THE UNIVERSITY OF AUCKLAND
FACULTY OF ENGINEERING
Department of Engineering Science
www.esc.auckland.ac.nz

DES News

June 2009 | **The Newsletter for Engineering Science Alumni and Friends**

Welcome to the June edition of DES News

In May, more than 400 people graduated with various degrees in Engineering. In particular 10 Engineering Science and 13 Biomedical Engineering BE students graduated, most of whom commenced Part II of their degree (the first year of specialisation) in 2006. A significant proportion of the 2006 intake undertook conjoint degrees, and these students will complete their degrees this year and graduate in 2010. We also had 5 students with higher degrees graduate, three of whom were awarded doctorates (see page 2). This year, the graduation ceremony was held in the Aotea Centre and an entire ceremony was devoted solely to the Faculty of Engineering. On stage, there was not a single spare seat as more than 100 Engineering staff honoured the achievements of the students. Unfortunately, for the first time in my recollection, the adverse weather forced the cancellation of the procession from the University to Aotea Square.

The Department continues to grow and we are pleased to announce the recent appointment of three new staff (see enclosed articles). Staff are currently all busy with exam marking and processing – a task that has grown in size over the years as the number of students enrolling in Engineering has grown. Most will be looking forward to a short break before Semester 2 begins, and we anticipate an increased urgency in the Part IV class as they realise how little time they have left to complete their project.

The Department is about to launch a nationwide competition for senior high school students to find NZ's "Next Top Engineering Scientist". The main reason for this initiative is to improve recognition of Engineering Science amongst high school students. In getting this competition up and running, the Department has received help support and sponsorship from members of our external Advisory board, particularly from two of our alumni Maury Leyland (Fonterra) and Ian McCrae (Orion Health). More on this competition will be included in the next newsletter.

The Part III classes (Engineering Science and Biomedical Engineering) challenged each other to a "Bake Off" of sweets, cakes and muffins. The competition was judged by Andrew Pullan, Rosalind Archer and John Cater, who sampled every item. Whilst "winners" were declared, there were no losers, as everyone got to eat the entires after judging finished.

Inaugural Bakeoff Competition. Left to right, Winning Cake by Tessa Paris, Centre, the two classes and their cakes, Right, Winning Slice by Iain Dunning.

As always, please feel free to provide feedback - you can now email desnewsletter@auckland.ac.nz - and especially, if there is something in particular you would like to see included in this newsletter, please do let us know.

Professor Andrew Pullan, hod_des@auckland.ac.nz

Your Department needs YOU!!!

Can you help with summer studentships and/or summer work?

In the current work environment, a number of undergraduate students have expressed difficulties in finding summer work suitable for the practical work requirements of their degree. If you can help with summer studentships and/or

In this issue

In Short

Become a DES fan on Facebook

Courtesy of Rosalind Archer, log on to Facebook, and search with 'Engineering Science Auckland'

PhD thesis published

Dr Jonathan Lever (former Phd student of Dr Unsworth) has had his thesis *"Characteristic Periodic Variations of Surface Geothermal Features: A study of springs and geysers using wavelet and Fourier analysis, and system dynamics modelling"* published as a book by VDM publishers. Jonathan has also been made an Associate Professor at Unitec.

Engineering staff in fundraiser

Rosalind Archer was part of the 'Well Engineered' team which completed this years Oxfam Trailwalker fundraising event. Teams must walk 100km within 36 hours and raise a minimum of $2500. 'Well Engineered' exceeded both time and fund raising targets by completing the distance in 30 hours and 49 minutes and raising $5,334.

HoD recieves HRC grant

Andrew Pullan will receive $1.3 million over 36 months from the Health Research Council of New Zealand (HRC) to conduct a detailed study of the behaviour and associated electrical rhythms of the human stomach in health and disease.

