List of Potential PhD Projects at UNSW@ADFA

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SCHOOL OF BUSINESS

http://bus.unsw.adfa.edu.au/index.html

ECONOMICS OF DEVELOPMENT

Project:	***Addressing state fragility***
Program Code:	*1541*
Supervisor:	*Prof Satish Chand (s.chand@adfa.edu.au)*
Co-Supervisor	*Prof Michael Hess (m.hess@adfa.edu.au)*

Aim: Investigate the nexus between defence and economic development.

Objectives:

(i) How does economic development affect security in hostile environment?
(ii) What are the means to reducing state fragility?
(iii) What are the mechanisms via which economic development affect peace?

Description of work:
Development is difficult in dangerous places. And achieving security in places lacking development is equally problematic. This research project investigates the nexus between defence and development.

There are strong theoretical reasons to believe that the level of security to person and property determine the level of effort and investments in any location. This in turn determines the level of income, employment, and levels of welfare in the general population.

The School of Business @ADFA has initiated a large research project aimed at exploring the defence-development nexus. In particular, this research explores the use of development as the means to achieving long-term security in fragile states.

The project has secured seed funding from the Asia-Pacific Civil Military Centre of Excellence to study the contributions of host communities to sustaining peace in post-conflict Bougainville. A PhD scholar has been recruited from Papua New Guinea to assist with this research.

It is envisaged that the country coverage of this work will, subject to funding and availability of research personnel, be extended to Afghanistan, Fiji, East Timor, Indonesia, Pakistan, Solomon Islands, Sri Lanka, and Vietnam. Doctoral students and post-doctoral fellows will form the core of this project. A student has been recruited to work on this issue in Pakistan.

Method:
The PhD scholars will first review the rapidly evolving literature on the relationship between defence and development. A mix of qualitative and quantitative data will then be collected to establish the causal links between the level of security and income generation in post-conflict states and the contributions of the above to reducing state fragility. Ideally, we would like the scholar to investigate these linkages at the level of individual households and firms in their home countries.

ADFA has large group of alumni who either are or have participated in peacekeeping missions abroad. The project will collect data from these personnel. This will be done via: (i) candidature of former peacekeepers turned scholars; and, (ii) through formal interviews of the others as part of the data gathering exercise.

The research methodology to be employed will include the conduct of purpose designed surveys, focus group discussions, and use of secondary sources for economy wide information. Much of the methodology for this research is being tested and its refinement

will be part of ongoing research.

Pre-requisites:
We expect the prospective student(s) to have some familiarity with basic statistics and undergraduate level economics. However, no prior knowledge of econometrics is assumed. The student will spend one semester doing post-graduate level coursework in quantitative research techniques within the School of Business. During this time, the student will also review the literature and refine his/her research question.

The student will spend a semester collecting data in the field. Analysis of the collected data and thesis writing will extend over the remaining two years.

Supervisory support:
Professors Chand and Hess will provide joint supervision.

Research on how best to address fragility is both timely and is of policy relevance. And ADFA provides the platform to conduct this research while the School of Business lends the tools for the conduct of this research.

Project:	***Land tenure and productivity***
Program Code:	*1541*
Supervisor:	*Prof Satish Chand (s.chand@adfa.edu.au)*
Co-Supervisor	*Dr Charles Yala (c.yala@adfa.edu.au)*

Objectives:
This project assesses the impact of land tenure system on the level of investments and productivity at the level of an enterprise.

Description of work:
There are strong theoretical reasons to believe that security of property rights to land will impact on the level of effort and investments expanded by an entrepreneur. This proposition is expected to hold across market and mixed economies.

The School of Business @ADFA has a large research project aimed at exploring the impact of the various land tenure regimes on productivity. The empirical analysis done to date has drawn on data from the smallholder oil palm sector in Papua New Guinea.

The project has collected data to test the impact of land reform on investment in housing at the level of the household. Purpose designed surveys have been conducted for this purpose in Port Moresby and Suva.

China recently embarked upon an ambitious land tenure reform project. There are compelling reasons to believe that these reforms will impact on domestic investment and thus the rate of economic growth. The Chinese experimentation provides fertile grounds to test the link, if any, between land tenure and productivity. This work can be undertaken both at the level of the individual farms and that at the level of households.

Method:
The PhD scholar will examine the impact of changes to land tenure regime on the levels of investment and productivity within PRC. Ideally, we would like one scholar to investigate the linkage at the level of individual farms while the other student will examine the same issue for settler housing.

The research methodology to be employed will include the conduct of a purpose designed surveys to collect the primary data for subsequent analysis. The collected data will be analysed using econometric techniques. Much of the methodology for this research has been tested and is being refined as part of an ongoing research within the School of Business at UNSW@ADFA.

Pre-requisites:
We expect the prospective student(s) to have some familiarity with basic statistics and undergraduate level economics. However, no prior knowledge of econometrics is assumed. The student will spend one semester doing post-graduate level coursework in quantitative research techniques within the School of Business. During this time, the student will also review the literature and refine his/her research question.
The student will spend a semester collecting data in the field. Analysis of the collected data and thesis writing will extend over the remaining two years.

Supervisory support:
Professor Satish Chand will provide primary supervision. Dr Charles Yala will be the co-supervisor.
Professor Chand and Dr Yala have a large externally funded research project to investigate the impact of land tenure reform on productivity within the Pacific islands. They are in the process of extending this project into Asia.
The Peoples' Republic of China is an excellent case study for several reasons including the following three: (i) land reforms are being experimented within several parts of the nation; (ii) macroeconomic data is available for this analysis; and (iii) there is a sufficiently large number of households and enterprises affected by ongoing reforms to land tenure. The last allows for serious econometric analysis of the impact of land tenure reforms on productivity..

FINANCE AND ACCOUNTING

Project:	***Comparative study of international approaches to prevent money laundering***
Program Code:	*1541*
Supervisor:	*Dr Frances Miley (f.miley@adfa.edu.au)*
Co-Supervisor	*Dr G. Manger (g.manger@adfa.edu.au)*

Objectives:
To provide a deeper understanding of the approaches to combat money being laundered for terrorist activities, so that governments may be able to select approaches that are most likely to maximise success in this area.

Description of Work:
There is a concerted effort worldwide to ensure that laundered money is not used to fund terrorist activities. Different countries have taken different approaches to this issue. This study would compare the approaches taken by China and Australia to prevent money laundering, and would consider whether cultural differences are relevant to the choices made. It would provide advice on successful and unsuccessful approaches made elsewhere and, in doing so, consider the strengths and weaknesses of the Chinese and Australian approaches. Although there has been considerable research on possible ways to detect or prevent money laundering, there has been little research on the success or failure of the methods that are currently in use.

Although Australia and China have been proposed, it is possible to substitute other countries or to expand the study to more countries.

Project:	***How users interpret financial information***
Program Code:	*1541*
Supervisor:	*Dr Frances Miley (f.miley@adfa.edu.au)*
Co-Supervisor	*Dr A. Griffin (a.griffin@adfa.edu.au)* *L.Grigg (l.grigg@adfa.edu.au)*

Objectives:
To provide a deeper understanding of how users of financial information use and interpret that information. Users may include sophisticated and unsophisticated users such as accounting students, accounting practitioners, investors and creditors. This project provides an opportunity for cross-cultural comparative work and field work. It has important ramifications for accounting standard setting and the presentation of financial statements. In education, it has important ramifications for understanding how students interpret and analyse financial information, which is critical when developing teaching strategies and assessing the effectiveness of teaching.

Description of Work:
Previous research in accounting about user behaviour has relied primarily on user assessment of their own ability to interpret data. This is flawed because it assumes that users are able to identify and comment on their own thought processes and their observations. This research uses scientific equipment to obtain observable independently verifiable data that can be matched against user perceptions of their own analytical processes. Doctoral students involved in this project would be undertaking a literature search. They would be trained in using the equipment and would be conducting user tests of financial interpretation. They would be involved in the analysis of data and formulating the implications for accounting disclosure. This project has potential for cross-cultural work in addition to Australian based research. It would be of interest to students who would like to undertake research into financial accounting, accounting disclosure, international accounting or accounting education.

Project:	***Accounting for environmental risk and hazards***
Program Code:	*1541*
Supervisor:	*Dr Frances Miley (f.miley@adfa.edu.au)*
Co-Supervisor	*Dr A. Griffin (a.griffin@adfa.edu.au)*

Objectives:
To develop a comprehensive platform to account for environmental issues and environmental hazards, that can be used internationally.

Description of Work:
There is growing awareness of environmental issues in society. In business, there is also a growing appreciation of the importance of a risk based management approach to dealing with potential environmental hazards. This research would involve investigating previous attempts at environmental accounting and the reasons that these attempts have been unsuccessful. Using case studies of environmental hazards, the researcher(s) will be developing accounting disclosure principles and practices, auditing guidelines and examining the implications of environmental accounting for international standard setting. There are opportunities for Australian based or international case studies, and for cross-cultural research.

SPORTS POLICY AND MANAGEMENT

Project:	***Managing Scandal in Sport***
Program Code:	*1541*
Supervisor:	*Dr Jason Mazanov (j.mazanov@adfa.edu.au) and Dr James Connor*

Objectives:
To explain the impact scandal has on sport.

Description of Work:
It is assumed that scandal has a detrimental effect on sport. However, in 2009 the National Rugby League had its most "scandalous" season and yet also recorded its highest audiences. Despite ongoing doping scandals, major sporting events like the Olympics and Tour de France continue to grow in popularity. This project seeks to explore sociological explanations of scandal in sport and their implications for sports management and policy.

Project:	***What Price Anti-Doping?***
Program Code:	*1541*
Supervisor:	*Dr Jason Mazanov (j.mazanov@adfa.edu.au), Dr Twan Huybers and Dr James Connor*

Objectives:
To model the impact of drugs and doping on the economic viability of sport.

Description of Work:
The essential question underlying this project is whether the anti-doping effort is worth the public and private funds that are invested into it. It is assumed that ongoing drug scandals will diminish the social and commercial value of sport. There is limited evidence this is the case, with professional cycling being the only sport reported to have suffered from drug scandals. This project examines the impact of scandals by assembling a data set of the financial position of sports around drug events.

Project:	***Marketing of Doping and Anti-Doping***
Program Code:	*1541*
Supervisor:	*Dr Jason Mazano (j.mazanov@adfa.edu.au), and Dr James Connor*

Objectives:
To explore how people understand the role of doping and anti-doping in sport .

Description of Work:
The role of drugs in sport is highly contested, with people often holding conflicting views. Part of the issue appears to be that people have an unsophisticated view of doping and anti-doping, including their understanding of how the administrative apparatus used to enact the World Anti-Doping Code influence athletes' human rights. This project seeks to use a combination of sociological, psychological and marketing approaches to understand how messages of doping and anti-doping are interpreted and understood by the general public.

LEADERSHIP

Project:	***A cross comparative study of the challenges of undertaking followership and leadership roles***
Program Code:	*1541*
Supervisor:	*Dr. James Warn (j.warn@adfa.edu.au)*

Objectives:
The aim of the research is to investigate the cultural and generational influences on the assimilation of Chinese immigrants into followership and leadership roles in Australian organisations.

Description of Work:
The project consists of a comparative study between overseas born Chinese, locally born Chinese and locally born Australians without any overseas cultural identification. Strong experience of Chinese cultural traditions is expected to influence attitudes towards social relationships, acceptance of authority and contentment through acceptance of one's social situation. These specific cultural influences are expected to be moderated by the countervailing influences of instant communication and mass media which enhance a global awareness of a cosmopolitan citizen. The project will identify the challenges by the three study groups in undertaking followership and leadership roles and attempt to identify the impact of specific cultural factors. The study will inform a better understanding of immigrant groups facing aspects of modernisation as a key factor in their assimilation into a host country..

SCHOOL OF ENGINEERING AND INFORMATION TECHNOLOGY

http://seit.unsw.adfa.edu.au/

Aerospace, Civil and Mechanical Engineering

ACOUSTICS & VIBRATION

Project:	***Adaptive modal superposition mirror***
Program Code:	*1661*
Supervisor:	*Dr Andrew Lambert (a.lambert@adfa.edu.au)*
Co-Supervisor	*Dr Murat Tahtali (m.tahtali@adfa.edu.au)*

Objectives:
Traditional adaptive optics (AO) deformable mirrors use segmented actuator patterns requiring elaborate manufacturing techniques. The range of surface curvatures used for corrective action can be described by Zernike polynomials, which are a sequence of orthogonal polynomials on the unit circle. The vibration modes of a circular membrane exhibit striking similarities to Zernike polynomials; it fact, they can be all expressed as functions of Bessel functions. This leads to the possibility of using a vibrating membrane mirror in adaptive optics. The objective of this project is to design, manufacture and test a modeshape mirror capable of reproducing the essential Zernike polynomials to be used in adaptive optics.

Description of Work:
This project involves design and conduct of laser experiments, high levels of signal processing and analysis techniques as well as possible numerical modelling.

CIVIL ENGINEERING

Project:	***Characterisation of Self Compacting High Performance Concrete***
Program Code:	*1631*
Supervisor:	*Dr Obada Kayali (o.kayali@adfa.edu.au)* *Prof Evgeny Morozov (e.morozov@adfa.edu.au)*

Objectives:
Self Compacting Concrete (SCC) is the way for the future of concrete technology. The necessity of using highly efficient superplasticisers and viscosity modifying agents means that it is highly probable that such sophisticated polymers may affect the processes of hydration, setting, and almost all of the mechanical and durability characteristics of the hardened concrete. The objective of this project is to conduct micro and nano-analysis on SCC and analyse the effects of the characteristics that SCC possesses on its long term mechanical and durability properties

Description of Work:
- Production of SCC using the state of the art methods.
- Conducting a micro/nano study using SEM, XRD and Spectrotomography.
- Analysis of microstructural results and relating them to macrostructural mechanical and durability characteristics.

Project:	***Creep and Shrinkage of Lightweight High Performance Concrete***
Program Code:	*1631*
Supervisor:	*Dr Obada Kayali (o.kayali@adfa.edu.au)* *Prof Evgeny Morozov (e.morozov@adfa.edu.au)*

Objectives:
High performance lightweight concrete has been produced in Australia and China based on an invention by Dr Kayali, the Supervisor of this research. The new concrete is an environmentally sustainable material due to many benefits that range from using waste products, to reducing cement use and increasing the durability of structures. The concrete science and industry must be supplied with evidence of systematic scientific study that shows and analyse the characteristics of this concrete on long term structural performance. High on the list of main structural performance properties are shrinkage and creep. These two characteristics make essential differences when designing prestressed, post-tensioned and high strength concrete structures.

Description of Work:

- Produce lightweight high performance concrete.
- Study the creep characteristics
- Study the shrinkage characteristics.
- Analyse the properties on both the microstructural and the macrostructural scales

Project:	***Drop-weight impact behaviour of a new high performance hybrid-fiber reinforced concrete panel***
Program Code:	*1631*
Supervisor:	*Chief Supervisor:* *Dr. Y.X. (Sarah) Zhang (y.zhang@adfa.edu.au)* *Co/joint supervisor:* *Dr. Krishna Shankar (k.shankar@adfa.edu.au)*
Co-Supervisor	*SCUT/TU*

Objectives:
Hybrid-fibre reinforced high performance concretes containing a mix of cement, fly ash, sand, water, adhesive chemical with randomly distributed short fibre exhibit significantly improved mechanical properties such as excellent tensile properties with large pseudo strain-hardening ability, excellent capacities of resisting microcracking, high energy absorption and impact resistance, and thus have been regarded as promising engineering materials especially for protective and defence structures. Ongoing research in Dr. Zhang's research group has been conducted to develop a new hybrid-fibre concrete mix with randomly distributed short steel fibres and PVA fibres and investigate the material properties of the new concrete panels and the their impact behaviour under high velocity projectile strike. The research has demonstrated the excellent mechanical behaviour and capability of impact resistance of the new concrete mix and structures.

In this research, low speed drop weight impact behaviour of the new concrete panels made of the same mix will be investigated experimentally and numerically. The commercial Finite element analysis software LS-DYNA will be used to simulate the impact process of the panel under drop weight. The results from the lab experimental will be used to compare and validate those from the numerical modelling.

