming wireless broadband services.

The project is partly funded through an ARC Discovery Grant.
The security of information that is passed over large communication networks is of paramount importance. Recently, physical layer security has been identified as the strictest notion of security, and therefore represents an important and critical component of future communication networks. The core principle of physical layer security is the ability to restrict the useful information that can be extracted at the symbol/signal level by any unauthorized receiver. This is achieved by carefully designing intelligent and appropriate coding and precoding techniques that exploit the wireless medium’s channel state information. As opposed to classic cryptography, physical layer security is based on information theoretic principles and it does not rely on secret keys or limited computational capacity of the eavesdropper. Recently, this information-theoretic aspect of secrecy at the physical layer has attracted significant interest. Physical layer security promises to have a considerable impact on both the theory and the practical design of future networks.

In this project we will develop novel and efficient information theoretic security techniques particularly aimed at multiuser wireless networks. Our proposed research investigates the fundamental ability of the physical layer to provide secure wireless communications. More specifically, our work will investigate how multiple users can exchange confidential messages over a wireless medium even in the presence of sophisticated malicious users.

Ultimately the secret capacity of multiuser wireless systems will be determined and exploited. The proposed research will exploit the variability of the wireless channel as a means of ensuring the secrecy of wireless communications. It is expected that the novel security techniques we develop will be used to dramatically improve the existing network security measures and open up a new frontier of opportunities for future wireless network developers. Potential applications of the project outcomes can be deployed in many settings, including critical-infrastructure networks and vital e-commerce wireless networks.

The project is partly funded through an ARC Discovery Grant.
CHARACTERIZING COOPERATIVE POSITIONING IN VANET

Cooperative positioning (CP), a localization means that has been widely used in wireless sensor networks, is emerging as one of the promising solutions for improving the vehicular positioning in VANET. CP allows each individual node in the network to calibrate its own position, by leveraging distance measurements between neighbor nodes with unknown or estimated (e.g., from GPS) positions. While concepts of applying CP in VANET have been introduced, the actual performance of CP in real-world vehicular communication scenarios is largely unknown. In this project, we bridge this gap by conducting a comprehensive simulation study to characterize the performance of CP in realistic VANET environments. We investigate the efficacy of CP under the effects of various communication factors exhibiting in VANET. Further, we analyze the performance of CP with respect to the constraints from underlying non-cooperative vehicular localization techniques.

The goal of this study is of two-fold: 1) We intend to characterize the efficacy of CP under realistic communication factors exhibiting in VANET, e.g., road traffic density, message broadcast pattern and DSRC radio transmission range; 2) We are interested to quantify the CP performance under the effect of the underlying non-cooperative localization constraints, e.g., the accuracies of GPS and radio-based ranging techniques. For this, we conduct realistic simulation experiments and evaluate the CP accuracy using the well-known metric Cramer Rao Lower Bound (CRLB). Our results demonstrate that CP can effectively reduce the vehicular positioning error by at least 40% as compared to the plain GPS approach, even under low traffic density scenarios. We find that, under communication constraints, the actual CP accuracy is noticeable less than that can be achieved in an ideal loss-less communication scenario. We also find that using CP is more beneficial when a larger DSRC transmission range is in use.

Further, we how that, affected by the accuracy of the state-of-the-art underlying non-cooperative localization techniques, it is difficult for CP to achieve the stringent positioning requirements of safety applications (e.g., CCW requires position accuracy of 1 m).

The project was partly funded by an FRG Grant.
Awards and Accolades
Dr Mihai Ciobotaru and Prof Vassilios Agelidis successfully received the competitive 2012 IBM Smarter Planet Innovation Faculty Award ($10,000) presented by the IBM TJ Watson Research Centre in Yorktown Heights in the USA.

Scientia Professor Andrew Dzurak, receiving the 2011 Eureka Award for Scientific Research, which was awarded jointly to Prof Dzurak and A/Prof Andrea Morello.