Featured Alumni – David Robb, class of '85

Childhood loves for problem solving, mathematics, and water led David to the Engineering School in 1983 where he joined a class of 15 TAM students. Leaning towards OR he worked with Rob McKibbin and David Ryan on a non-linear optimisation model of a group heating scheme - which he hoped would save some geysers in Rotorua. However, his interest in business - fueled by a summer job developing the forecasting engine for one of NZ's first Material Requirements Planning implementations at Dulux Paints – provided the impetus to join Fletcher Steel as "Inventory Controller" upon graduation. In designing and implementing a new inventory and distribution system he learned that optimisation extended beyond parameter selection to both system design (e.g., decentralised inventory management makes little sense in New Zealand), and human factors (developing trust with employees and management is critical).

In 1987 David headed for Canada, undertaking MBA and PhD degrees in Operations Management under the supervision of Ed Silver. He has fond memories of hiking and cross-country skiing in the Canadian Rockies, but moreover of being blessed with a Canadian wife and two daughters with whom he returned to Auckland in 1994. He took up a position at the University of Auckland Business School, and consulted on Supply Chain in the Building Products, Pharmaceuticals, and Postal Systems sectors.

Since early 2007 David has resided in Beijing, where he is on staff at Tsinghua University – regarded by many as China's leading University. Some highlights have included teaching a course to 29 MBA students from 20 different countries, writing a case study on Wal-Mart China's supply chain, beginning research into China's Dairy supply chain, and playing the piano at Beijing Baptist church which he attends with his wife and their six children (born on three continents).

New Doctors of Philosophy (Engineering Science)

Dr Ziming Guan

I was lucky enough to be supported by a Bright Futures Enterprise Scholarship, sponsored by Fonterra. For my PhD, I first developed inventory models aimed at enabling Fonterra to make good decisions in the international dairy commodity market in the face of uncertainty in milk supply. I developed a set of optimisation models that produced policies to maximize expected earnings, developed a new algorithm to solve these models and gave a mathematical proof of the convergence of the algorithm. The policies computed by the algorithm demonstrated in computational experiments that they were a substantial improvement over existing policies.

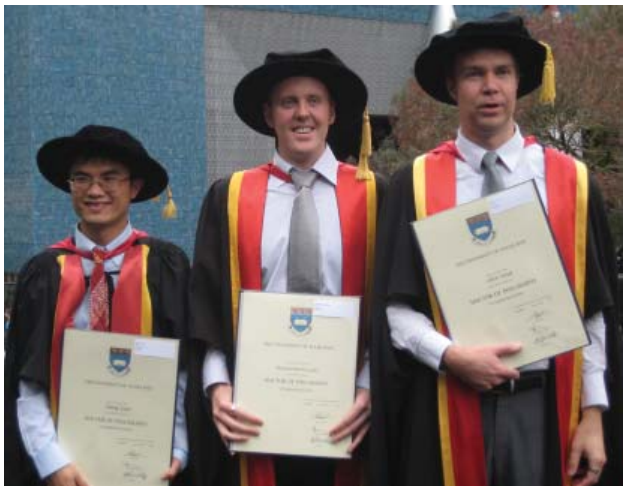
I also study the strategic behaviour of other agents in the market. I used game-theoretic models to compute inventory policies that emerge in a Nash equilibrium, and performed computational experiments to assess the importance of strategic considerations for suppliers to the European dairy market. During my PhD I developed an interest and expertise in production planning and global trade, and I am currently seeking employment in a corporate environment.

Dr Richard Lusby

For my PhD I considered the problem of routing trains through railway junctions. This problem entails efficiently coordinating the often large number of timetabled train movements within compex railway junctions while satisfying a number of operational requirements.

My thesis presents a new generalised set packing formulation of the problem and describes a tailored branch-and-price based solution approach. The formulation is characterised by a resource based constraint system that allows one to explicitly represent the movement of trains over time and is fundamentally different to all previous approaches. We show that our approach is superior in terms of mathematical bounds and, furthermore, is more flexible from a modelling perspective in that it can dynamically include spatial and/or temporal changes to train movements. Data supplied by the major German rail company, Deutsche Bahn, is used to test the methodology and the results suggest near optimal solutions can be found in reasonable time.