Project:	***Mechanical behaviour of a new high performance hybrid-fiber reinforced concrete mix***
Program Code:	*1631*
Supervisor:	*Chief Supervisor:* *Dr. Y.X. (Sarah) Zhang (y.zhang@adfa.edu.au)* *Co-supervisor:* *Dr. C.H.(Richard) Yang (chunhui.yang@deakin.edu.au)*
Co-Supervisor	*SCUT*

Objectives:
Hybrid-fibre reinforced high performance concretes containing a mix of cement, fly ash, sand, water, adhesive chemical with randomly distributed short fibre exhibit significantly improved mechanical properties such as excellent tensile properties with high strength, large pseudo strain-hardening ability, excellent capacities of resisting microcracking, and etc. and thus have been regarded as promising engineering materials especially for protective structures.
Ongoing research in Dr. Zhang's research group has been conducted to develop a new hybrid-fibre concrete mix with randomly distributed short steel fibres and PVA fibres and investigate the material properties of the new concrete mix under both static and dynamic loading experimentally.
In this research, the material properties and mechanical behaviour of the new material under static and dynamic loading will be investigated analytically or numerically. Micromechanics method maybe used in the analyses. The experimental results will be used to validate the results obtained from this research.

Project:	***Optimization of Self Compacting High Performance Concrete***
Program Code:	*1631*
Supervisor:	*Dr Obada Kayali (o.kayali@adfa.edu.au)* *Prof Evgeny Morozov (e.morozov@adfa.edu.au)*

Objectives:
With Self Compacting Concrete (SCC) becoming the dominant method of concrete production, it is necessary to be able to obtain optimum mix designs. The optimisation will take into consideration the environmental necessity to reduce cement use, using waste materials, reducing energy consumption, reducing overall cost, increasing ease of production and placing, reducing short term shrinkage and cracking problems and designing for long term durability and sustainability.

Description of Work:
- Study and analyse the rationale that underlies the different design procedures used in SCC.
- Theorise models that will take into consideration the objectives of the research.
- Design a large number of different mixes based on the models in step 2 above.
- Test and analyse the results.

COMPOSITE MATERIALS & STRUCTURES

Project:	***Application of Advanced Composites for Construction of Offshore Structures***
Program Code:	*1661*
Supervisor:	*Dr Krishna Shankar, (k.shankar@adfa.edu.au)*

Objectives:
Polymer matrix composites made reinforced with carbon and glass fibers are extensively used in aerospace and automotive applications due to their high strength, high stiffness, low weight and ease of manufacture. GFRP is also extensively used for building high speed boats and yachts. Advanced composites are also employed for repair of metallic structures to restore their load carrying capability. Another advantage fiber reinforced composites offer over metallic materials for marine structures is their resistance to corrosion, although protection against moisture absorption may have to be implemented, especially for glass reinforced polymers. The objective of proposed research is to undertake a study involving design, manufacture and analysis of structural components of offshore oil platforms, with a view to identifying and quantifying the possible benefits of replacing existing metallic components with advanced composite materials.

Description of Work:
Conduct a survey of present state of art in application of composites in offshore engineering;

- Select candidates from load carrying components on a typical offshore platform, for possible replacement with advanced composites and identify the design loads;
- Identify candidate advanced composite materials which can be used for offshore applications;
- Conduct finite element modelling of the selected component with fiber reinforced composite materials using a metallic model as benchmark for comparison
- Conduct structural tests in the laboratory with scaled down or simplified components for validation of the numerical simulation
- Perform a feasibility study including manufacturing options and perform a cost benefit analysis over the life cycle of the component.

Project:	***Ballistic Resistance of Laminated Plastics***
Program Code:	*1661*
Supervisor:	*Dr Krishna Shankar (k.shankar@adfa.edu.au)*

Objectives:
Laminated plastics are the preferred material for the construction of transparent ballistic armour and impact resistant structures such as bullet proof windows, windshields and aircraft canopy. They are preferred over conventional and reinforced glass because of their relatively low density and higher toughness. Some polymeric materials have even greater transparency than glass. Further plastics are easier to manufacture in different geometric shapes and as multiple laminates to suit the application. Previous experimental studies have shown that hybrid plastic laminates containing layers of plastics with different properties, are more impact resistant and offer greater protection against bullets than monolithic laminates. The objective of the proposed project is to study the impact behaviour and ballistic resistance of hybrid plastic laminates numerically, by finite element modelling, and experimentally.

Description of Work:
- Conduct a survey of present state of art in impact resistant and transparent ballistic armour
- Develop an appropriate finite element model in LS-Dyna for simulating the dynamic behaviour of hybrid laminates under impact loading including the non-linear material behaviour and post failure response
- Construct laminates using combinations of selected plastics with different mechanical properties and test them in the laboratory under impact loading
- Compare experimental and numerical results to check the accuracy of the numerical model
- Conduct a parametric study of selected laminate configurations to optimize the ballistic performance of the hybrid laminate

Project:	***Design Optimisation of Composite Structures***
Program Code:	*1661/1663*
Supervisor:	*Prof Evgeny Morozov (e.morozov@adfa.edu.au)*

Objectives:
The project is concerned with the development of design optimisation procedures formulated for composite materials, thin-walled and sandwich structures, hybrid metal-composite structural components with applications in aerospace, marine, offshore, shipbuilding and other industries. The relevant modelling approaches and optimisation techniques are to be developed and implemented.

Description of Work:
- Development of mechanical and numerical models
- Model implementation into the FE code
- Structural design and analysis
- Development of the theoretical and specialised numerical optimisation techniques
- Sensitivity analysis of the composite components-demonstrators

• Material characterisation and prototype testing

Project:	***Green bricks – building a better way***
Program Code:	*1631*
Supervisor:	*Dr Obada Kayali (o.kayali@adfa.edu.au)* *Dr Andrew Neely (a.neely@adfa.edu.au)*

Objectives:
A novel building material which uses the waste fly-ash from coal-fired power stations to make bricks has been developed and is currently undergoing production start-up in a dedicated factory in China. This project will firstly establish the cradle to grave energy requirements for the manufacture of these bricks using established analytical techniques. This work is required to help establish the "green" credentials of these novel building products. This project will also establish an experimental method to measure the thermal properties of the range of bricks produced using fly-ash. It is anticipated that numerical modelling of the thermal behaviour of the bricks could also be performed using FEM. This work will lead to recommended recipes to optimise the thermal properties of the bricks both via composition and via geometry.

Description of Work:
Identify the main components of the manufacturing process and use the literature to establish approximate energy budgets for each process.

- Set up a computational model to calculate the overall energy budget for a range of parameters.
- Design and perform experiments to measure the thermal conductivity and heat capacitance of the bricks at a range of humidity levels.
- Determine the dependence of these thermal properties on the brick constituents.
- Vary the geometry of the bricks to optimise the thermal performance .

Project:	***Integrated metal-composite joint design for the filament wound transmission shafts***
Program Code:	*1661*
Supervisor:	*Prof Evgeny Morozov (e.morozov@adfa.edu.au)* *Mr Alan Fien (a.fien@adfa.edu.au)*

Objectives:
Adhesive bonding of high-loaded composite transmission shafts does not provide sufficient strength and stiffness. In order to create a highly rigid and efficient joint, it is necessary to search for fundamentally novel design and engineering solutions. The fastening should be designed in the way that the torque is transmitted from the metal fitting to the filament wound shaft through the reinforcing material, rather than a layer of the binder. This could be achieved by integrating the metal fitting into the composite material during the formation of the joint.

Description of Work:

- Develop novel design solution for metal-composite joint with integrated metal fitting, using CAD technology
- Perform finite-element parametric analysis and design optimisation
- Prototype design and manufacture
- Prototype testing

Project:	***Long term durability of hybrid FRP-Concrete beams***
Program Code:	*1631*
Supervisor:	*Dr Amar Khennane (a.khennane@adfa.edu.au)*

Objectives:
Composite materials, particularly fibre-reinforced polymers (FRP) are increasingly being used in infrastructure applications. However, there remain concerns regarding their long-term

performance under load for civil engineering applications. Understanding the mechanisms of composite failure under load is an important issue for structural design. In particular, it is useful to have a theory capable of assessing how the environment and details of the constituents and microstructure affect the resulting composite material behaviour. The objective of this work is to assess the long term behaviour a hybrid beam (FRP-Concrete) for infrastructure and to develop through life estimation methods

Project:	***Modelling and characterisation of the fibre reinforced reactive powder concrete***
Program Code:	*1661*
Supervisor:	*Prof Evgeny Morozov (e.morozov@adfa.edu.au)* *Dr Obada Kayali (o.kayali@adfa.edu.au)*

Objectives:
The project is concerned with the experimental material characterisation and micro-mechanical modelling of the reactive powder concrete reinforced with randomly oriented short fibres. The modelling will involve identification of the input parameters and development of the relevant testing procedures of the material characterisation. The model validation will be performed by comparison of the theoretical/numerical predictions and experimental results obtained for the structural components – demonstrators

Description of Work:

- Development of micro-mechanical (FE) model for the reactive powder
- concrete reinforced with randomly oriented short fibres
- Specimens design, manufacture and testing
- FE analysis of the structural components - demonstrators (beams)
- Demonstrator manufacture and testing
- Model validation

Project:	***Production of High Performance Fibre Reinforced Geopolymer Lightweight Aggregate Concrete***
Program Code:	*1631*
Supervisor:	*Dr Obada Kayali (o.kayali@adfa.edu.au)* *Prof Evgeny Morozov (e.morozov@adfa.edu.au)*

Objectives:
With the emphasis on sustainability of building activities, the geopolymers have regained interest from the industry. Dr Kayali, the supervisor of this research, has patented a new unique lightweight aggregate that posses superior qualities and is made from fly ash. The combination of geopolymers and the new lightweight aggregates to produce high quality structural concrete is technically a very promising objective. More importantly this combination is an environmentally important and responsible objective as it lies at the core of sustainability of concrete materials and production.

Description of Work:
Fully understand the geopolymers and the method of their manufacture within ease and cost efficiency.

Arrive at an easy to produce mix design using geopolymers instead of cement, together with fibre reinforcement and the newly produced lightweight aggregates.
Test and analyse the results in view of the microstructural and mechanical properties whether characteristic or required of such material

Project:	***Progressive damage modelling and crash simulation for laminated composite structures***
Program Code:	*1661*
Supervisor:	*Prof Evgeny Morozov (e.morozov@adfa.edu.au)* *Dr Krishna Shankar (k.shankar@adfa.edu.au)*

Objectives:
The project is concerned with the development of a modelling approach to the simulation of the dynamic response of thin-walled composite structural components subjected to crushing loads. The progressive damage model should be developed and implemented into a FE code using a material characterisation process that is based on the material's experimentally recorded behaviour. The material characterisation involves impact testing of the composite specimens. The performance of the implemented models will be evaluated by comparison of the results of numerical modelling and experimental data obtained from the dynamic testing of composite laminated structural components.

Description of Work:

- Development of numerical progressive damage model
- Model implementation into the FE code
- Specimens design, manufacture and impact testing
- FE analysis of the laminated components-demonstrators
- Demonstrator manufacture and testing
- Model validation

Project:	***Radio Frequency Health Monitoring of Composite Structures***
Program Code:	*1661*
Supervisor:	*Dr Murat Tahtali (m.tahtali@adfa.edu.au)*
Co-Supervisor	*Dr Krishna Shankar, (k.shankar@adfa.edu.au)*

Objectives:
The objective of this thesis is to investigate and develop a Radio Frequency (RF) method to monitor internal stresses in composite structures. The premise behind the method is that a conductive fibre will reflect an incident RF wave and that the frequency of the reflected wave will be modulated as a function of the strain induced in the conductive fibre due to the stress in the surrounding composite matrix.

Project:	***Structural Health Monitoring of Composites using Vibration Measurements***
Program Code:	*1661*
Supervisor:	*Dr Krishna Shankar (k.shankar@adfa.edu.au)*

Objectives:
The principle behind damage detection using vibration measurements is that degradation due to damage in a structure changes its vibration parameters, namely, natural frequencies, mode shapes and damping characteristics. Any one of these vibration parameters, or a combination can be used to identify the presence of damage and to assess its location and size. Previous research in the school has successfully demonstrated that measurement of changes in frequencies can be used to locate and assess the size of cracks in metallic structures, such as beams and plates. Studies on use of damping characteristics for damage identification have not been so conclusive. The objective of the proposed project is to extend the use of vibration measurements to identify and assess damage in fiber reinforced laminated composites. Damage in composite laminates is usually in the form of delaminations which may not be visible externally but can reduce the structural integrity considerably. Hence the project is aimed at developing vibration measurements as a Structural Health Monitoring (SHM) to identify and assess delamination damage in laminated composites.

Description of Work:

- Conduct a literature survey of application of vibration methods for structural health

monitoring

- Manufacture composite specimens with and without simulated delaminations in the laboratory
- Conduct vibration tests to determine dynamic properties such as natural frequencies and damping characteristics of the composite specimens with and without damage
- Conduct dynamic finite element analysis on composite laminates with and without simulated damage to determine their vibration characteristics.
- Identify the relationship between damage parameters such as damage location, depth, delamination Discipline, etc and changes in vibration characteristics such as reduction in frequencies, increase in damping etc using the experimental and numerical data
- Develop a theoretical model to relate the changes in vibration parameters to the damage parameters causing them
- • Develop an algorithm to solve the reverse problem, i.e., to determine the presence of damage, identify its location and size from measured changes in frequencies or damping characteristics

COMPUTATIONAL FLUID MECHANICS

Project:	***Aeromechanical modelling of hot jet engine components***
Program Code:	*1661*
Supervisor:	*Dr Andrew Neely (a.neely@adfa.edu.au)*
Co-Supervisor	*Dr John Young (j.young@adfa.edu.au)*

Objectives:
Gas turbine engine components are subject to both low and high cycle fatigue loads during operation. To improve engine reliability, durability, and maintainability through improved engine structural integrity it is necessary to understand the interaction of high-cycle and low cycle fatigue in these components. Existing research is already underway at UNSW@ADFA to investigate fatigue interaction in the fan section of aero engines.
This project will extend the work into the turbine section of the engine where the addition of thermal loading becomes the major contributor to the fatigue life of the rotating components. The work will be numerically based through a combination of computational fluid dynamics (CFD) and finite element modelling (FEM) analysis to investigate the fluid structure interaction in the turbine section.

Description of Work:

- Develop CFD and FEM models of the rotating turbine blades.
- Apply high-cycle (aerodynamic, vibration) and low-cycle (rotational and thermal stresses) fatigue loads on the component.
- Incorporate fluid-structure interaction into the numerical modelling.
- Predict stress and strain histories during engine operation.
- Investigate the interaction of these loads with internal and external cooling geometries in the turbine blades.

Project:	***Numerical modelling of Brain Cooling***
Program Code:	*1661*
Supervisor:	*Dr Andrew Neely, ACME UNSW@ADFA, Assoc Prof Christian Lueck, Canberra Hospital* *Email: a.neely@adfa.edu.au*
Co-Supervisor	*SCUT*

Objectives:
Therapeutic hypothermia is a method of treatment being trialled for use in ischaemic stroke patients. In this treatment the brain is deliberately cooled in an attempt to slow the death of brain tissue downstream of a blood clot to buy the doctors time to remove the clot. A number

of methods of cooling the brain have been investigated by various researchers including cooling of the scalp, cooling of the cerebral spinal fluid and cooling of the blood supply to the brain. This PhD project will use numerical engineering tools (FEM) to model the heat transfer in the brain and assess the performance of these different brain-cooling methods.
The project will be performed in collaboration with an ongoing clinically based research project which is assessing the performance of a blood cooling scheme for inducing therapeutic hypothermia. The numerical project will use measurements obtained from the clinical work to validate the simulations. The work will be performed in collaboration with staff from Canberra Hospital.

Description of Work:

- Model the thermal regulation process in the brain.
- Conduct detailed transient FEM simulations of brain cooling via the different cooling strategies.
- In collaboration with clinical specialists, blood-cooling strategies will be modelled and validated
- Some experimental support for the clinical work may be needed to measure temperature distributions using infrared thermography during clinical MRI scans

FLOW VISUALISATION

Project:	***Image Processing of Axi-symmetric Interferograms for Flow Field Visualisation***
Program Code:	*1661*
Supervisor:	*A/Prof Harald Kleine (h.kleine@adfa.edu.au)*
Co-Supervisor	*Dr Murat Tahtali (m.tahtali@adfa.edu.au)*

Background:
One of the ongoing projects in this group is the investigation of axisymmetric compressible flows that are established when a shock wave exits an open shock tube. This rather simple scenario generates a large number of secondary waves and flow features, and the details of this process are not fully clarified. We have conducted a number of studies to investigate this flow pattern, and one of the test campaigns has yielded a large number of time-resolved interferometric visualisation results such as the ones shown below. One important task that to-date has not been tackled is to evaluate the obtained results to extract information on the density distribution in this flow. This information is crucial for a comparison with other experimental data and the results of numerical simulation.