Prof Francois Ladouceur, Dr Zourab Brodzeli and Dr Leonardo Silvestri are the winners of the UNSW Early Stage Innovation Award 2012 in their work on the development of a new class of optical transducer with potential application in the power distribution industry (smart grid), oil & gas distribution, surveillance and ocean monitoring (hydrophones).
A/Prof Iain MacGill is Joint supervisor (with A/Prof Mark Diesendorf of UNSW’s Institute of Environmental Studies) of Ben Elliston who was Joint Winner of the Wal Read Prize for Best Student Paper at the Australian Solar Energy Society Conference, in December 2011

Dr Tim Moors received “Intellectual Ventures Spirit of Invention Prize’ in UNSW Inventor of the Year Awards 2011

- OSA Fellow, 2011
- Co-General Chair, the 3rd Asia-Pacific Optical Sensors Conference 2012 (APOS 2012) Sydney, Australia

A/Prof Toan Phung was invited as a Key-Note Speaker at the 16th ASEAN Conference on Electrical Discharge (ACED 2012), held in Johor Bahru, Malaysia from 10 - 12 December 2012. ACED is a biennial event and considered to be an important conference in electrical discharge in the Asia-Pacific Region.
Dr Jayashri Ravishankar, Phil Allen, Dr Stephen Redmond, Dr Ray Eaton and Prof Eliathamby Ambikairajah received the Best Paper Award at the IEEE International Conference on Teaching, Assessment and Learning for Engineering 2012. The paper entitled “Taste of Electrical Engineering Workshops for High School Students”

Prof David Taubman was invited to one of two “Invited Talks” at the “ASP-DAC: 17th Asia and South Pacific Design Automation Conference” in February 2012. His presentation was one of three “Invited Research Overview Presentations” at “ICME: IEEE International Conference on Multimedia and Expo”, July 2012. His conference paper was in the top 10% paper award from “MMSP: IEEE International Workshop on Multimedia Signal Processing”, September 2012.

Prof Jinhong Yuan co-authored three Best Paper Awards and one Best Poster Award, including:
1. a Best Paper Award of IEEE Wireless Communications and Networking Conference (WCNC), Cancun Mexico in 2011. The paper entitled “Outage Performance of Analog Network Coding in Generalized Two-way Multi-Hop Networks”.
He is also a keynote speaker in Performance Analysis and Design Physical Layer Network Coding at the 2011 IEEE International Conference on Information Theory and Information Security (ICITIS 2011)

A/Prof Wei Zhang co-authored a Best Paper Award at the IEEE International Conference in Wireless Communications and Signal Processing, Nanjing, China, November 9-11, 2011. The paper entitled “On Design of Asymmetric Interference Alignment and Cancellation Scheme in MIMO X Network” (The first author is his research student Lu Yang).
He was invited to present a talk at the 1st IEEE International Conference on Communications in Beijing, China, August 15-17, 2012.
A/Prof Wei was also invited to present a talk at the IEEE International Conference on Communication Systems, Singapore, November 21-23, 2012.

A/Prof Andrea Morello’s research student Jarryd Pla (left) won CiSRA Best Postgraduate Research Paper Award with the prize monies of $2000. Jarryd is the first author of the paper “A Single-Atom Electron Spin Qubit in Silicon”, published in Nature. The result from this paper represents a major milestone for the worldwide effort towards building a realistic quantum computer. This paper represents one of the most important milestones in Australian research in the last decade. This award is generously sponsored by CiSRA.
Over $3 Million in ARC Grants in 2011 and 2012

64 Research Staff, 118 Research Students and 341 Publications
## 2012 Discovery Grants

**Prof Andrew Dzurak, Adj/Prof Mikko Möttönen**  
Single electron pumping for current measurement standards  
2012: $170,000  
2013: $150,000  
2014: $120,000  

Precision measurement standards for electric current and voltage are necessary to ensure the safe and accurate operation of much of the electronic equipment that underpins modern society. This project will develop a new ultra-high-precision current standard, providing a missing link in today’s world standards for electrical measurement.

**Dr Andrea Morello, A/Prof Jonathan Finley**  
The best of both worlds: electrically detected optical spectroscopy at the single atom limit  
2012: $260,000  
2013: $120,000  
2014: $120,000  

One atom, one photon, one electron, in a silicon crystal. We will demonstrate a novel technique to detect the absorption of light by a single atom, in the most significant environment for nanoelectronics and photovoltaics. Our technique will help unravel how light is turned into electricity at the most microscopic and fundamental level.