Since completing my PhD I have been working as a Post-Doctoral Research Fellow in the Operations Research section of the Department of Management Engineering at the Technical University of Denmark. This is the largest OR group in Scandinavia and has research interests that are very similar to that of DES.



Left to right: Dr Ziming Guan, Dr Richard Lusby, Dr Oliver Weide

Dr Oliver Weide

I completed my PhD of Engineering Science in February this year. In my thesis "Robust and Integrated Airling Scheduling" I considered the problems aircraft routing and crew pairing, allocating aircraft and crew to flights of a schedule in a minimal cost way. I developed a solution method that is capable of generating solutions that not only incur small costs but are also robust to typical stochastic variability in airline operations. My research was successfully implemented at Air New Zealand before I finished my degree.

I started to work for The Optima Corporation in May 2008. I work as a software developer and design mathematical optimisation models. Recently, I have been working on a Theatre Optimisation project seeking to optimally allocate surgeons and procedures to operating theatre sessions.

New Staff

Dr David Long

Originally from the United States, David Long graduated summa cum laude with his Bachelor Degree in Mechanical Engineering from Tennessee Technological University in Cookeville Tennessee in 1998. Subsequently, he enrolled at the University of Illinois at Urbana-Champaign to pursue his MS and PhD degrees in Mechanical Engineering. His PhD research focused on studying microvascular hemodynamics in microvessels in vivo.

Before joining the Department of Engineering Science and the Auckland Bioengineering Institute as a Lecturer in May, David was a Post-Doctoral Fellow in the Department of Biomedical Engineering at Duke University in Durham North Carolina studying cardiovascular mechanobiology with specific emphasis on the development of coronary atherosclerosis, a continued focus of his research. David is joined in New Zealand by his fiancée, Dr. Heidi Koschwanez, and both are looking forward to living and working in New Zealand.

Andrea Raith

Andrea Raith received a Bachelor of Science in Mathematics from the Technische Universität Darmstadt, Germany, in 2002 and the degree of Diplom Mathematikerin (MSc) in 2005. As part of her MSc, she wrote a thesis titled 'Bicriteria optimisation of synchronous generators for wind power plants' in collaboration with the Department of Electrical Engineering and Information Technology. After the completion of her thesis, she continued working at the department and developed an extension of the bicriteria optimisation method to the multi-objective case. This was used in consulting work for a major manufacturer of wind power plants.

Before her appointment as a Lecturer, Andrea came to Engineering Science as a PhD candidate, and is working on her thesis titled 'Multi-objective Transportation and Routing Problems' which she hopes to complete in the near future. Her main research interests are algorithms for bi- and multi-objective network optimisation problems such as the shortest path problem, network flow problems, and the transportation problem. Furthermore, Andrea currently applies bi-objective optimisation in the context of the so-called traffic assignment problem, which models the route choice of network users in traffic networks. These techniques can be applied to transportation planning, and especially when modelling the effects of road tolling.

Dr Andrew Taberner

Andrew Taberner received his PhD in Physics in 1999 from The University of Waikato where his thesis work focussed on applying finite- and boundary-element methods to loudspeaker cone design, in collaboration with a leading hi-fidelity loudspeaker manufacturer. Subsequently, he joined the Departments of Engineering Science and Physiology at the University of Auckland as a Post-Doctoral Fellow, spending 3 years developing instrumentation for conducting mechanical and calorimetric measurements on cardiac muscle.