Objectives:
High-speed interferograms of an axi-symmetrical flow field are used to visualise its expansion. Without unwrapping the fringe patterns, the analysis remains mainly qualitative. However, a technique called the Abel transform, similar to tomography, can be used to unwrap the fringe patterns and obtain pressure gradients. The project described here has the aim of developing a computational tool that can reconstruct an axisymmetric density distribution from interferograms of high-speed flows. These interferograms are provided as time-resolved records, which can then be used to determine how the density field develops in space and time.

Description of work:
It is expected that this project will deliver a fast and efficient algorithm that allows one to determine the density distribution in a transient, axisymmetric flow field recorded in sequences of line-of-sight interferometric visualisations. The principal techniques for image acquisition are well established and a large amount of expertise and high-class equipment for this purpose is available in the School. There already exists a large amount of image data that is suitable for the proposed analysis. Image registration algorithms that have been developed in the School for atmospheric imaging can be adapted and expanded to this application.

Project:	***Reconstruction of three-dimensional flow patterns from line-of sight visualisations***
Program Code:	*1661*
Supervisor:	*A/Prof Harald Kleine (h.kleine@adfa.edu.au)*
Co-Supervisor	*Dr Murat Tahtali (m.tahtali@adfa.edu.au)*

Background:
Density-sensitive flow visualisation techniques such as shadowgraphy, schlieren or interferometry have a so-called line-of sight character. This poses serious problems when the flow field is three-dimensional, as the visualisation record can only provide a projected view of the flow which will not reveal how the flow changes along the line of sight. A possible solution is to apply a tomographic approach, where several projected views, each taken from a different view angle, are combined to reconstruct the flow field in all its spatial dimensions. An example of such visualisations is given below. One piece of information that is very important for the design of vehicles travelling at supersonic speeds is the knowledge of the exact shape of shock fronts, contact surfaces and expansion zones. This information can be extracted from the aforementioned tomographic views.

Objectives:
The quantitative analysis of three-dimensional compressible flows remains one of the major challenges in fluid mechanics, and only few and specialised attempts have been made to tackle this problem. Typical visualisations of such flows have a line-of-sight character, that is, they integrate all information of the flow along the depth of the flow field. It is the aim of this project to develop robust and efficient algorithms that can be used to extract the spatial distribution of the flow field from adequate visualisations, with special emphasis on sequences of images obtained from time-resolved recordings. The high number of such image records – typically more than 100 in a single experiment – poses a particular challenge as the algorithm for image processing has to be highly efficient and fast. The final goal of the project is to create a tool that allows one to reconstruct how three-dimensional features observed in a high-speed compressible flow evolve with time.

Description of work:
It is expected that this project will deliver a fast and efficient algorithm that allows one to reconstruct a three-dimensional, transient flow field from a sequence of line-of-sight visualisations, obtained with techniques such as schlieren or interferometry. This project will deal with the general case of a fully three-dimensional flow and the main objective is to determine the three-dimensional shape of the observed flow features. The principal techniques for image acquisition are well established and a large amount of expertise and high-class equipment for this purpose is available in the School. There already exists a large amount of image data that is suitable for the proposed analysis. Image registration algorithms that have been developed in the School for atmospheric imaging can be adapted and expanded to this application.

GEOTECHNICAL AND INFRASTRUCTURE ENGINEERING

Project:	***Behaviour and stabilisation of potentially liquefiable alumina tailings***
Program Code:	*1631*
Supervisor:	*A/Prof S.R. Lo (r.lo@adfa.edu.au) & Dr Gnanendran*

Objectives:
Alumina tailings, commonly known as red mud, is potentially liquefiable. Its disposal and stabilisation is of directly relevance to both Australia and China. The primary objectives of our research in this area are:

- Understanding the liquefaction behaviour of red mud.
- Developing innovative solutions in stabilisation red mud. At presence we intend to focus on two approaches:
    - Using chemical additives

- Using e-PVD

Description of Study:
We intend to take in 1 to 2 PhD candidates to conduct PhD research in this pioneering area.

- The research approach can be based on experimental studies, mathematical modelling and finite element analysis.
- We intend to incorporate the critical soil mechanics framework, and hopefully developed constitutive (mathematical) modelling.
- In the case of e-PVD, finite element studies will be used to modelling the electro-osmotic consolidation process.

Project:	***Behaviour of granular base materials as unsaturated geomaterials.***
Program Code:	*1631*
Supervisor:	*A/Prof S.R. Lo (r.lo@adfa.edu.au) & Dr Gnanendran*

Objectives:
Motorways have to be designed to very high performance level to ensure safety at high car speed. One component that controls the performance of a motorway pavement system is the behaviour of road foundation constructed with granular base (GB) subject to cyclic loading. A granular base (GB) material is a heavily compacted well-graded silty sandy gravel. It may be unbound (ie no cementing agent added) or stabilised (ie with cementing agent added to give an unconfined compressive strength of ~2MPa). Traditional pavement design is based on empirical rules, and the associated prescriptive requirements may place severe environmental pressure because of the need of extensive quarrying and haulage over long distances. Furthermore, some of the empirical rules on fines content, role of cement additives are inconsistent.

As part of an effort to develop analysis-based design for pavement foundations, a new research area, referred to as "*Pavement Geotechnics*", has been initiated recently.
A significant component of pavement geotechnics is on material behaviour and modelling. As the pavement foundation materials is in an unsaturated state its behaviour of is also governed by the fundamentals of unsaturated soil mechanics. We are the only research group in Australia, and one of the few internationally, that have a track record in this area of research.

Description of Study:
We intend to take in one PhD (maybe two if we have outstanding applicants) to conduct PhD research in this pioneering area. The research work involves:

- Conducting cyclic triaxial testing on GB materials (unbound or stabilized) with using unsaturated soil mechanics testing technology.
- Synthesizing the test results to establish the stress state parameters (including matric suction) for characterizing the influence of fines. This in return will ensure under top model the role of fines using initial stress state parameters.
- Characterizing the cumulative effects of load repetitions framed in term of stress state parameters.

Project:	***Liquefaction of silty geo-materials materials***
Program Code:	*1631*
Supervisor:	*A/Prof S.R. Lo (r.lo@adfa.edu.au)*
Co-Supervisor	*Dr Gnanendran*

Objectives:
Liquefaction in (loose near-saturated) granular material is confusing as it can be triggered by both rapid monotonic loading and/or cyclic loading. Furthermore most studies are based on either clean sand or sand with a small amount of fines. However, a silty soil can also liquefy. Both mine tailings and coal ash are silt that may be prone to liquefaction. The primary

objectives of our research in this area are:

- Advancing the modelling of the influence of fines on sandy soil by having a unifying framework for both static and cyclic liquefaction.
- Understanding the liquefaction of silts, and hopeful extend our liquefaction theories for sandy soil to silty soil.
- Understanding the effects of slight unsaturation on liquefaction behaviour.
- The influence of the soil grains being crushable.

Description of Study:
We intend to take in 1 to 2 PhD candidates to conduct PhD research in this pioneering area.

- The research approach is largely experimental and using our specially developed in-house triaxial stations that can perform both instability testing and impart cyclic stress pulses of varying (in a given test) waveform. One of such station also incorporates unsaturated soil testing technologies.
- We intend to synthesise/ interpret the experimental findings within the critical soil mechanics framework, and hopefully developed constitutive modelling to characterise liquefaction behaviour.
- For study on silty soil, we will be using actual coal ash from a particular ash disposal site. This also allows some insights into the effects of crushable grains, noting that some of the grains of coal ash are crushable glass particles.

Project:	***Pavement geotechnics: Behaviour of subgrade under cyclic loading***.
Program Code:	*1631*
Supervisor:	*A/Prof S.R. Lo (r.lo@adfa.edu.au) & Dr Gnanendran*
Objectives: Similar to Project "*Behaviour of granular base materials as unsaturated geometerials.*" but the focus is on in situ soil as functioning as pavement foundation.	

Project:	***Soft clay engineering involving sensitive soil or rate dependent soil*** *(or both)*
Program Code:	*1631*
Supervisor:	*A/Prof S.R. Lo (r.lo@adfa.edu.au) & Dr Gnanendran*
Objectives: The challenge of geotechnical work involving thick deposits of soft clay is well known in infrastructure engineering. The primary objectives of our research work in soft clay engineering are: Advancing the modelling of geo-structures on soft soil (in the context of infrastructure engineering). The advances can be made at the constitutive (material) modelling level or at the analysis model level or both. Development of innovative solutions, including but not limited to use of geosynthetics. **Description of Study:** Several PhD projects involving a combination of experimental, constitutive modelling, and FEA-based cased studies can be configured depending on the aptitude of the student.	

GUIDANCE AND CONTROL

Project:	***Integrated Guidance and Control of Underwater Vehicles***
Program Code:	*1661*
Supervisor:	*Dr Sreenatha G Anavatti (s.anavatti@adfa.edu.au)*
Objectives: The proposed work is aimed at integrated guidance and control of AUV. The work involves the development of an overall objective of combining the two schemes and the development	

of the two subsystems in a coupled fashion. Intelligent systems like Fuzzy Logic and Neural Network provide very good platform for handling non-linear coupled and time-varying systems. These techniques will be applied to design the integrated guidance and control system. Dynamic path planning will be utilised for the guidance scheme to avoid collisions.

HIGH SPEED AND AERODYNAMICS

Project:	***Modelling of NO Fluorescence for nonequilibrium thermometry and velocimetry at high speeds***
Program Code:	*1663*
Supervisor:	*Dr. Sean O'Byrne (s.obyrne@adfa.edu.au)*
Co-Supervisor	*A/Prof Andrew Neely (a.neely@adfa.edu.au)*

Objectives:

This project builds upon previous successful projects in the school related to understanding the physical processes involved with boundary layer separation in hypersonic flows in thermal nonequilibrium. We have developed a suite of experimental techniques based upon laser-induced fluorescence of the nitric oxide molecule that are capable of measuring translational temperature, rotational temperature, vibrational temperature and velocity in low-density flows. The purpose of the project is to develop a framework in which direct simulation Monte Carlo (DSMC) calculations can be used to better design the experiments performed using our techniques by simulating the fluorescence expected from these computational simulations.

Description of Work:

- Develop a cutting-edge model for nitric oxide fluorescence that includes saturation, absorption quenching and thermal nonequilibrium processes.
- Use this model to generate fluorescence maps from DSMC-generated maps of flowfield quantities
- Develop a new algorithm using Bayesian statistical methods that can generate velocity maps from fluorescence images while minimising the amount of tunnel run data for a given degree of uncertainty in the results

MECHANCIAL ENGINEERING

Project:	***Development of a PIV for micro-flows using non-laser based method***
Program Code:	*1661*
Supervisor:	*Dr Jong-Leng Liow (j.liow@adfa.edu.au)*

Objectives:

To develop an LED based PIV and the associated analysis program to measure flow characteristics of micro-channels.

The use of particle image velocimetry (PIV) in fluid flow is an important analytical and diagnostic tool, particularly for ensuring that the simulation results are validated by experimental measurements on the flow field of interest. In recent years, there has been active development of PIV for studying micro-flows. A major drawback is the use of laser based techniques for illuminating the region of interest but stricter requirements have restricted the use of high intensity lasers. Currently the illumination power of LEDs has increased tremendously and the green wavelength LED has a wavelength close to that of the lasers used for PIV. It is proposed to develop a PIV system using LED rather than laser. In parallel a code will be developed to analyse the images obtained from the PIV setup.

Description of Work:

- Develop a simplified set-up with the current microscope set-up to illuminate the test section with LED based high intensity flashes.
- Develop PIV procedures to extract flow velocity data and methods to optimise data recovery as the signals can be faint.
- Extend the framing rate to allow for high framing rate micro-PIV.
- Validate the micro-PIV system by measuring the velocity field of liquid flows in micro-channels.

Pre-requisites:
The prospective student(s) should have some experience in programming in C++ as this is a useful platform for the development of the PIV analysis software.

Project:	***Development of Genetic Programming Methods for Rule Extraction and Knowledge Representation***
Program Code:	*1661*
Supervisor:	*Dr Tapabrata Ray (t.ray@adfa.edu.au)*
Co-Supervisor	*Appropriate Co-supervisor will be identified*

Brief: Genetic programming (GP) is a powerful evolutionary computing paradigm which allows for search and representation of solutions often with structure. The research is aimed to develop a GP platform that can be used to support decision making in design.

Skills Required:: A candidate from Computer Science would be preferred. Good coding skills in C#/C++ is required. An understanding of optimization methods an in particular population based approaches such as Evolutionary Algorithms would be useful

More details of the research activities at http://seit.unsw.adfa.edu.au/research/sites/mdo/

Project:	***Development of Methods to Solve Large Scale Optimization Problems***
Program Code:	*1661*
Supervisor:	*Dr Tapabrata Ray (t.ray@adfa.edu.au)*
Co-Supervisor	*Appropriate Co-supervisor will be identified*

Brief:
Large scale optimization problems are commonly encountered in real life applications. This research will focus on the development of decomposition based algorithms to deal with problems with thousands of variables. Behaviour of decomposition based algorithms is still poorly understood and this research will investigate when-why-where such algorithms will perform well.

Skills Required:: A candidate from Computer Science would be preferred. Good coding skills in C#/C++ is required. An understanding of optimization methods an in particular population based approaches such as Evolutionary Algorithms would be useful.

More details of the research activities at http://seit.unsw.adfa.edu.au/research/sites/mdo/

Project:	***Development of Optimization Methods to Support Concept Design***
Program Code:	*1661*
Supervisor:	*Dr Tapabrata Ray (t.ray@adfa.edu.au)*
Co-Supervisor	*Appropriate Co-supervisor will be identified*

Brief:
Concept design is a critical step in the process of mechanical design where multiple promising concepts are identified. Subsequently, such concepts are carried through to the phase of preliminary and detailed design. Development of effective and efficient optimization methods to support concept design activity is a challenge as number of variables representing a concept

might vary from one another while there could be some commonality in terms of several set of variables associated with a component. The objective is to develop optimization methods that are capable of handling such classes of problems.

Skills Required::
Good Matlab coding skills will be required. An understanding of optimization methods an in particular population based approaches such as Evolutionary Algorithms would be useful.

More details of the research activities at http://seit.unsw.adfa.edu.au/research/sites/mdo/**:**

Project:	***Encapsulated drop formation in micro-channels***
Program Code:	*1661*
Supervisor:	*Dr Jong-Leng Liow (j.liow@adfa.edu.au)*

Objectives:
The formation of liquid drops using micro-channels has been put forward by many researchers. The advantage of using micro-channels is that the shearing of a liquid by a second liquid can be used to control the size and type of drops that are formed. Micro-devices with simple or complex channels can be configured and produced that will allow a sequence of steps to be applied to the drop formation and the drops formed. This gives rise to the possibility of creating micro-factories that can take the raw material (liquid) and produce a product that has characteristics for a particular application (drops with coating and trace chemicals present). This project will look at the formation of droplets that encapsulate multiple droplets of other liquids and model the drop formation process

Description of Work:
- Carry out a survey of the current status with encapsulated drop formation using micro-devices.
- Design and manufacture micro-devices for encapsulated drop formation using the micro-milling facility available.
- Study the characteristics of encapsulated drop formation using Newtonian and non-Newtonian fluids.
- Develop a model to predict the drop encapsulation processes.

Project:	***Impact Behaviour of Laminated Composite and Sandwich Panels***
Program Code:	*1661*
Supervisor:	*Dr Krishna Shankar, (k.shankar@adfa.edu.au)*
Co-Supervisor	*Evgeny Morozov (e.morozov@adfa.edu.au)*

Objectives:
Laminated fibre reinforced composites are routinely used in many high strength and low weight applications such as in aircraft manufacturing, and often as face sheets for sandwich panel constructions for applications requiring impact resistance such as bicycle helmets, crash barriers, aircraft wing skins, ship superstructure and so on. The school has currently an ongoing programme of research into impact resistance and crashworthiness of fibre reinforced laminated composites and sandwich structures including both experimental testing and numerical simulation. In additional to extensive facilities for manufacture and characterization of laminated composites and sandwich panels, we have a drop tower, low velocity and medium velocity pneumatic test facilities for impact testing and are in the process of augmenting these with facilities for high velocity (up to 1000 m/s) impact test machines. The objective of the proposed research is to conduct further experimental and simulation studies to improve the impact resistance and crashworthiness of composite and sandwich panels for low velocity as well as high velocity (ballistic) applications

Description of Work:
Conduct a survey of present state of research into impact testing of composites and sandwich panels;
- Manufacture, mechanical characterization and experimental testing of

composite/sandwich panels;

- Numerical simulation of impacts on composite/sandwich panels using LS_Dyna
- Validation of numerical results with experimental tests
- Parametric study and exploration of means to improve optimise impact resistance using numerical simulation

Project:	***Incorporation of material layers, circuits and other small scale features into micro-devices with end milling***
Program Code:	*1661*
Supervisor:	*Dr Jong-Leng Liow (j.liow@adfa.edu.au)*

Objectives:

The use of micro-end milling gives rise to a 2.5D structure which is based on the base material that is being milled. However, a single base material is limited in its properties. For example, use of a plastic means that electricity cannot be conducted. Hence sensor signals cannot be collected for measurement. Layers of other material can be built on the base material and then micro-machined to provide useful structures. This can be done as many times as possible to form a 3-D structure where signals can be transmitted and other physical effects can be incorporated through different materials. Thereafter the micro-device can be packaged similar to the computer chips. This project will study the conditions for deposition of different material for micromilling using a variety of methods including spin coating and electrodeposition.