**Prof Rodica Ramer, Dr Yingjie Guo, Dr Raafat Mansour**  
Advanced microwave and millimetre-wave microelectro mechanical technologies for wireless communications  
2012: $120,000  
2013: $100,000  
2014: $100,000  

The project deals with the development and integration of radio frequency microelectromechanical devices that can reduce space and cost concomitant with enhanced performance. The outcomes of this proposal are devices with increased functionality required for multi-gigabit data rate transmission and millimetre wave wireless technologies.

**Prof David Taubman, Dr Reji Mathew, Prof Michael Frater, A/Prof Mark Pickering**  
Compression and communication of single and multi-view video based on overlapping motion hint fields  
2012: $120,000  
2013: $100,000  
2014: $100,000  

This project explores a new way of communicating motion for video and multi-view (3D) applications, facilitating efficient interactive access to content. Outcomes will include new compression methods that avoid redundant transmission of motion side information, plus client/server technology that leverages metadata from smart surveillance cameras.

**Prof Jinhong Yuan, A/Prof Robert Malaney, Dr Ingmar Land, Prof Lars Rasmus sen**  
Physical layer security techniques for multiuser wireless networks  
2012: $120,000  
2013: $90,000  
2014: $90,000  

This project will develop innovative new security techniques for wireless networks. The novel techniques we develop will exploit the natural variability of wireless communication channels in order to deliver much-enhanced data security to a whole range of applications over the mobile internet.

**Dr Guoqiang Mao, Dr Wei Zhang**  
Large scale highly dynamic wireless networks: architecture and communication strategies design  
2012: $120,000  
2013: $90,000  
2014: $90,000  

Administering Organisation: The University of Sydney  
This project will develop novel techniques for the modelling, design and management of highly dynamic networks, with wireless vehicular networks for autonomous vehicles being a typical but not sole example. Social and economical benefits are expected in the areas of road traffic management and road safety, communication and environment protection.
2012 Linkage Grants

Dr Toan Phung, A/Prof Trevor Blackburn, Prof Eliathamby Ambikairajah, Dr Mohammad Salay Naderi, Mr Patrick McMullan
Improving grid performance: detection of arc faults and determination of energy losses in electricity distribution networks

2012: $60,000
2013: $40,000
2014: $40,000

This project will develop a monitoring system to address the critical need to ensure safe operations of overhead power lines, particularly in rural areas, and prevent bushfires caused by electrical faults. The research also enable monitoring of power losses in electricity distribution networks and improving the energy efficiency of the supply system.

Prof Jinhong Yuan; Prof Li Ping
Efficient cross-layer coding techniques for wireless networks

2011: $80,000
2012: $80,000
2013: $80,000

This project is proposed to develop novel wireless communication/networking design theory and practical strategies based on the emerging network coding technique. The expected outcomes can be used to substantially increase network throughput and reliability of future wireless services, such as wireless internet and mobile broadcasting.

2011 Discovery Grants

Dr Julien R Epps, Prof Eliathamby Ambikairajah, Prof Haizhou Li
Joint modelling and recognition of linguistic and paralinguistic speech information

2011: $90,000
2012: $85,000
2013: $85,000

A new modelling framework will be developed exploiting interdependence between linguistic and paralinguistic cues to improve automatic recognition of emotion-related information. Application in the high-tech industry include automatic routing of angry telephone customers or pre-suicidal crisis centre callers to specialist operators/clinicians.

A/Prof Tuan D Hoang, Prof. Andrey V Savkin
Exploring new tools in nonlinear filtering and control

2011: $100,000
2012: $100,000
2013: $100,000

The conceptual advances with new design rules to be developed in the area of nonlinear filtering and control. Major benefits of this project will be direct applications to state estimation and control problems in automobile, manufacturing, military hardware and medical device industries, and its increased capacity of contact research.
Other Funding

2012 Funding

Prof Vassilios Agelidis secured the funding of $19.1 millions for the Solar Flagships Research Infrastructure.

Prof Eliathamby Ambikairajah secured the funding of $300,000 from CSIRO - Commonwealth Scientific and Industrial Research Organisation/Commonwealth Government Contract with a project entitled “Collaborative Relationship Agreement for research in sensor data, information networks and machine learning”.