In 2002, Dr Taberner was awarded a New Zealand Science and Technology Post-Doctoral Fellowship, allowing him to travel to Boston, USA, and develop microcalorimeter technology in the BioInstrumentation Laboratory of Professor Ian Hunter at Massachusetts Institute of Technology. After his Post-Doc, Dr Taberner continued in the BioInstrumentation Lab for a further three years as a Research Scientist playing a leading role in developing instrumentation for needle-free drug-delivery and high-throughput drug-discovery, before returning to work with the Auckland Bioengineering Institute in January 2008. He then rejoined this Department at the beginning of this year. His present research interests include the development of instrumentation for microcalorimetry, with applications in muscle thermodynamics measurements and in high-throughput drug discovery.

Featured Alumni / Staff – Rosalind Archer, class of '93

Since the last newsletter, the Dean of Engineering announced the 2008 winners of the Faculty's five major teaching awards. The quality of teaching in the Engineering Science program was recognised via two awards made to Rosalind Archer (a senior lecturer in the Department).

Rosalind received awards for "Sustained Excellence in Teaching" and the "Supreme Teaching Excellence Award". She has lectured for the past eight years at Stanford University, Texas A&M University and the University of Auckland. In addition to her University work, she has taught industrial short courses in nine overseas countries including Algeria, China, Russia and the USA.

At Part I (first year) level Rosalind teaches part of the computing course (ENGGEN 131) and sometimes teaches part of the first year mathematics course (ENGSCI 111).

Rosalind's specialist teaching is in the area of fluid mechanics and petroleum engineering. Two overseas universities - Montana Tech and the University of Adelaide - have also benefitted from Rosalind's lecturing in petroleum engineering via courses delivered in a compressed "block course" format and/or over the internet. The teaching awards also acknowledge teaching in the form of research supervision.

Rosalind communicates her enthusiasm for research to her final year project students with such success that 47% of her project students have gone on to postgraduate degrees at Auckland or overseas. Rosalind has supervised 18 students to the completion of their Masters or PhD degrees and is currently supervising a further four students.

Rosalind wishes to acknowledge that most courses in Engineering Science are team taught so credit for her teaching awards must be shared among many colleagues who are also very committed to teaching excellence.

Featured Alumni / Staff - Iain Anderson, Class of '81

I became fascinated with the sea as a teenager, snorkelling and diving in the cold waters of New Jersey. It was this love affair with the silent world that eventually brought me out to the Pacific. When I turned 18 I left home for Australia on a one-way ticket, determined to work or swim my way back. A year in Australia that included time in a Barrier Reef resort was followed by a year as a volunteer teacher at Queen Salote College, Nukualofa. My time in Nukualofa on a very meagre volunteer's stipend left me seriously short of funds. The best way forward was to fly to New Zealand and look for work. This is where all my plans came unstuck, for I fell in love with the place.

Years of underwater photography that included quite a few articles for Dive New Zealand have provided me with resources and many useful marine biologist contacts. Several years ago I set out to produce a book about New Zealand's upper ocean life: The Surface of the Sea. The book highlights the structure and function of upper ocean organisms from an engineering perspective, and covers topics such as mechanisms of swimming, buoyancy and the roles played by these creatures in the broader ecosystem.

My work on the book project has directly benefited my work as an academic. During research for this book I came across a creature that has inspired a PhD project within our Biomimetics Laboratory: the ctenophore or comb jelly. Comb jellies swim using coordinated actuation of rows of extra long cilia. A small research grant to develop a cilium-like actuator led to other things and eventually the formation of the Biomimetics Laboratory in the Auckland Bioengineering Institute. One of my PhD students is currently researching and fabricating artificial cilia arrays inspired by the control system of the comb jelly.

I am on a quest to find other sources of inspiration like this in the hope that one day there will be a seamless linkage between my diving and my job.