Description of Work:

- Familiaristion with the area of spin coating and electrodeposition.
- Develop methods to optimise spin coating and electrodeposition of material that can then be easily micromachined to produce micro-devices.
- Investigate and model the conditions for optimising the spin coating and electrodeposition of material.

Project:	***Measurements of CO and CO_2 in an automobile exhaust***
Program Code:	*1661*
Supervisor:	*Dr. Sean O'Byrne (s.obyrne@adfa.edu.au)*
Co-Supervisor	*Dr Alan Fien (a.fien@adfa.edu.au)*

Objectives:

This project aims to develop an automobile exhaust sensor using diode laser absorption spectroscopy of the CO and CO_2 molecules in a motor vehicle while the vehicle is being driven. This capability can be used to determine whether the engine is running too lean or too rich and, if implemented in each branch of the exhaust manifold, can make measurements sufficiently quickly to resolve the processes occurring during each part of the 4-stroke internal combustion cycle. Such a sensor can be used to keep the engine operating at peak and can sense when the engine operation needs to be tuned over the lifetime of a vehicle

Description of Work:

- Develop computational models of the absorption process and quick-fitting routines to determine temperature and species concentrations in the vehicle exhaust.
- Implement a diode-laser-based sensor using a vertical cavity surface-emitting laser that can measure exhaust composition and temperature in a car while it is running, at frequencies in excess of 100 Hz.
- Compare the output of the sensor to standard methods of measuring exhaust composition.

Project:	***Micromachining of plastics using micro-end mills***
Program Code:	*1661*
Supervisor:	*Dr Jong-Leng Liow (j.liow@adfa.edu.au)*

Objectives:
This project aims to 1) provide an understanding of the mechanics of the micro-end milling process, and 2) develop a novel way of manufacturing micro-devices that is applicable to plastic materials. The manufacture of micro-devices is currently primarily by lithography or soft polymer moulding, which limits them to silicon, glass and soft carbon based polymers as their starting material. This also places limitations on the scope of micro-devices that can be produced. Although developments are being carried internationally to expand the processes available for micro-device manufacture, the CNC machining process found in every mechanical workshop and industry has not been developed to any significant extent for the manufacture of micro-devices. The use of plastics for micro-device manufacturing has been expanding rapidly but there is no research as to the behaviour of plastics during micromachining.

Description of Work:

- Carry out cuts with end-mills (diameters from 25 to 200 micrometres) and vary the feed-rate, rpm of the end-mill, depth and width of cut, and base materials (soft plastic through to hard metals).
- Measure the surface roughness and accuracy of the cut using the atomic force microscope (AFM) available in ITEE.
- Develop a model to predict the surface roughness and cut accuracy, taking into account end-mill deflection, material properties and cutting parameters

Project:	***Numerical simulation of drop formation in micro-channels via VOF/Level set methods and immersed boundary methods***
Program Code:	*1661*
Supervisor:	*Dr Jong-Leng Liow (j.liow@adfa.edu.au)*

Objectives:
Develop immersed boundary methods and VOF/Level set methods for the numerical simulation of multiphase fluid flows in micro-channels.

The use of numerical simulation is a convenient means of understanding the two-phase flow in a micro-device. The flow of two or more phases requires the accurate tracking of the fluid interfaces as surface tension is an important physical parameter. Discretisation of the surface tension term often gives rise to parasitic currents or error that can grow with time and distort the results. Currently, the use of the volume of fluid method is a well-known technique for modeling two phase flow problems. An equally promising approach is that of the level set method. It is proposed that it is possible to merge the better attributes of both techniques to bring about a more accurate method for multi-phase flow simulation.

The use of a structured grid for modeling provides efficiency over an unstructured grid. However, there are drawbacks. The structure grid has many unused cells when modeling a micro-device resulting in wastage of memory and calculations on cells with no fluid. The use of a structured grid also gives rise to difficulties in correctly modeling geometries that are not rectangular but curved. Recent work has been done on using the immersed boundary method and extending it to 3-D problems for VOF based codes, using higher order discretisation (pseudo spectral accuracy) and improving the speed and robustness of the solution of the algebraic equations through the use of preconditioning and Krylov methods. Recent advances in the tracking of the liquid-liquid and gas-liquid interface include high order interface reconstruction (Liovic et al. 2006) has not been incorporated into current CFD packages and significant smearing of the interface limits the accuracy of the results. The project will look at building on earlier work in 2D and 3D multi-phase codes for micro-fluidics simulation and incorporating the newer ideas as outlined. The effect of surface tension on the accuracy of the code as well as the 3 phase contact line will be looked at to improve the code for multiple

fluid interfaces.

Description of Work:

- Continue development of a volume of fluid code for multiphase simulation incorporating the immersed boundary method to handle irregular boundaries.
- Improve the current preconditioned generalized residual method (which is a member of the Krylov subspace method) to provide better stability when solving the algebraic equations with the immersed boundary method coded.
- Applying the code to study drop and bubble formation in micro-channels where the code is validated through results from experimental work being carried out in the supervisor's research group.

Pre-requisites:
The prospective student(s) is expected to have be able to program in Fortran as this requires the writing of computational fluid dynamics code. An understanding of numerical methods in the solution of the equations of fluid flow will be an asset.

Project:	***Surfactant effects on droplet formation in microfluidic channels – MD modelling***
Program Code:	*1661*
Supervisor:	*Dr Jong-Leng Liow (j.liow@adfa.edu.au)*

Objectives:
Droplet formation in microfluidic channels and micro-devices has significant applications in chemical and biological processing as well as in biomedical engineering. The diameter of the droplet formed is critically dependent on the physical properties of the dispersed phase and the dynamics of fluid flow. Surface or interfacial tension of the liquid-air, liquid-liquid and solid-liquid interfaces of the dispersed phase is one of the most important properties affecting the droplet formation mechanism. Other properties such as the viscosity of the dispersed phase and the concentration of the surfactants can also affect the droplet formation and the droplet diameter. This project will:

- investigate the effects of the polysaccharide concentration in the dispersed phase on the viscosity of the solution using Molecular Dynamics (MD) simulations
- investigate the interfacial forces between the surfactant and the water/polysaccharide mixture at the critical concentrations and determining liquid-liquid interfacial tension using MD simulations;
- develop a hybrid MD and micro-fluid mechanics code to simulate the droplet formation process.

Description of Work:

- Familiarisation with the NAMD MD code.
- Build a model of a polysaccharide molecule(s) and carry out modelling of the motion of the molecule within a micro-channel to investigate slip effects and non-Newtonian flow behaviour.
- Relate the results to the behaviour of the polysaccharide molecule(s) to experimental results on the drop formation in micro-channels.
- There may be a possibility at the later stages of the project to spend time with collaborators in USA on this molecular dynamics project.

Pre-requisites:
The prospective student(s) is expected to have some familiarity with experience in computer programming and use of computational packages and an understanding of chemistry

NEURAL NETWORKS

Project:	***Bio-control application of Neural Networks***
Program Code:	*1661*
Supervisor:	*Dr Sreenatha G Anavatti (s.anavatti@adfa.edu.au)*

Objectives:
This research proposes the development of computational algorithms for gene sequencing using neural networks. This is turning out to be a very hot topic of research with computational biologists. Significant effort and collaboration between engineering scientists and biologists all over the world is put in this direction. The potential of the research lies in reducing the computational effort using clustered, parallel neural networks or suitable other algorithms. This research work will have a collaborator from CSIRO who is an expert in gene sequencing.

UNMANNED AERIAL VEHICLES

Project:	***Control of height and speed using visual sensing in a UAV***
Program Code:	*1663*
Supervisor:	*Dr M.A. Garratt (m.garratt@adfa.edu.au)*

Objectives:
In past work, non-visual sensing modes (e.g. GPS) have been combined with visual sensing to determine either range given speed or speed given range. The problem of how vision might be used in a standalone mode without a secondary sensing mode has not been tackled. For example, is it possible to use image motion to determine height above terrain when there is no available measure of ground speed? Preliminary experimental work suggests that bees deliberately impart a lateral sinusoidal displacement of known amplitude upon their flight path in order to generate image motion in a defined way. As the velocities corresponding to the lateral wiggle are a function of the amplitude, the bees would be able to deduce range from the lateral image motion and thereby control their height. Apparently, bees can also regulate their flight speed based on the longitudinal image motion. With range known from lateral optic flow and forward speed known from longitudinal optic flow, the bees are able to regulate both speed and height using the one sensory system. The objective of this project is to investigate whether such as scheme could be implemented on an unmanned helicopter.

Description of Work:

- Using existing in-house rotorcraft simulation, develop a robust scheme for controlling the height and speed of a helicopter from simulated image motion.
- Refine the algorithm to incorporate obstacle avoidance techniques. Implement and test on a UNSW@ADFA unmanned helicopter.

Project:	***Flight Control System for UAVs***
Program Code:	*1663*
Supervisor:	*Dr Sreenatha G Anavatti (s.anavatti@adfa.edu.au)*

Objectives:
This research proposes the development and implementation of flight control systems for school's fixed wing UAV. Currently, we have flight tested fuzzy logic and neural network based controllers for simple flight paths. These need to be developed further to include manoeuvring paths and for various types of missions. Development of on-board implementable control logics is a challenging problem for UAVs since the payload capacity is restricted along with restricted computational power. Hence, the development of control algorithms needs to cater for these restrictions and provides the impetus for newer tools.

Project:	***Miniature Vision Sensors for UAVs.***
Program Code:	*1663*
Supervisor:	*Dr M.A. Garratt (m.garratt@adfa.edu.au)*

Objectives:

The objective of the proposed thesis is to investigate and develop a small embedded vision sensor for control of an Unmanned Aerial Vehicle (UAV). The work will leverage the unique parallel processing architecture of Field Programmable Gate Arrays (FPGA) to develop a novel, small, low-power unit for determining optic flow and stereo range. This work will build on preliminary work demonstrated at UNSW@ADFA that shows that it is possible to compute optic flow using FPGA

Description of Work:

- Determination of the most efficient algorithm for processing of optic flow and stereo, taking in to account the parallelisation possible with an FPGA. This stage will be progressed in MATLAB. Initial work will focus on use of the optic flow interpolation algorithm. Later work will look at alternative and more elaborate algorithms for calculating image motion.
- Implementation of algorithms in embedded hardware. This step will make use of existing hardware at UNSW@ADFA initially, but may involve design of new circuits to support high performance FPGA chips.

Once the algorithms are proven on a real-UAV, work will progress towards use of the optic flow information in a feedback loop to control the trajectory of one of the UNSW@ADFA UAV platforms.

Information Technology and Electrical Engineering

ADAPTIVE SYSTEMS

Project:	***An Artificial Brain to Play GO***
Program Code:	*1885*
Supervisor:	*Prof Hussein Abbass (h.abbass@adfa.edu.au)*
Co-Supervisor	*Dr Michael Barlow*

Objectives:
Developing a computer system that is capable of playing GO at a professional level is one of the greatest challenges facing artificial intelligence research at the moment. This project will look at advanced artificial intelligence techniques to build a human-competitive professional GO player. The project will develop a large-scale neural-based system to model strategies at both the tactical and strategic levels of GO. The research will focus on a computational neural architecture for GO inspired by a number of models in human psychology.

Description of Work:

- Understanding neural architectures, strategies, and thinking models
- Understanding a number of architectures and models in Cognitive Science
- Developing a large-scale neural architecture for GO
- Developing multi-stage methodologies for training the architecture
- Testing the competitiveness of the GO player

Project:	***Robots that tell Stories***
Program Code:	*1643 or 1885*
Supervisor:	*Prof Hussein Abbass (h.abbass@adfa.edu.au)*
Co-Supervisor	*Dr Michael Barlow*

Objectives:
Storytelling is the art of narrating stories. Computer generated stories are common in virtual world. However, the research in this area relies to a large extent to scripted stories or stories with fixed themes. A robot that interacts with human should not use a fixed storyboard or fixed themes. The interaction requires from the robot to adapt in a changing environment. This project aims at equipping a robot with the ability of telling stories on the fly. These stories will be auto-generated by the Robot based on the situations it will encounter in the environment.

Description of Work:

- Developing an understanding of basic linguistics and the principles of natural language processing
- Developing an understanding of Chomsky Hierarchy and formal grammar
- Develop methodologies for representing and evolving stories
- Testing the methodology and scoring it against human-generated stories.

ARTIFICAL INTELLIGENCE

Project:	***Generative Design of Adaptive Virtual Worlds***
Program Code:	*1885*
Supervisor:	*Dr Kathryn Merrick (k.merrick@adfa.edu.au)* *Web: www.itee.adfa.edu.au/~s3229187*

Objectives:
A new generation of persistent virtual worlds such as *Second Life* and *There* has opened the way for new kinds of remote environments to support commerce, education, defence, health, design and other industries. Design approaches for virtual places to support these industries

have drawn on architectural concepts from the physical world. However, virtual places offer possibilities beyond physical places, including remote collaboration, adaptive spaces and intelligent environments. The objective of the project is to develop new models for generative design of adaptive virtual worlds.

Description of Work:

- Survey of existing literature for computational creativity and generative design, including cellular automata, shape grammars and motivated agents
- Design of computational models of artificial agents capable of creative, generative design behaviour in virtual environments
- Implementation of the models in simulated applications or in live virtual worlds such as *Second Life* and *There*
- Evaluation of the application using empirical metrics, case studies or user studies. This will include comparison to existing techniques for generative design.

Project:	***Learning How to Learn Using Computational Models of Motivation***
Program Code:	*1885*
Supervisor:	*Dr Kathryn Merrick (k.merrick@adfa.edu.au)*

Objectives:

Computational models of motivation – such as novelty, interest and curiosity – can provide a way for artificial agents to select their own learning goals. Agents identify highly motivating experiences then learn how to repeat those experiences. Existing work with motivated agents has focused agents with a fixed learning mechanism to learn about highly motivating goals. This project will develop new motivated learning approaches in which agents are also motivated to select between different action approaches in different situations. This may include reflexive responses, learning by trial-and-error or learning by mimicry

Description of Work:

- Review of psychological literature describing motivation and learning.
- Design computational models of motivation that can mediate between different learning approaches.
- Implement the models in simulation and at least one live application, such as virtual world or the *Lego Mindstorms NXT* robotic platform.
- Evaluate the models using empirical metrics and/or case studies. This may include comparison to existing computational models of motivation or motivated learning.

Project:	***Mimic This: Societies of Curious Robots***
Program Code:	*1885*
Supervisor:	*Dr Kathryn Merrick (k.merrick@adfa.edu.au)*

Objectives:

In robotic systems, curious agents offer a way for developmental robots to select their own goals. Such robots have a range of potential applications, including support for tool use, fault tolerance and robot reconfigurability. Existing work with curious robots has focused on reward based learning approaches such as reinforcement learning. Such robots can learn by trial-and-error, but cannot draw on the experiences of other robots. This project will develop new models for curious robots that can learn to mimic interesting behaviours of other robots using supervised learning techniques. Models will be implemented and tested on the *Lego Mindstorms NXT* platform.

Description of Work:

- Review of relevant robotics and artificial intelligence literature
- Design computational models of curious supervised learning for continuous, real-world environments.

- Implement the models on the *Lego Mindstorms NXT* platform
- Evaluate the models using empirical metrics and/or case studies. This may include comparison to existing computational models of motivation or motivated learning.