Dr Julien Epps was the key investigator on the project “Above and Beyond Speech, Language and Music: A Virtual Lab for Human Communication Science (HCS vLab)” under the National eResearch Collaboration Tools and Resources (NeCTAR) scheme. The funding worths $1.4m, with a $400k cash and $1.9m in-kind co-investment. This project aims to deconstruct a cloud-style computing resource that will make research databases and tools accessible to everyone.

Non ARC grants that A/Prof Iain MacGill and colleagues are currently undertaking include:


Prof Gang Ding Peng with his project “Grating and DFB Fibre Laser Fabrication and Application” received funding of $72,150 from Laser Institute - Shandong Academy of Sciences.

The Australian Power Institute (API) funding with the total value of $152,000 in the following proposals:

- Continuation of Early Career Teaching Support - Dr Jayashri Ravishankar (3rd and final year of funding)
- Continuation of Teaching and Research Support in Electrical Protection - Dr Daming Zhang (2nd year of funding)
- Support to Establish a Power System Protection Laboratory
- Implementation of API Undergraduate Modules

Dr Jayashri Ravishankar successfully secured funding from Transfield Foundation towards early career researchers for a project “To investigate, develop and demonstrate the operation and control concepts of a DFIG based wind turbines”.

2011 Funding

Dr Elias Aboutanios successfully led a team in securing an education grant of $675,173 for a project entitled “A Comprehensive Tertiary Education Program in Satellite Systems Engineering”.

A/Prof John Fletcher and Dr Jayashri Ravishankar successfully secured the funding of $100,000 from the Australian Power Institute in the following projects:

- Development of a Micro Generation Test Facility for the Assessment of Power Quality and Hybrid System Control – A/Prof John Fletcher
- Continuation of Support for an Early Career Academic – Dr Jayashri Ravishankar

2011 School Research Publications

Books

Journal Papers
- *Chan, KY, Ramer, R & Mansour, R*, *Novel Miniaturized RF MEMS Switch Matrix*, *IEEE Microwave and Wireless Components Letters*.

Publications listed below are those included in the University’s verified annual Higher Education Research Data Collection (HERDC) Report.

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Morisson, G. S., "A comparison of procedures for the calculation of forensic likelihood ratios from acoustic-phonetic data: Multivariate kernel density (MKD) versus Gaussian mixture model-universal background model (GMM-UBM)," * Speech Communication*, vol. 53, pp. 242-256.


"Bagheri, M & *Salay Naderi, Mohammad, "Moisture Diagnostics of Transformers Using Dielectric Response and Paper Samples Methods," Electrical Insulation Conference (EIC2011), Annapolis, Maryland, USA, 5-8 June 2011.


"Bagheri, M & *Salay Naderi, Mohammad, "Impact of Compact Fluorescent Lamp on Transformer Losses," 28th International Power System Conference (PSCC11), Tehran, Iran, Oct.31-Nov.2, 2011.


"Jang, M, "Ciobotaru, M & "Agelidis, VG, "Grid-connected fuel cell system based on a boost-inverter with a back-up unit," 9th International Conference on Power Electronics - ECCE Asia, Jeju, Korea, 30 May - 3 June, 2011.


"Pasha, SA & "Hoang, TD, "Stochastic intensity propagation via LiF modelling," 18th IFAC World Congress, Milan, Italy, August 28 - September 2, 2011.


2011.


*Seneviratne, AP, Pedrasa, J & *Rathnayake, U, "Network availability prediction: Can it be done?," Global Information Infrastructure Symposium, GIIS 2011, Da Nang, Vietnam, 4-6 August, 2011.


"Yan, Phung, BT, Han, ZJ & Ostrikov, K, "Effects of plasma modification of nanofillers on insulation properties of epoxy resin/SiO2 nanocomposites," 54th IEEE International Conference on Electrical Insulating Materials, Kyoto, Japan, 6-10 September 2011.


### Patents

**Patents at the provisional filing stage in 2012:**


**Patents reaching the PCT stage in 2011 and 2012:**


**Patents Granted in 2011 and 2012:**


- D. Taubman and A. Secker, “Method of signalling motion information for efficient scalable video compression” (Application No. 13/421788) was published as US2012/0230414 on 13 September 2012.
If you are interested to collaborate with our researchers, please visit our school website: www.eet.unsw.edu.au/Research

Our academics’ contact details are:

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<th>Head of School</th>
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