Teaching Update

Our third year design course opens the design space on swim fins:

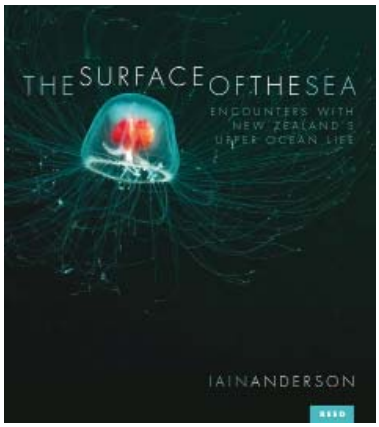
What is the common ground between ergonomics, solid mechanics and fluid mechanics? The answer is swim fins. Students enrolled for last years' Part III design paper ENGSCI 363 joined the ranks of Leonardo da Vinci and Benjamin Franklin as swim fin designers. Their design project involved them in considerations of hydrodynamic efficiency, structural rigidity, material strength and comfort. All students completed an initial report describing their own design that included some CAD modelling, structural analysis, and fluid dynamic calculations. But there was a twist to the challenge as the fin was to be fabricated in Perspex; a material that is rather stiffer than the softer polymers normally used. Thus, simply copying existing fin designs was out of the question. Realistic commercial fin stiffness data and material data for Perspex were obtained using the Department's Instron test facility. Students completed a second report that included a detailed finite element model of their design.

Designing goes hand in hand with building prototypes and also testing them. Students were formed into groups of 5 and each group designed a fin for prototyping. This enabled them to pool their ideas and work as a team. Their fins were fabricated within the Auckland Bioengineering Institute's new fast prototyping facility and tested in a flume at the Civil Engineering Department. Each design was, in turn, attached to a reciprocating mechanical virtual leg. Work input was calculated using a strain gauge device and thrust output was measured using a downstream fluid velocity probe. The day we spent in the lab was informative and fun for students as well as academics.

All the designs performed well and each had product potential. But when it came to efficiency we discovered that the fins that produced the biggest swept area performed best, something that nature already knows.

The course was designed by Dr Iain Anderson.

Department Lab Technician Michael Byrne with a flipper in the Civil Engineering flume



The Surface of the Sea

Finalist in the 2008 Montana NZ Book Awards, and not your usual Engineering Scientist's book.

Iain completed his BE (Engineering Science) in 1981 and his ME in 1983. He joined Fisher and Paykel's Laundry Division where he assisted in the development of the world's first electronic washing machine. In 1985 he left F&P to join the Department of Scientific and Industrial Research as a dynamics consultant. During the late 1980's Iain became involved in an orthopaedist's project to develop a shock-absorbing hip implant. In 2000, Iain returned to us as a Lecturer. He is currently a Senior Lecturer and leads the orthopaedic and artificial muscle group with 8 postgraduates in the field of Biomedical Engineering.

Research Update

This edition features the Nonlinear Signal Processing Group of Dr Charles Unsworth

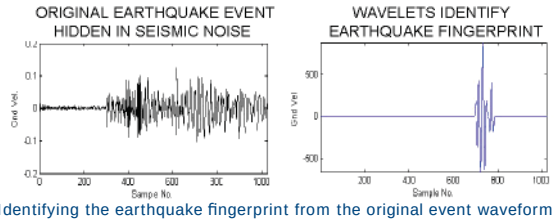
In the real world, we will encounter signals in the form of electromagnetic radiation such as radio waves which have applications in AM & FM radio and radar; microwaves with applications in mobile phones and military communications; and visible light with applications in optics and lasers. Vibrational signals also exist with applications in speech, acoustics, music and ultrasound. Two dimensional visual signals occur in television, video and camera images and three dimensional visual signals occur in holographic images. Furthermore, the 'Flow of Data' over time can be viewed as a signal - for example: the stock markets' financial time-series, heart signals from ECG monitors and brain signals from EEG monitors. Thus, signals pervade our world in many different guises. In order to understand such signals, one must develop techniques to describe complicated signals in simpler forms. The field of Nonlinear Signal Processing deals with highly irregular waveforms occurring in real world signals and data. It specialises in the development of techniques that can classify, manipulate, filter, synthesise and predict such highly irregular signals.