ATMOSPHERIC SCIENCE AND ASTRONOMY

Project:	***Adaptive modal superposition mirror***
Program Code:	*1661*
Supervisor:	*Dr Murat Tahtali (m.tahtali@adfa.edu.au)*
Co-Supervisor	*Dr Andrew Lambert (a.lambert@adfa.edu.au)*

Objectives:
Traditional adaptive optics (AO) deformable mirrors use segmented actuator patterns requiring elaborate manufacturing techniques. The range of surface curvatures used for corrective action can be described by Zernike polynomials, which are a sequence of orthogonal polynomials on the unit circle. The vibration modes of a circular membrane exhibit striking similarities to Zernike polynomials; it fact, they can be all expressed as functions of Bessel functions. This leads to the possibility of using a vibrating membrane mirror in adaptive optics. The objective of this project is to design, manufacture and test a modeshape mirror capable of reproducing the essential Zernike polynomials to be used in adaptive optics.

This project involves design and conduct of laser experiments, high levels of signal processing and analysis techniques as well as possible numerical modelling.

Project:	***Multiple Object Adaptive Optic***
Program Code:	*1643*
Supervisor:	*Dr Andrew Lambert (a.lambert@adfa.edu.au)*
Co-Supervisor	*Dr Murat Tahtali*

Objectives:
Large Field of View telescopes observe celestial objects through regions of atmosphere that are different and temporally changing. Traditional adaptive optics (AO) techniques involving single mirror correction will only correct a small region of this atmospheric effect, and typically destroy imagery outside this region. It is possible to assign different correcting elements to each region, but the logistical difficulty and light loss in determining the distortion at each region and the actual shape taken by the corrector, mean that other techniques must be investigated to predict the turbulent structure and evolution across the whole field of view from a limited set of measurements. Non-optical methods must also be designed to determine the state of each corrector. This project will involve design of correctors, wavefront sensors, and control algorithm design to address MOAO implementations

Description of Work:
- Investigate commercial and custom designed deformable mirrors; Determine non-optical methods for determining their shape;
- Develop algorithms for the prediction of turbulence evolution both spatially and temporally from limited observations of optical wavefronts;
- Design control algorithms within embedded FPGA hardware for the manipulation of wavefront sensed data to control an array of deformable mirrors; Implementation of such a system on a small wide-field of view telescope as a proof-of-principle suitable for adoption of large telescope instrumentation.

The project will involve laboratory work, materials science, simulation and algorithm development, astronomical observation, and development of high-speed digital and analog electronics.

BIOINFORMATICS

Project:	***Analysis and Mapping of Human or Mouse***
Program Code:	*1643:EE or 1845:CS*
Supervisor:	*A/Prof Tuan D. Pham (t.pham@adfa.edu.au)*

Objectives:
Most previous research on morphological brain changes in relation to ageing concentrated on white matter lesions, atrophy and lacuna infarctions potentially contributing to ageing as well as cognitive decline of the human brain. The pathology of end aetiological factors contributing to, for example, white matter changes have been discussed as being part of small vessel disease and an inflammatory hypothesis overall. There has been support for the hypothesis of inflammatory response affecting white matter lesions and atrophy in the human brain with negative consequences on cognitive functioning such as memory, cognitive speed and motor function. Gray matter not only may play a role in the association between depression and cardiovascular diseases, but also in association with depression itself, possibly as part of the vascular depression hypothesis. At present, the causes of gray matter damage are unclear and there are several exciting new hypotheses on gray matter pathogenesis. These hypotheses remain to be validated over the coming years, and could substantially change our current views on multiple sclerosis that has been classically regarded as a white matter disease. In order to analyse the potential contribution of gray matter lesions, we are interested in determining an indicator of complexity of gray matter of various areas of the brain such as frontal lobe, temporal lobe, parietal lobe, and occipital lobe in order to relate these morphological measures and intensities to, for example, cognitive functioning in the elderly, and also to potential aetio-pathological models such as inflammatory responses. In the study of cell biology of human disorder, we are interested in the analysis of a mouse model of a human neurodegenerative disease, Zellweger syndrome, which manifests with severe brain morphological and functional abnormalities. Zellweger syndrome results from defective biogenesis of the peroxisome, a ubiquitous cellular organelle. Manual analysis and quantification of changes in microscopic images of brains of the mutant mice is a cumbersome task. We are therefore interested in developing an automated process for establishing patterns of change in brain morphology and intensity.

Description of Work:
This project involves image processing, image segmentation, 3-D imaging, and fuzzy fractal and entropy analyses. It also extends to link image data with genetic information for biomedical hypothesis validation.

Project:	***Dynamical Behaviours of Cardiovascular and Neural Systems***
Program Code:	*1643:EE or 1845:CS*
Supervisor:	*A/Prof Tuan D. Pham (t.pham@adfa.edu.au)*

Objectives:
Our knowledge of automatic nervous system has increased with an understanding of heart rate variability (HVR), a non-invasive measure of cardiac automatic control. Two main frequency components of HRV have been demonstrated - low frequency reflecting the interaction of both the sympathetic and parasympathetic nervous systems, and high frequency reflecting solely the activity of the parasympathetic nervous systems. The most prominent aspect of this new measure (HRV) has been its use as a predictor of mortality in patients with cardiovascular disease and in the general population. This study proposes the investigation of the methodology of signal-processing and complexity-based pattern analysis for such physiological time-series data. The expected outcomes of this project will be the development of a set of new computational methods that can better predict samples of control and diseased populations, examine whether HRV following intensive cycling training contribute to the mechanism of training-induced bradycardia. Investigation of the spatiotemporal characteristics of physiological data is also an area of interest of this project.

Description of Work:

This project involves non-linear dynamic analysis using entropy analysis, fuzzy fractal and chaos, and pattern recognition

Project:	***High-Content Bio-Imaging***
Program Code:	*1643:EE or 1845:CS*
Supervisor:	*A/Prof Tuan D. Pham (t.pham@adfa.edu.au)*

Objectives:
The Human Genome Project has provided a significant landmark in mapping the human genome and identifying key genes that regulate cell and tissue function. More recently, however, the research focus has shifted to the study of some areas of the emerging field of computational systems biology that focuses on biological systems consisting of molecular components rather than just sequence of nucleotide acids and proteins. Some areas of such focus include proteomics, molecular imaging, and its combination of information where informatics plays an important role to enable life-science researchers to gain insight into cell functions and networks. In particular, the application of computational methods to systems biology opens new doors in the search for greater understanding of the mechanism of disease progression that will lead to the identification of useful biomarkers of diseases, improvement of therapeutic treatment, and new drug discovery. High-content microscopic imaging technology provides essential information for biomedical research in studying the structures and functions of cells and molecules. Such studies require the processing and analysis of huge amounts of image data, and manual image analysis is very time-consuming, thus costly, and also potentially inaccurate and poorly reproducible

Description of Work:
This project involves cellular image segmentation, novel image feature extraction, and pattern classification.

Project:	***4-D Image Analysis of Lung Cancer Motion***
Program Code:	*1643:EE or 1845:CS*
Supervisor:	*A/Prof Tuan D. Pham (t.pham@adfa.edu.au)*

Objectives:
Cost for 4D-CT instrument for lung cancer diagnoses is tremendous. Due to this, only A small number of hospitals are able to afford such an apparatus. Our goal is to replace the external respiratory gating system and replace it with software, so that the cost is reduced significantly. Therefore, the goal is to develop a tool which, given 4D-CT data, classifies the images into different bins, each corresponding to a respiratory. In addition, since the external gating system is removed, the data will be much bigger due to over-sampling. In other words, during data acquisition, since we do not know the current respiratory phase precisely, images are acquired for a time duration that is greater than one respiratory cycle. The purpose of the research is to estimate the extent of the tumour motion. For example, tumours associated with lungs move as the patient respires. For an effective treatment plan, therapists have to determine the extent of the tumour motion. The whole extent of tumour motion is then exposed to radiation. Traditional CT suffers from disadvantages due to motion caused by respiration. The goal of 4D-CT is to build a 3D CT model with an added dimension of time so that the tumour motion can be easily detected

Description of Work:
This project involves 4D-image analysis, image registration, motion detection, prediction modelling, and optimization.

Project:	***Image Analysis of Abdominal Aortic Aneurysm***
Program Code:	*1643:EE or 1845:CS*
Supervisor:	*A/Prof Tuan D. Pham (t.pham@adfa.edu.au)*

Objectives:
Abdominal aortic aneurysm (AAA) is a serious vascular disease most commonly affecting elderly people, and increasing in incidence. AAA is the progressive dilation of the abdominal

aorta caused by the weakening of the aortic wall. The most feared complication of an AAA is rupture, which is fatal in most patients. The decision to repair an AAA is presently based primarily on maximal aortic diameter, which is the only parameter having been reliably related to AAA growth. Screening and assessment of AAAs are currently performed by either ultrasound or computed tomography (CT) angiography, with the latter imaging technology being the current gold standard. A typical AAA will have some areas of wall calcification, intraluminal thrombus and intimal atheroma. The amount of calcification, thrombus and atheroma varies from one small AAA to another and based on clinical association and experimental data is believed to influence rupture risk. To date there has been minimal development of computer methods which can specifically analyse these features of AAA. This project aims at translating novel frontier of imaging science and computational intelligence methods into clinical relevance by developing a fully automated image analysis of abdominal aortic aneurysms. The proposed image analysis system will facilitate accurate assessment and optimal therapeutic intervention of abdominal aortic aneurysms. In combination with other biological data, it has potential for discovering new biomarkers for early prediction of presence and progression of this serious vascular disease that most commonly affects elderly people.

Description of Work:
This project involves image segmentation, 3-D image analysis, and pattern classification. It also extends to link image data with genetic information for biomarker discovery.

Project:	***Imaging and Computational Prediction Techniques for Biomarker Discovery***
Program Code:	*1643:EE or 1845:CS*
Supervisor:	*A/Prof Tuan D. Pham (t.pham@adfa.edu.au)*

Objectives:
The discovery of protein biomarkers has been predominantly performed with serum or plasma for early prediction of diseases and new drug discovery. Our objective is to develop a novel pattern classification strategy for protein biomarker identification and early disease prediction using mass spectrometry and imaging data. We are interested in applying the theory of geostatistics to extract the statistically spatial features of the mass spectrometry (MS) peak signals of the control and patient populations in a linear prediction fashion. We have been investigating the mathematical framework of signal error matching to estimate the dissimilarity between the MS peaks in the form of vectorized spatial prediction coefficients, and applied a mathematically robust decision rule to classify the samples based on the best match between the unknown and known MS peaks. High-throughput, SELDI-TOF MS are used o acquire the protein profiles from patient and control populations for developing a general computational bioinformatic model for proteomic-pattern based biomarker discovery

Description of Work:
This project involves signal processing, prediction modelling, peak detection, and pattern classification using mass-spectrometry data

Project:	***Image and Computation based***
Program Code:	*1643:EE or 1845:CS*
Supervisor:	*A/Prof Tuan D. Pham (t.pham@adfa.edu.au)*

Objectives:
The molecular pathogenesis of neurodegeneration is poorly understood. Possible clues, however, relate to the fact that neurons are particularly vulnerable to a number of cellular challenges that reflect their unique morphology, differentiation state, and energy dependence. These challenges include high energy demand, the length of the neuronal axon and dendrites, resulting susceptibility to cytoskeletal transport defects, and their high metabolic rate, which together with their relative paucity of antioxidant capacity, makes them highly susceptible to damage caused by reactive oxygen species. Not surprisingly then, factors implicated in the molecular pathogenesis of age-related neurodegenerative disorders include all of these

factors. In vitro approaches to studying neuronal cell changes have typically involved the culture of brain neurons from newborn mouse mutants that recapitulate features of the human disease. A widely used approach is to challenge cultured neurons with relevant chemical agents and look for morphological changes that may indicate a process of neuronal cell death. The monitoring of neurite retraction is a particularly useful approach as it can provide an early indicator of neuronal cell damage. We are interested in exploring the concepts of structural pattern recognition and complexity science to developing novel methods for precise quantification of morphological changes in neuronal cells

Description of Work:
This project involves image analysis, image segmentation, feature extraction, and complexity analysis of neuronal images.

BIOMETRIC SECURITY

Project:	***3D Fingerprint Indentification***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*
Co-Supervisor	*Prof Ian Petersen*

Objectives:
Conventional authentication mechanism relies on password or possession of token. However, password and token cannot genuinely identify a person as both password and token can be presented by someone else. Biometrics such as fingerprint, face, iris etc are quite uniquely representing individual. Therefore they are good tools for identity authentication. This project investigates latest biometrics authentication technology, i.e., 3D fingerprint identification.

Description of Work:
- Studying and analysing existing 3D fingerprint identification algorithms
- Investigating 2D fingerprint to 3D fingerprint mapping algorithms

Skills Required::
Good math background especially statistics and concrete programming skills. Image processing knowledge will be a plus.

Project:	***Biometric Cancellable Template Design***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*

Objectives:
Conventional authentication mechanism relies on password or possession of token. However, password and token cannot genuinely identify a person as both password and token can be presented by someone else. Biometrics such as fingerprint, face, iris etc are quite uniquely representing individual. Therefore they are good tools for identity authentication. However, biometrics stored in the template also needs to be protected. This project investigates how to protect biometrics stored in the template.

Description of work:
- Studying and analysing existing cancellable template algorithms
- Designing new cancellable template algorithms

Skills Required::
Good math background especially statistics and concrete programming skills.

Project:	***General Biometrics Security***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*

Objectives:
Conventional authentication mechanism relies on password or possession of token. However, password and token cannot genuinely identify a person as both password and token can be presented by someone else. Biometrics such as fingerprint, face, iris etc are quite uniquely representing individual. Therefore they are good tools for identity authentication. This project investigates the latest development in the field of biometrics such as bio-cryptography etc. This project is in collaboration with Carnegie Mellon University (USA).

Description of work:
- Studying and analysing existing relevant biometrics security algorithms
- Designing new algorithms

Skills Required::
Good math background especially statistics and concrete programming skills. Image processing or machine learning will be a plus.

COGNITIVE ENGINEERING

Project:	***Adapting Games to Human Mental Resources***
Program Code:	*1643 or 1885*
Supervisor:	*Prof Hussein Abbass (h.abbass@adfa.edu.au)*

Objectives:
Engaging in a game can be mentally demanding. It is difficult to estimate the long-term impact of mental load of the gaming experience. This project will develop artificial intelligence models to extract cues of cognitive load and use these cues to adjust and adapt a game to maintain and sustain a healthy gaming experience. Cognitive load is defined here as the rate of depletion of mental resources as a player engages and plays a game.

Description of Work:
- A literature review of models for cognitive load
- A literature review of cognitive load in games
- Creating an artificial intelligence model to measure indicators for mental resources
- Creating an artificial intelligence model to integrate the information on mental resources with a gaming environment
- Testing the system

Project:	***Controlling games using the eye***
Program Code:	*1643 or 1885*
Supervisor:	*Prof Hussein Abbass (h.abbass@adfa.edu.au)*

Objectives:
Eye tracking is a fast evolving technology. Currently, a number of problems exist in many eye-tracking systems when head movements occur, and other sources of noise interfere with the video signal. This project is to develop efficient and fast techniques for generating a smooth and robust control of objects on a screen using artificial intelligence models. The expected outcome of this project is a better eye tracking system and an artificial intelligence model that integrates eye movement with actions in a game environment.

Description of Work:
- A literature review of eye tracking technologies and methods
- A literature review of cues that can extracted from the eye and eye movements

- Creating an artificial intelligence model for eye tracking
- Creating an artificial intelligence model to integrate the cues from the eye tracking model within an game
- Testing the system

Project:	***Emotional Linguistic Cues to Play Games***
Program Code:	*1643 or 1885*
Supervisor:	*Prof Hussein Abbass (h.abbass@adfa.edu.au)*

Objectives:
A true gaming experience occurs when the human becomes situated and embodied within the game. Integrating the human emotion in a game would engage the human and improve the game experience. This project will build a model to extract linguistic cues that capture human emotion and integrate these cues in an intelligent manner within a game. The project will develop an artificial intelligence model to extract and integrate these cues within a game.

Description of Work:
- A literature review of models for human emotion
- A literature review of linguistic cues for human emotion
- Creating an artificial intelligence model to extract emotion-based linguistic cues
- Creating an artificial intelligence model to integrate the extracted cues with a gaming environment
- Testing the system

Project:	***Evolutionary Algorithms Through Adaptive Decomposition***
Program Code:	*1885*
Supervisor:	*Prof Hussein Abbass (h.abbass@adfa.edu.au)*

Objectives:
Evolutionary algorithms are implicitly parallel search techniques inspired by evolutionary principles. Work in evolutionary algorithms can take many forms including biologically motivated models and statistical modelling of an optimization problem. The objective of this project is to develop decomposition techniques for evolutionary algorithms in optimization and/or machine learning problems. The decomposition needs to be self-organizing, as such, it is not a fixed predefined scheme of decomposition.

Description of Work:
- A literature review of evolutionary algorithms for optimization and/or machine learning problems
- A literature review of decomposition techniques
- Creating a new evolutionary algorithm technique that is based on self-organized decomposition principles
- Testing the new technique

COMPUTATIONAL DECISION MAKING

Project:	***Interdependent Combinatorial Optimization in Complex Systems***
Program Code:	*1885*
Supervisor:	*Prof Hussein Abbass (h.abbass@adfa.edu.au)*

Objectives:
This project aims at understanding the dynamics of interdependency between combinatorial optimization problems. In complex systems, it is natural that two or more sub-systems are interconnected. Each of these sub-systems attempts to optimize its own performance. However, the optimal solution for one sub-system depends on the optimal solution for the other sub-systems. This interdependency is not understood well in the combinatorial optimization literature. This project will make a breakthrough in this area.

Description of Work:

- Understanding what makes a combinatorial optimization problem hard
- Developing a framework for analysing interdependency of combinatorial optimization problems
- Developing methodologies for solving interdependent combinatorial optimization problems.
- Testing the competitiveness of the different methodologies.

Project:	***Computational Scenario Planning for Disaster Management***
Program Code:	*1885*
Supervisor:	*Prof Hussein Abbass (h.abbass@adfa.edu.au)*

Objectives:
Scenarios are pen-pictures of plausible futures, used for strategic planning. The aim of this project is to expand the horizon of scenario-based planning through computational models that are able to aid the analyst in the planning process of a disaster. The investigation builds upon the advances of Information and Communication Technology (ICT) to create a novel, flexible and customizable computational capability-based planning methodology that is practical and theoretically sound. The project relies on fusing skills in Strategic Management and Scenario Planning with Evolutionary Computation, Simulation, and Graph Theory.

Description of Work:

- Developing an understanding of scenario planning
- Building skills in evolutionary computation, computational intelligence, simulation and graph theory
- Developing methodologies for representing and simulating large scale disaster scenarios
- Evaluating the system on a number of real-world situations.

COMPUTER SCIENCE

Project:	***Agent based evolutionary algorithms for solving constrained multi-objective optimization problems***
Program Code:	*1885*
Supervisor:	*A/Prof Ruhul Sarker (r.sarker@adfa.edu.au)*

Objectives:
The objective of this research is to develop a new agent based evolutionary algorithm for solving multi-objective constrained optimization problems.

Description of Work:

- Studying and analysing the existing multi-agent and evolutionary computation based approaches for solving different optimization problems.
- Designing and developing a new agent based evolutionary algorithm for solving small and medium scale constrained multi-objective optimization problems.
- Analysing the algorithm performance and carrying out the sensitivity analysis of different parameters required by the algorithm.
- Solving a reasonable number of well-known benchmark problems and comparing them with the state-of-the-art algorithms.

Skills Assumed:
Knowledge of optimization /operations research /management science and good computer programming skills.

Project:	***Job-shop scheduling with production interruption***
Program Code:	*1885*
Supervisor:	*A/Prof Ruhul Sarker (r.sarker@adfa.edu.au)*

Objectives:
The objective of this research is to develop a new evolutionary algorithm for solving and resolving job-shop scheduling problems when the production process is interrupted by any internal or external factors.

Description of Work:

- Studying and analysing the job-shop scheduling problems and their solution approaches.
- Designing and developing a new evolutionary algorithm for solving and resolving medium scale job-shop scheduling problems where the production can be interrupted by internal and external factors.
- Analysing the algorithm performance and carrying out the sensitivity analysis of different parameters required by the algorithm.
- Solving a reasonable number of benchmark problems and comparing them with the state-of-the-art algorithms (if any).

Skills Assumed:
Knowledge of optimization /operations research /management science and good computer programming skills.

Project:	***Multi-methodology for constrained optimization***
Program Code:	*1885*
Supervisor:	*A/Prof Ruhul Sarker (r.sarker@adfa.edu.au)*

Objectives:
The objective of this research is to develop a new solution approach by combining multiple evolutionary and related algorithms within a population based stochastic search structure for solving constrained optimization problems.

Description of Work:

- Studying and analysing the existing evolutionary computation based approaches and traditional optimization techniques for solving constrained optimization problems.
- Designing and developing a new solution approach where multiple evolutionary and related algorithms will explore the solution space in parallel by exchanging information at a regular interval.
- Analysing the algorithm performance and carrying out the sensitivity analysis of different parameters required by the algorithm.
- Solving a reasonable number of well-known benchmark problems and comparing them with the state-of-the-art algorithms.

Skills Assumed:
Knowledge of optimization /operations research /management science and good computer programming skills.

Project:	***Solving large scale multi-objective optimisation problems using evolutionary algorithms***
Program Code:	*1885*
Supervisor:	*A/Prof Ruhul Sarker (r.sarker@adfa.edu.au)*

Objectives:
The objective of this research is to develop a new evolutionary algorithm for solving large-scale multi-objective constrained optimization problems by dividing the tasks and using parallel machines.

Description of Work:

- Studying and analysing the existing evolutionary multi-objective algorithms for solving single and multi-objective constrained optimization problems.
- Designing and developing a new evolutionary algorithm for solving large-scale multi-objective constrained optimization problems that will allow an intelligent way of dividing the tasks for implementation in parallel machines.
- Analysing the algorithm performance and carrying out the sensitivity analysis of different parameters required by the algorithm.
- Solving a reasonable number of well-known benchmark problems and comparing them with the state-of-the-art algorithms.

Skills Assumed:
Knowledge of optimization /operations research /management science and good computer programming skills.

CONTROL THEORY AND CONTROL APPLICATIONS

Project:	***Consensus, Estimation and Control in Complex Large-Scale Quantum Systems***
Program Code:	*1643*
Supervisor:	*Prof Ian Petersen (i.petersen@adfa.edu.au)*

Objectives:
Advances in experimental physics are leading to exciting new possibilities in the area of quantum technology. The dynamics of quantum systems are fundamentally different from classical systems. New methods in control theory are needed to allow for these dynamics and to exploit the opportunities arising. The control challenges in these emerging quantum technologies require the control of systems with complex interactions of many particles and subsystems, as well as decoherence effects resulting from interaction with the environment. The aim is to build a substantial research effort to address these challenges by developing new theories of consensus, synchronisation, estimation and control for complex large-scale quantum systems. *This project is supported by an Australian Research Council Laureate Fellowship for Professor Petersen*

Description of Work:

- This research will involve fundamental control theory research in the area of Consensus, Estimation and Control in Complex Large-Scale Quantum Systems

Project:	***High-Bandwidth Control for Unmanned Helicopters***
Program Code:	*1643*
Supervisor:	*A/Prof Hemanshu R Pota (h.pota@adfa.edu.au)* *http://www.ee.adfa.edu.au/staff/hrp/*
Co-Supervisor	*Dr Matt Garrat (m.garratt@adfa.edu.au)*

Objectives:
This PhD work is a part of the project to develop high bandwidth control methods and advanced dynamic modelling for Rotorcraft Unmanned Aerial Vehicles (RUAVs). This will enable new roles such as the precision landing of RUAVs to the moving deck of a ship in rough seas. This and numerous other potential RUAV tasks are presently limited by the simple controllers used for such a responsive dynamic system. High-bandwidth control will be achieved by: a) developing higher fidelity modelling of helicopter dynamics, b) application of non-linear control techniques with novel extensions, c) sensing critical but previously unmeasured states of the helicopter system, and d) flight test validation. The advances will expand RUAV uses in many military and civilian applications.

Description of Work:

- Design on acceleration measurement control for disturbance rejection

- Design of state feedback optimal H-infinity Controllers for unmanned helicopters
- Implementation of the control algorithms on high fidelity simulation and special experimental test rig

Project:	***High Precision Control of Agricultural Equipment***
Program Code:	*1643*
Supervisor:	*A/Prof Hemanshu R Pota (h.pota@adfa.edu.au)* *http://www.ee.adfa.edu.au/staff/hrp/*
Co-Supervisor	*Dr Ray Eaton (r.eaton@unsw.edu.au)*

Objectives:
This PhD is a part of the project to develop robust control methodologies to precisely guide articulated off-road vehicles and attached trailers which are affected by slip. The significance in the research lies in the generic hybrid modelling approach to vehicle control, whereby the generic nature and relative simplicity of a kinematic model is beneficial in determining the trajectory tracking controller, yet the benefits of consideration of the vehicle's dynamics are also afforded without explicitly needing to know them. It is expected that a new class of non-linear control methodologies will be developed and experimentally verified, which deliver robust and precise trajectory-tracking performance for slip affected vehicles.

Description of Work:
- Obtaining velocity kinematic models of tractor-implement system with side-slip velocities
- Obtaining input-output pairs for the dynamic model which satisfy passivity conditions
- Design of controllers for the velocity kinematic that incorporate passive dynamic models
- Implementation of the controller on the experimental tractor-trailer system

Project:	***Interconnected Power Systems and Complex Dynamic Networks***
Program Code:	*1643*
Supervisor:	*A/Prof Hemanshu R Pota (h.pota@adfa.edu.au)* *http://www.ee.adfa.edu.au/staff/hrp/*
Co-Supervisor	*Prof David J. Hill (david.hill@anu.edu.au)*

Objectives:
Analysis of complex dynamical networks has been used to predict synchronisation of nodes with similar dynamics and certain types of network configurations. Interconnected power systems form a complex dynamical network, but there is neither an apparent regularity in the interconnections nor do all the nodes have identical dynamics. Traditionally interconnected power systems are analysed using tools which penalise strong interconnections but the practical reality is that strong interconnections help in synchronising the system. Complex dynamical network analysis rewards strong interconnections so it is natural to analyse interconnected power systems in this framework. The PhD work will involve the analysis and control of power systems with large wind generators.

Description of Work:
- Literature review of complex dynamical network analysis with irregular networks and non-identical nodes.
- Modelling of power systems with large wind generation.
- Design of controllers in the complex dynamical networks' framework for synchronising nodes with non-identical generation nodes.

Project:	***Research in Decentralized and Distributed Robust Control***
Program Code:	*1643*
Supervisor:	*A/Prof V. Ougrinovski (v.ougrinovski@adfa.edu.au)*
Co-Supervisor	*Prof Ian Petersen*

Objectives:
Interconnected control systems are widespread in engineering, defence and communications applications. Examples of such systems include a team of unmanned aerial vehicles pursuing a set of coordinated objectives, a platoon of vehicles on the highway, an array of actuated micro-electromechanical systems (MEMS), to name a few. Such systems are coupled dynamically or via team objective constraints and are characterized by a high level of complexity including modelling uncertainties and changes in the system configuration. The project will look into methodologies of robust control design for distributed and large-scale uncertain systems, which make use of the interconnection structure of the system.

Description of Work:
- Develop new mathematical methodologies of robust control design for uncertain distributed and large-scale nonlinear interconnected systems. Possible theoretical applications and models involve control of large systems consisting of interacting agents, control of large-scale networked systems.
- The project will involve mathematical research in the area of modern control theory.

Project:	***Robust scanning controllers for Atomic Force Microscopes (AFM)***
Program Code:	*1643*
Supervisor:	*A/Prof Hemanshu R Pota (h.pota@adfa.edu.au)* *http://www.ee.adfa.edu.au/staff/hrp/*
Co-Supervisor	*Prof Ian Petersen (i.petersen@adfa.edu.au)* *http://routh.ee.adfa.edu.au/~irp/P1.html*

Objectives:
The overall aim of this project is to increase the image scan rates of scanning AFM. Our control applications research laboratory has a scanning AFM. The work in this project involves both theoretical design of controllers and their experimental implementation. The AFM consists of a three degrees-of-freedom piezoelectric stack, a cantilever, and an optical arrangement to measure the cantilever tip-position. The image is the cantilever tip-position as the sample is moved in the x-y direction. Presently a PhD student is working to increase the x-y scan rate of this AFM. The proposed PhD is to include the cantilever dynamics and z-position loop in the design of the controller.

Description of Work:
- Model the z-position loop using experimental data and theoretical analysis.
- Obtain a suitable representation of the hysteresis nonlinearities and sensor noise.
- Design high bandwidth controller for faster image scan rates.

FORENSIC INSTRUMENTATION

Project:	***Analysis of bulk organic explosives for forensic laboratories***
Program Code:	*1643*
Supervisor:	*A/Prof Charles Harb (c.harb@adfa.edu.au)*
Co-Supervisor	*Prof Elanor Huntington*

Objectives:
Analysis of bulk organic explosives is a straightforward task for well-equipped forensic laboratories, but it is more difficult for them to analyse trace amounts of organic explosive residues; this usually requires an elaborate sequence of solvent extraction from swabs and some form of chromatographic or electrophoretic separation. Suitable detection techniques

include ion mobility spectrometry (IMS), mass spectrometry and thermal energy analysis, however, such analytical systems lack the sensitivity to analyse explosive residues in vapour samples because of the very low vapour pressures. We aim to develop a cavity-enhanced spectroscopic instrument as a high-throughput screening tool for trace explosive detection, and potentially for other threats such as biological or chemical hazards. The method that we shall use to achieve this aim is **cavity ringdown spectroscopy (CRDS)**, which is a laser-based direct-absorption technique. CRDS offers a significant increase in sensitivity, sufficient to permit detection of organic explosives in the vapour phase.

Description of Work:

- Design and build the CRDS System;
- Design and build the detection and modulation/demodulation systems;
- Make measurements on different substances of interest, and catalog the data.
- Investigate algorithms to pattern match the database with unknown samples.

HIGH FREQUENCY ENGINEERING

Project:	***Composite Right-Left Hand Transmission Line Structures***
Program Code:	*1643*
Supervisor:	*Dr Greg Milford (g.milford@adfa.edu.au)*

Objectives:
The non-conventional propagation characteristics of composite right-left hand transmission lines (CRLH TL) offer a new degree of freedom for the design of high frequency wave-guiding and wave-radiating components. Although this field is relatively new, various methods for inserting left-handed behaviour into conventional right-handed structures have been demonstrated for 1-dimensional and 2-dimensional structures. This project will investigate new ways of constructing planar CRLH TL unit cells, making use of equivalent circuit models to link electrical performance specifications and physical geometry parameters. New fabrication methods may need to be developed, and various CRLH TL devices will be constructed to demonstrate device performance.

Description of Work:

- Develop equivalent circuit models for distributed CRLH TL unit cells
- Develop synthesis methods for determining distributed circuit element geometry
- Develop fabrication methods to construct unit cells; construct and characterise 1D and 2D demonstration devices.

Project:	***Nonlinear Transmission Line Metamaterials***
Program Code:	*1643*
Supervisor:	*Dr Greg Milford (g.milford@adfa.edu.au)*
Co-Supervisor	*Dr Ilya Shadrivov (ivs124@physics.anu.edu.au)*

Objectives:
The non-conventional propagation characteristics of composite right-left hand transmission lines (CRLH TL) offer a new degree of freedom for the design of high frequency wave-guiding and wave-radiating components. The inclusion of nonlinear circuit elements to the CRLH TL adds an extra dimension to the dispersion engineering potential of these structures. This project will investigate the behaviour of nonlinear CRLH TL structures, with the aim of developing improved analytical techniques (time and frequency domain) for describing NL CRLH TL behaviour. Additionally, distributed nonlinear CRLH TL structures will be investigated with a view to operation at millimetre-wave and THz frequency operation, for signal generation and processing applications at these frequencies.

Description of Work:

- Develop improved methods for analysing nonlinear CRLH TL structures
- Develop techniques for fabricating and controlling distributed nonlinearities

- Design and characterise planar CRLH TLs with distributed nonlinearities for harmonic generation and/or parametric amplification.

Project:	***Optimisation of Planar Antenna Structures***
Program Code:	*1643*
Supervisor:	*Dr Greg Milford (g.milford@adfa.edu.au)*
Co-Supervisor	*Prof Hussein Abbass (h.abbass@adfa.edu.au)*

Objectives:
Planar antenna structures are well suited to portable communications equipment due to their small size, low cost and ease of integration with associated electronics. The design of these antennas generally requires use of full-wave electromagnetic simulators to include the effects of the conducting and dielectric environment surrounding the radiator. This project will investigate the application of evolutionary computation (EC) methods to the optimisation of antenna structures to achieve the specified design goals, with a view to determining which algorithms work best under various circumstances. This will require tight coupling of the optimiser and electromagnetic simulator to minimise the computational cost in arriving at the optimum antenna design.

Description of Work:
- Determine the applicability and limitations of EC methods to planar antenna design
- Develop methods of integrating full-wave electromagnetic simulators with the EC optimiser to minimise the overall computation cost
- Use this approach to devise new antennas with superior performance characteristics.