The Nonlinear Signal Processing Group specialises in the extraction/filtering of critical information, modelling of systems and prediction of system behaviour. They adapt the methodologies of nonlinear signal processing techniques such as Chaos Theory, Independent Component Analysis (ICA), Time-Frequency Analysis, Multi-resolution Wavelet Analysis, and Artificial Neural Networks (ANNs) to generate new hybrids to solve specific aspects of their research.

Team Leader Charles Unsworth's main research interest is in the synchronisation effects that occur in lattices of coupled neurons with particular emphasis on the abnormal synchrony that occurs in human epilepsy. The group had adapted the well-known Kuromoto coupled oscillator model to allow for the study of neuronal synchronisation. Such work demonstrated that theoretically the synchronisation was dependent on the architecture of the network, and was awarded the Neurological Foundation's Goddard Prize. The group has also adapted Artificial Neural Network lattice models and Chaotic Neural Network lattice models to describe epilepsy, which have again confi rmed theoretically that synchronisation is architecture dependent. Recently, Charles is embarking on the development of new computer models where the inference is derived directly from in vitro experiment of human neurons grown on silicon chip to come closer to understanding the neural circuitry of the human brain.

The team is also heavily involved in Multi-Channel Signal Analysis. Currently, Anita Walbran is identifying key biomarkers (visible on EEGs) that are responsible for hypoxic ischemia - a significant cause of brain damage in newborn infants. Once the key biomarkers are identified, it would be possible to detect them automatically within a critical seven hour window after birth, using the signal processing technique of time-frequency analysis to identify if a newborn infant is at risk. Such rapid detection would allow hypothermia head cooling treatment to be administered and brain damage to be circumvented.

Sepideh Rastin is working on the automatic detection of earthquake events in New Zealand (in collaboration with the Geological & Nuclear Science Division (GNS), Wellington). Currently it is very hard to identify the earthquake P & S phase fingerprint from recording stations due to excessive seismic noise. In addition, it is hard to distinguish earthquakes from non-earthquake events. By a novel application of multi-resolution wavelet analysis we have recently shown that it is possible to cut through the seismic noise floor and highlight the earthquake fingerprint. If successful, it is intended for the outcome of this work to be implemented in New Zealand's National Seismographic Network.



Identifying the earthquake fingerprint from the original event waveform

Previous work of the group includes the tracking human motion using ANN's to understand the human gait; NZ geothermal resource protection using wavelets to detect if the geothermal feature was becoming damaged as a result of energy extraction; development of new secure mobile communications using chaotic signal encryption; detecting osteoarthritis in the knee (with AUT); and detection of smell using ANN's (with Hort Research).

Dr Charles Unsworth
Senior Lecturer

Charles joined DES in 2002, and specialises in Nonlinear Signal Processing. He is a member of the Institution of Engineering & Technology (IET) and is a reviewer for several leading IET journals. He has also acted as a nonlinear signal processing consultant for several NZ companies.

Previously he was a Higher Scientific Officer of the Defence Evaluation Research Agency (DERA) Ministry of Defence UK, a Post-Doctoral Fellow at the University of Edinburgh in Radar Signal Processing and a Post-Doctoral Mobility Fellow at Edinburgh University collaborating with the Royal Hospital of Sick Children, Edinburgh in Biomedical Signal Processing.

He holds a BSc Hons in Mathematical Physics (University of Liverpool), an MSc in Astronomy (Royal Observatory, University of Edinburgh), and a PhD in Physics (University of St Andrews).

From the last edition

Results from Franz Edelman Award in Phoenix, Arizona
Hewlett Packard emerged the winner of the 2009 Franz Edelman Award, and the Norske Skog team including Professor Andy Philpott, and alumni Graeme Everett received finalist medals.

Backissues

Available at
www.esc.auckland.ac.nz/Alumni

For future editions

Do you have news to share?
News on current Department members is easy to include, because they're right here. News on wider family members - alumni and former staff - doesn't necessarily reach us. If you have something to share, email it to: desnewsletter@auckland.ac.nz