IMAGE PROCESSING

Project:	***Automated digitising and cataloguing of insects and plants***
Program Code:	*1661*
Supervisor:	*Dr Andrew Lambert (a.lambert@adfa.edu.au)*
Co-Supervisor	*Dr Murat Tahtali (m.tahtali@adfa.edu.au)* *Dr John LaSalle (john.lasalle@csiro.au)* *Dr Robert Furbank (Robert.Furbank@csiro.au)*

Objectives:
The objective of this thesis is to develop an automated 3D digitising and cataloguing platform for insects and plants. The specimen will be digitised into a 3D model and, through feature extraction, catalogued using an adaptive algorithm.

This project involves design of opto-mechanical equipment and the development of image processing software.

Project:	***General Image Processing***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*
Co-Supervisor	

Objectives:
This project investigates image processing related issues such as medical image encryption, transmission, e-health and pattern recognition etc.

Description of Work:
- Studying and analysing related image processing algorithms
- Designing new algorithms

Skills Required::

Good math background especially statistics, solid image processing knowledge and concrete programming skills.

LASER INSTRUMENTATION

Project:	***Continuously Tuneable Wavelength-Measurement Technology for Optical DWDM Communication Systems***
Program Code:	*1643*
Supervisor:	*A/Prof Charles Harb (c.harb@adfa.edu.au)*
Co-Supervisor	*Prof Elanor Huntington*

Objectives:
This project is designed to address the needs for the next generation of tuneable optical wavelength sources for optical telecommunications, biotechnology, antiterrorism, and medical diagnostics. We propose to develop a simple, accurate, extremely fast, low cost, and compact wavelength meter for use with tuneable lasers. The proposed system will increase the speed for testing tuneable lasers – by factors of thousands (or millions). If successful, this technology can replace large, bulky wavemeters and optical spectrum analysers with compact, fast modules. It tunes tuneable lasers more precisely, diagnoses DWDM channels more economically, and provides tuneable intelligence for optical telecommunications.

Description of Work:
- Design and build the wavelength locking system;
- Design and build the detection and modulation/demodulation systems;
- Make measurements at different wavelengths, and catalogue the data;
- Investigate digital signal processing techniques that compare the data with an unknown wavelength.

Project:	***Efficient Broadband Beamforming Algorithms and Structures***
Program Code:	*1643*
Supervisor:	*A/Prof Lal C Godara (l.godara@adfa.edu.au)*

Smart antennas technology is becoming a hot topic for its applications in the areas of radar, sonar and communications. Signals, induced on an array of sensors such as antennas, microphones and hydrophones, are normally processed using narrowband processor structures when signal bandwidth is much smaller than its centre frequency. However, as the signal bandwidth increases, the performance of an array processor using narrowband structure where induced signals on sensors are multiplied by complex weights, starts to deteriorate. To process broadband signals, a tapped delay line (TDL) filter in front of each element is used and this normally requires a large computation time particularly when a large array of sensors is used. This becomes a problem in many applications where real time computation of TDL filter coefficients is required.

Aim of this research is to develop new robust smart antenna structures and algorithms, which deliver real time computational saving, provide immunity against various implementation errors present in the existing array processors and have efficient scanning properties.

Project:	***Hyperspectral Data Representation for Signal Enhancement***
Program Code:	*1643*
Supervisor:	*Dr Xiuping Jia (x.jia@adfa.edu.au)*

Objectives:
As the advance of the technology in sensor design and manufacture, hyperspectral imagers have become available since late of 80s. A typical hyperspectral data cube is composed of about 100 to 200 spectral measurements and provides rich spectral information of the ground cover materials, in general. However, not all the measurements are important and essential for individual applications where users have their focused culture or natural classes of interest.

The use of the unnecessary measurements creates difficulties in machine learning processing and reduces the reliability of thematic mapping. Another problem is that the original measures may not be the distinct features. Data representation is required to generate better signatures of the classes of interest. In this project, supervised feature selection and generation will be investigated. The outcome is significant practically and scientifically.

Description of Work:

- Examine the materials spectral characteristics quantitatively
- . Evaluation of current feature selection and generation methods
- Develop new effective techniques
- Implement and validation

Project:	***Large scale network measurement***
Program Code:	*1643*
Supervisor:	*Dr Weiping Zhu (w.zhu@adfa.edu.au)*

Objectives:

A large network as the Internet is often divided into a number of domains (like ISPs) and all domains are independently managed. One ISP cannot access other ISPs networks. However, we need to find the characteristics of the whole network, such as link-level loss rates, link level delay distribution, available bandwidth, network topology. etc. to understand the network behaviours. Using the characteristics, we can further to set up models and study the interactions between different components. The key question here is how to find those characteristics without direct measurement, simply rely on end-to-end measurement. The research at this moment are focused on the following three areas:

a) Loss tomography, which aims to estimate/infer loss rates of each link by end-to-end observation. We have some good results for a tree topology and is going to extend them into a general topology
b) Delay tomography, which is for estimating delay distribution. In this area, we also have some good results by using sequential imputation. The work needs to be extending to general topology.
c) Temporal tomography, which aims to find the temporal/spatial correlations, such as transition matrix, of the links. In this situation, observations are related to each other, as Markov chain. With transition matrix, we will be able to understand the temporal correlation between network states. Hidden Markov model, etc. are under investigation to uncover the temporal information.
d) Spatial tomography, in contrast to temporal tomography, aims to find spatial correlation between links in a network, such as a link has heavy delay, whether this delay will have any impact to its neighbours and by how much.

Topology estimation/identification can use in some bioinformatics techniques, such as inferring motif.

Project:	***Stochastic Network Control***
Program Code:	*1643*
Supervisor:	*Dr Weiping Zhu (w.zhu@adfa.edu.au)*

Objectives:

TCP has been used in the Internet for 30 years. Despite of its success, it has shown the sign of strain. Previously used feedback control falls short of providing what we want, in particular the necessity to handle the dynamics of traffic. Network community starts to worry about this but has not come out with a rescue. This research aims to build a stochastic model that considers the impact of feedback delay on the addictive increase and multiplicative decrease used by TCP, and investigate the degree of the impact on the resource utilization, transmission rate, transport latent, jitter, etc. The findings will lead to a proposal of a new protocol.

Project:	***Subpixel Information Retrieval from Remote Sensing Data***
Program Code:	*1643*
Supervisor:	*Dr Xiuping Jia (x.jia@adfa.edu.au)*

Objectives:
Remote sensing image data generated by various sensors, especially, hyperspectral sensors, have limited spatial resolution. Subpixel signal retrieval is challenging. One of the issues is the collinearity when a least squared solution is involved. The problem damages the subsignal inversion robustness. This project will investigate the problem and develop effective solutions.

The outcome is significant practically and scientifically.

Description of Work:

- Examine the collinearity problem quantitatively
- . Evaluation of current studies
- Develop the techniques to overcome the problem
- Implement and validation

Project:	***Super Resolution of Remote Sensing Data***
Program Code:	*1643 or 1845*
Supervisor:	*Dr Xiuping Jia (x.jia@adfa.edu.au)*

Objectives:
Remote sensing image data generated by various sensors, especially, hyperspectral sensors, have limited spatial resolution. It is valuable to improve the resolution via post possessing. Mathematical modelling and computer power can be used to generate finer classification map than the original pixel resolution. Super resolution has been investigated in different ways in recent years, including super resolving data and super resolving decision. There are wide issues and research in this area. The outcome is significant practically and scientifically

Description of Work:

- Evaluation of current studies
- Improve the modelling or reducing computational complexity
- Implement real data processing framework.

Project:	***Traffic control over overlayed networks***
Program Code:	*1643*
Supervisor:	*Dr Weiping Zhu (w.zhu@adfa.edu.au)*

Objectives:
The emergence of Ipv6 allows a node to use multiple paths connecting itself to a destination to transfer data for high performance. The questions that one needs to consider are:

- How to select paths dynamically that can maximize its performance?
- How to distribute packets to each path that can balance the traffic on the available paths?
- How avoid competition with other users (game theory in distributed control)?
- How to predict traffic on each path/link (related to network tomography)
- Relayer selection and functions
- Interconnection between overlays
- Whether the above steps will lead to a stable system?

We have some basic results in this direction, but a lot of them require further investigation

NETWORKING

Project:	***General Networking***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*

Objectives:
This project investigates latest development in Networking such as P2P etc..

Description of Work:
- Studying and analysing P2P networking and applications algorithms
- Designing new algorithms

Skills Required::
Good math background especially statistics, solid networking knowledge and concrete programming skills.

Project:	***Internet of Things***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*
Co-Supervisor	*Prof Ian Petersen*

Objectives:
Internet of things is considered as a next big topic in networking. This project investigates latest development in Internet of Things.

Description of Work:
- Studying and analysing Internet of Things algorithms
- Designing new Internet of Things algorithms

Skills Required::
Good math background especially statistics, solid networking knowledge and concrete programming skills.

NETWORK SECURITY

Project:	***General Cyber Security***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*

Objectives:
This project investigates general cyber security issues such as access control, social engineering, face book, privacy etc.

Description of Work:
- Studying and analysing existing relevant cyber security algorithms
- Designing new algorithms

Skills Required::
Good math background especially statistics, solid networking knowledge and concrete programming skills.

Project:	***Host-based Intrusion Detection***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*

Objectives:
Firewalls cannot prevent new attacks. This project investigates how to detect attacks that have penetrated the firewalls.

Description of Work:
- Studying and analysing existing host-based intrusion detection algorithms
- Designing new host-based intrusion detection algorithms

Skills Required::
Good math background especially statistics, solid networking knowledge and concrete programming skills.

Project:	***Network Intrusion Detection***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*

Objectives:
Network attacks are happening daily and have caused huge damage to our society. This project investigates latest network intrusion detection technology such DDoS attack detection.

Description of Work:
- Studying and analysing existing network intrusion detection algorithms
- Designing new network intrusion detection algorithms

Skills Required:
Good math background especially statistics, solid networking knowledge and concrete programming skills.

Project:	***Wireless Sensor Network Security***
Program Code:	*1885*
Supervisor:	*Prof Jiankun Hu (J.hu@adfa.edu.au)* *http://seit.unsw.adfa.edu.au/staff/sites/hu/*

Objectives:
Wireless network especially sensor networks are pervasive. This project investigates security issues in wireless sensor networks such as key management and back hole detection.

Description of Work:
Studying and analysing existing sensor network security algorithms
Designing new sensor network security algorithms

Skills Required::
Good math background especially statistics, solid networking knowledge and concrete programming skills

OPTICAL DEVICES

Project:	***Automated digitising and cataloguing of insects and plants***
Program Code:	*1661*
Supervisor:	*Dr Murat Tahtali (m.tahtali@adfa.edu.au)*
Co-Supervisor	*Dr John LaSalle (john.lasalle@csiro.au)* *Dr Robert Furbank (Robert.Furbank@csiro.au)*

Objectives:
The objective of this thesis is to develop an automated 3D digitising and cataloguing platform for insects and plants. The specimen will be digitised into a 3D model and, through feature extraction, catalogued using an adaptive algorithm.

This project involves design of opto-mechanical equipment and the development of image processing software.

Project:	***Plasmonic nano-antennas at optical wavelengths.***
Program Code:	*1643*
Supervisor:	*Dr Haroldo T. Hattori (h.hattori@adfa.edu.au)* *Prof Elanor Huntington (e.huntington@adfa.edu.au)* *Associate Prof Tuan Pham (t.pham@adfa.edu.au)*

Objectives:
Plasmonic waves are electromagnetic excitations that propagate at the interface between dielectrics and metals (surface waves). Devices based upon the propagation of plasmonic waves have opened the possibility of developing very compact optical devices. Among a multitude of plasmonic optical devices, nano-antennas offer the most promising applications. These nano-antennas generate high intense electrical fields in very small regions, which allow the selective attraction of certain nano-particles, investigate molecular processes in living cells and create new biological and chemical sensors

Description of Work:

- Design these nano-antennas to operate with semiconductor materials (GaAs or InP platforms).
- Integrate these nano-antennas with active devices such as quantum dot lasers.
- Examine the possibility of creating novel bio-sensors and novel bio-imaging systems.
- Fabricate these devices with either focused ion beam milling systems and/or electron beam.
- Lithography and reactive ion etching systems
- Characterise the fabricated nano-antennas and test it with selective biological applications..

QUANTUM OPTICS

Project:	***Experiments in Coherent State Quantum Computing***
Program Code:	*1643*
Supervisor:	*Prof Elanor Huntington (e.huntington@adfa.edu.au)*
Co-Supervisor	*A/Prof Charles Harb*

Objectives:
There is considerable international research effort focused on the development of viable quantum computer technologies. Linear Optical Quantum Computing has proven to be a successful test-bed for experimental quantum computation with seminal experimental demonstrations of quantum logic operations on single photons. All of these schemes encode the quantum information on two different modes of an optical field and are known as "dual-rail" encoding schemes. A series of alternative, potentially superior, optical quantum computation schemes have been proposed based on "single-rail" encoding schemes.
Single-rail optical quantum computing is an alternative, and potentially superior, approach to optical QC. The basis states are coherent states (multi-photon states that exhibit classical optical coherence) that can be created deterministically from well-stabilised lasers. Such states are non-orthogonal, but can serve as qubits under appropriate conditions.
Such experiments will require quantum optics outside the realm of coincident measurement techniques and involve real-time quantum control, thus providing new techniques of direct relevance to our other optical quantum computation schemes. The goal of this project is to demonstrate basic quantum logic operations on non-classical optical states suitable for single-

rail encoding schemes. Successful completion of this project has the potential to demonstrate an alterative optical quantum computation scheme which may be more amenable to scale-up that existing schemes.

Description of Work:

- Design and build the "cat-state" source;
- Design and build the detection systems;
- Measure the states and compare to theoretical models.

Project:	***Optimal control of Quantum Optical Systems***
Program Code:	*1643*
Supervisor:	*Prof Elanor Huntington (e.huntington@adfa.edu.au)*
Co-Supervisor	*Prof Ian Petersen (i.petersen@adfa.edu.au)* *http://routh.ee.adfa.edu.au/~irp/P1.html*

Objectives:

There is considerable international research effort focused on the development of viable quantum computer technologies. Linear Optical Quantum Computing has proven to be a successful test-bed for experimental quantum computation with seminal experimental demonstrations of quantum logic operations on single photons. All of these schemes encode the quantum information on two different modes of an optical field and are known as "dual-rail" encoding schemes. A series of alternative, potentially superior, optical quantum computation schemes have been proposed based on "single-rail" encoding schemes.
Single-rail optical quantum computing is an alternative, and potentially superior, approach to optical QC. The basis states are coherent states (multi-photon states that exhibit classical optical coherence) that can be created deterministically from well-stabilised lasers. Such states are non-orthogonal, but can serve as qubits under appropriate conditions.
Such experiments will require quantum optics outside the realm of coincident measurement techniques and involve real-time quantum control, thus
providing new techniques of direct relevance to our other optical quantum computation schemes. The goal of this project is to demonstrate the application of modern control techniques such as LQG, H-infinity and Kalman filtering to non-classical optical states suitable for optical quantum computation.

Description of Work:

- Design and build the non-classical plant;
- Define H-infinity control objectives;
- Design and construct optimal controllers.

UNDERWATER NETWORKS

Project:	***High Capacity Underwater Networks***
Program Code:	*1885 or 1643*
Supervisor:	*Prof Michael Frater (m.frater@adfa.edu.au)*

Objectives:

This project is part of a larger program to build a low-cost, large-scale, high-capacity underwater sensor network consisting of thousands of nodes. The aim of this project is to understand the bounds on the performance of underwater networks, and to develop better networking protocols.

Description of Work:

- Apply ideas from information theory to underwater networks
- Investigate scalability of networking protocols for underwater networks
- Develop improved protocols for underwater networks.

Project:	***Distributed Processing in Underwater Sensor Networks***
Program Code:	*1885 or 1643*
Supervisor:	*Prof Michael Frater (m.frater@adfa.edu.au)*

Objectives:
This project is part of a larger program to build a low-cost, large-scale, high-capacity underwater sensor network consisting of thousands of nodes. The aim of this project is to develop algorithms for sharing and processing sensor data from large numbers of low-quality sensors. Applications include measurement of environmental data such as ocean currents, and direction finding for underwater transmitters.

Description of Work:

- Investigate suitability of distributed processing algorithms for underwater networks
- Adapt and improve selected algorithms for the underwater environment
- Implement algorithms in a large-scale sensor network.

SCHOOL OF HUMANITIES AND SOCIAL SCIENCES

http://hass.unsw.adfa.edu.au/

For all of the research areas listed below, please contact the Postgraduate Coordinator, Dr Craig Stockings: hasspgresearch@adfa.edu.au.

POLITICS PROGRAM

- Political Theory & International Relations Theory
- Asian Politics & Asian Regional Security
- Australian Politics and Foreign/Defence Policy
- History of political thought
- Comparative political thought
- Democracy and democratisation
- Political culture
- International relations theory
- Australian politics
- Australian foreign and Defence policy
- Politics and international relations of China, Japan and North/South Koreas
- Politics and international relations of Southeast Asia
- Australia-Asia relations
- Terrorism
- Maritime security issues
- Non-traditional security

HISTORY PROGRAM

- World history
- History of the two World Wars
- Australian History
- Australian military history
- Korea War
- Vietnam War
- Russian and Soviet history
- German history
- British & Empire history
- Economic history
- Asian history
- Naval history

INDONESIAN STUDIES PROGRAM

- Indonesian language
- Indonesian culture and society
- Indonesian literature and art
- Indonesian media
- Contemporary Islam in Southeast Asia

ENGLISH PROGRAM

- Australian literature and literary history
- American Studies
- Contemporary Australian Art and Media
- Scholarly editing and bibliography
- Applied linguistics
- Discourse analysis

ETHICS PROGRAM

- Applied Ethics
- Theoretical Ethics
- Military Ethics & the Ethics of Conflict
- Ethical Decision-making

SCHOOL OF PHYSICAL, ENVIRONMENTAL & MATHEMATICAL SCIENCES

http://pems.unsw.adfa.edu.au/

APPLIED MATHEMATICS

Project:	***Analysis of stagnant regions in flowing granular materials***
Program Code:	*1881*
Supervisor:	*A/Prof H.S. Sidhu (h.sidhu@adfa.edu.au)*
Co-Supervisor	*Drs Grant Cox and Mark Nelson*

Project Description:
Many industrial processes involve the flow of granular materials under gravity. Under certain circumstances the granular material may stop flowing due to the formation of 'rat-holes' or 'arches'. We will develop advanced mathematical models to predict when rat-holes or arches form, which will enable the size, shape and location of resulting regions of stagnant material to be predicted. Such regions are particularly dangerous in the coal industry, where there is a potential for spontaneous combustion to provide a trigger for a dust explosion. We will assess the tendency of any regions of stagnant material that are formed to spontaneously combust. This will lead to design criteria that will prevent these obstructions and explosions

Objectives:
The major concern of this proposal is to develop a stability condition that will predict whether a rat-hole or arch is going to be stable or unstable, and whether silos and stockpiles containing a stable rat-hole or arch have regions of stagnant material that may combust. Gaining the ability to accurately predict the formation and stability of rat-holes and arches will enhance the technology of designing silos and stockpiles, preventing such unwanted phenomena from occurring. Further, once the methodology is correctly developed, it may be applied to other granular problems, such as avalanches and earthquakes in nature, and settlement and impact moulding in industry.

Project:	***Efficient Operation of Bioreactors using Nonlinear Dynamical Systems Theory***
Program Code:	*1881*
Supervisor:	*A/Prof H.S. Sidhu (h.sidhu@adfa.edu.au)*
Co-Supervisor	*Dr Mark Nelson*

Project Description & Objectives:
A recent novel strategy, using two bioreactors in series with one forcing the other, has shown promising results in terms of yield improvement. Work so far has been preliminary, and has relied only upon numerical calculations. This approach is not only slow but has been reported to omit optimum operating conditions. This interdisciplinary project will apply systematic, efficient and robust mathematical techniques from dynamical systems theory to such reactor engineering problems. We will also establish a general framework by which multiple reactor chemical or bioengineering systems (such as sludge wastewater treatment plants, production of ethanol via fermentation tanks) can be efficiently investigated to determine optimum reactor performance.

Project:	***Multi-step combustion mode***
Program Code:	*1881*
Supervisor:	*A/Prof H.S. Sidhu (h.sidhu@adfa.edu.au)*

Project Description & Objectives:
Inefficient combustion arising from instabilities during industrial processes adversely affects the environment and has serious safety and economic implications. Current modelling schemes are (i) single-step kinetics which oversimplify the process; (ii) detailed schemes that allow only numerical investigation without providing a deeper understanding of the underlying behaviour. To enable a better understanding of combustion dynamics we will

investigate reactions ranging from two- to multi-step kinetics in several configurations using mathematical tools developed by our group. In the process, we will be tackling the fundamental problem of efficient algorithms for analysing the stability of solutions from differential equations. This has immediate applications to various fields of science.

Project:	***Mathematical modelling of the gastrointestinal tract (GIT)***
Program Code:	*1881*
Supervisor:	*A/Prof H.S. Sidhu (h.sidhu@adfa.edu.au)*
Co-Supervisor	*Prof X.D. Chen & Dr Mark Nelson*

Project Description & Objectives:
The project examines the use of mathematical tools to model the GIT. We utilize the chemical engineering approach and treat the GIT as a unique chemical reactor (or a series of them), and the digestion, and absorption processes can be quantitatively modeled using knowledge of chemical engineering, physiology and biochemistry. Having a successful in vitro model of the human GIT may lead to a revolution in the area of food engineering.

Project:	***Nonlinear Effects in Bent Optical Waveguides***
Program Code:	*1881*
Supervisor:	*Dr Zlatko Jovanoski (z.jovanoski@adfa.edu.au)*

Project description: A detailed theoretical study of non-linear effects in bent optical waveguides is proposed. This involves the numerical modelling and solution of the equations describing the propagation of light in non-linear bent waveguides. With the continuing development of optical communications systems it is fundamentally important to understand how light beams that have intensities in the non-linear regime are affected by bends in the waveguide. Once this behaviour is modelled, the potential exists to exploit the polarization and pulse propagation properties of non-linear light beams in bent structures to systematically design optical devices for use in future all-optical communication systems.

The specific aims are:

- To begin the basic mathematical analysis using continuous-wave theory that will be used to synthesize the theory of bends and nonlinearities.
- To extend the basic theory to include the effects of polarisation, taking into account different waveguide structures. This is the first stage of this grant proposal.
- To build into the theory the effect of propagating frequency-dependent pulses, and comparing results to continuous-wave theory.
- To move to a more advanced mathematical regime and examine the full theory of bends and nonlinearity, where now the nonlinearity may be high enough to change the transverse modal field.

Project:	***Optimizing performance of chemical reactions via periodic operation***
Program Code:	*1881*
Supervisor:	*A/Prof H.S. Sidhu (h.sidhu@adfa.edu.au)*
Co-Supervisor	*Prof A.A. Adesoji & Dr Mark Nelson*

Project Description & Objectives:
The project examines the use of mathematical analysis to determine the best parameters for minimum resource use for a exothermic chemical reactor (such as that used for the production of hydrogen (a clean fuel) from liquefied petroleum gas). This makes the new reactor applicable to petrochemical and fuel cell industries for both stationary and mobile purposes like cars, space craft and oil tankers.

More specifically the project aims to:

- Evaluate the unsteady-state model for the periodic flow catalytic reactor (PFCR) in order to provide a basis for computer-aided prediction of its performance for wide

ranging input conditions as may be encountered in practical situations.
Optimize cycle parameters (frequency, split, etc) to achieve thermal self-sustainability simultaneously with coke minimization in the PFCR and hence, establish a dynamic optimal control strategy for product selectivity for either stationary or mobile application.

ASTRONOMY

Project:	***Star Formation in Dark Clouds***
Program Code:	*1892*
Supervisor:	*Dr Robert G. Smith (r.smith@adfa.edu.au)*

Objectives:
This project examines star formation in dark clouds in the plane of the galaxy.

Background: The earliest stages of star formation which can be reasonably studied are when a dense core forms within a dusty envelope in a dark cloud. This is followed by the formation of a disk and bipolar outflows. As the star evolves, the envelope transfers all its mass to the disc and the disc in turn transfers this to the core (which will eventually become a star) and the outflows disappear. Each of these stages has characteristic signatures which can be seen in different parts of the spectrum, radio, infrared and optical. The problem is recognizing which dark clouds are likely to form stars and determining what type (i.e. mass) of star is likely to be formed. One step on the way to understanding these problems is identifying and studying more stars at this stage of their evolution.

Description of Work:

- Initially, data from available online catalogues of infrared observations (2MASS and Spitzer GLIMPSE) will be used to first map the dust density distribution in the dark cloud regions to locate likely sites of recent star formation and then (from the catalogue colours), to identify candidate Young Stellar Objects (YSOs) within these clouds;
- Subsequently, the YSO's will be studied using ground-based infrared, optical and radio telescopes to identify their evolutionary status and characterize their disks and/or envelopes;
- The initial dust density distributions will be combined with existing radio atomic and molecular line surveys for those dark clouds in which YSO's are identified to distinguish between those with and without star formation.

ATMOSPHERIC PHYSICS AND METEOROLOGY

Project:	***A new Radio Acoustic Sounding System (RASS) for probing fog***
Program Code:	*1892*
Supervisor:	*Dr John Taylor (j.taylor@adfa.edu.au)*

Objectives:
To develop a combined acoustic and electromagnetic instrument, a RASS, that operates in the 2.4 to 3.0 GHz band and is able to resolve the temperature structure in the lowest 150 m of the nocturnal boundary layer. This instrument will then be utilized in an investigation of methods for predicting local fog formation and clearance.

Description of Work:

- We have a RASS that operates at a radio frequency of 1.275 GHz. The initial part of this project would be to use this as the basis of a "mini" RASS that operates at approximately twice the frequency, hence has double the spatial and temporal resolution, of the present instrument.
- Once the developed and tested we could use the temperature and wind profiles from the RASS and a high frequency sodar to test a range of models for fog formation and

clearance. Earlier work suggests that a dynamical one-dimensional model may be useful for "now casting" fog clearance.

Project:	***Development and application of an improved electromagnetic wind profiler.***
Program Code:	*1892*
Supervisor:	*Dr John Taylor (j.taylor@adfa.edu.au)*

Objectives:
To improve the range and resolution of our existing 1275 MHz boundary layer wind profiler by incorporating pulse coding and compare the wind and turbulence information from this instrument with the Bureau of Meteorology's operational 70 MHz spaced antenna profiler located at Canberra Airport.

Description of Work:

- We have a prototype 1275 MHz boundary layer wind profiler that we used for a successful field experiment in south eastern Australia in 2000. We would like to modify this system to include pulse coding to improve its range and resolution. The initial part of this project would involve working on the hardware and software for the system.
- Once completed, we would look at data obtained simultaneously from our 1275 MHz system and the Bureau of Meteorology's operational 70 MHz boundary layer wind profiler installed at Canberra airport. This part of the project would focus on the information about the atmosphere that can be acquired by having these two systems (almost) co-located.

Project:	***Testing the representation of boundary layer turbulence in mesoscale meteorological models***
Program Code:	*1892*
Supervisor:	*Dr John Taylor (j.taylor@adfa.edu.au)*

The numerically-based forecasting of mesoscale meteorological phenomena, such as sea breezes, thunderstorm outflows and other density-driven flows, are dependent on the accuracy of the turbulence parameterization in the model. This is because density-driven flows in the atmosphere are generally embedded within the atmospheric boundary layer, and characteristics such as their propagation speed and velocity structure will be dependent on the vertical exchange of momentum within the boundary layer.
Ground-based remote sensing instrumentation provides information on some key atmospheric turbulence parameters beyond the height range that is readily accessible to surface- and tower-based instrumentation, and over much longer periods of time than can be acquired with airborne sensors such as aircraft or moored balloons and kites.
Within the Lower Atmosphere Research Group in the School of PEMS, UNSW@ADFA, there is an extensive set of spectral data from acoustic wind profilers, or SODARs (SOund Detection And Ranging systems), collected in regions in Australia ranging from tropical far northern Queensland to the Canberra region in south eastern Australia. A wide range of interesting mesoscale phenomena have been captured in this data. The principles of deriving turbulence information from sodar data are relatively well understood, so that this data set provides a valuable resource for testing the turbulence parameterisations built into mesoscale models.
The objectives of this project would be:

1. To complete the analysis of the sodar data set to extract turbulence parameters and estimates of the parameter reliability;
2. Compare cases from the sodar data set with selected numerical runs for a range of flow phenomena: sea breezes and plateau winds; frontal systems; convective outflows; atmospheric solitary waves; etc.
3. Use a statistical approach to compare model predictions with observations over the full periods of the available data sets.

The Lower Atmosphere Research Group in PEMS has used the meteorology component of

the CSIRO model TAPM (The Air Pollution Model) in previous studies, and it will also be used in addressing objectives 2 and 3 above. For the case study component (2) we intend to access numerical simulations from other mesoscale models such as MM5. This component of the work will be in collaboration with the Centre for Dynamical Meteorology and Oceanography at Monash University, who were also involved in the northern Queensland sodar deployments as part of ARC DP0558793.

CHEMISTRY

Project:	***Electrochemical methods for remediation of industrial wastewate***
Program Code:	*1871*
Supervisor:	*Dr Lynne Wallace (l.wallace@adfa.edu.au)*

Objectives:
The project will examine environmentally-friendly, electrochemical methods of treating effluent from industrial scale manufacturing. Explosives in particular are used widely in military and civil/industrial applications, but the wastewater from their manufacture is notoriously polluting. Various electrochemical, chromatographic and spectroscopic methods will be employed in the electrolysis and investigation of products formed.

Description of Work:

- Determination of the electrochemical response of various target pollutants using cyclic voltammetry, and carry out initial experiments on bulk oxidation or reduction in various media
- Characterization of the solution and gaseous electrolysis products by a variety of analytical methods such as HPLC, FITR spectroscopy and voltammetry
- Develop theoretical pathways to account for the breakdown products formed, and perform parallel studies on structurally similar molecules where possible, to help elucidate general decomposition mechanisms for different classes of compound.

Project:	***Dinuclear ruthenium complexes as therapeutic agents***
Program Code:	*1871*
Supervisor:	*A/Prof Grant Collins (g.collins@adfa.edu.au)*

Brief outline of proposed research
We have recently demonstrated the potential of inert bulky dinuclear ruthenium complexes as DNA and RNA binding agents. These ruthenium complexes show a significant selectivity and affinity for non-duplex structures e.g. bulges and hairpin-loops. They bind non-covalently in the minor groove and preferentially target specific non-duplex DNA/RNA sites by matching the shape, symmetry and functionalities of the metal complex to the nucleic acid target. However, for a dinuclear ruthenium complex to be converted into a therapeutic agent requires significantly stronger binding at non-duplex sites that control a disease (such as cancer and HIV-AIDS). The aim of the proposed research is to synthesise analogues of our current dinuclear ruthenium complexes that can covalently bind non-duplex sites. Two basic approaches are proposed for the ruthenium complexes: (i) the incorporation of labile chloro ligands, and (ii) the incorporation of "dangling" amines, which upon intracellular activation can covalently react with DNA/RNA.

Di- and trinuclear ruthenium complexes containing chloro groups or "dangling" amines will be prepared, and their binding to specific non-duplex DNA and RNA structures will be examined by nuclear magnetic resonance (NMR) spectroscopy. In addition, the intracellular transport and organelle localisation will be studied using confocal microscopy. Finally, all the analytical results will be correlated with the determined therapeutic effect against a variety of disease types.

Project:	***New compounds of iridium for use in supramolecular assemblies***
Program Code:	*1871*
Supervisor:	*Dr Lynne Wallace (l.wallace@adfa.edu.au)*

Objectives:
This project will involve the development of synthetic methods for the preparation of novel redox-active iridium(III) complexes that have the potential for use in many areas such as nanotechnology, photovoltaic devices or anti-cancer therapy. The redox and optical properties of the new species will be characterized and their suitability for incorporation into supramolecular assemblies will be investigated.

Description of Work:

- Synthesize and purification of new and established iridium(III) polypyridyl complexes, both mononuclear and multinuclear.
- Investigate the electrochemical and spectroscopic behaviour of the free complexes in various media to extend our knowledge of such systems; and utilise this knowledge in the design of new complexes.
- Extend the work to include measurements on host-guest species and multinuclear complexes and assess their potential for use in various types of supramolecular assemblies such as molecular switches, photovoltaics or electrochromic devices.

Project:	***Studies in desalination***
Program Code:	*1871*
Supervisor:	*Prof Ric Pashley (r.pashley@adfa.edu.au)*

Brief outline of the proposed research project
This project has three parts, each related to different aspects of desalination and each directly linked to commercial applications.

1. We recently developed a novel method for measuring the latent heat of vaporization (ΔH_v) of concentrated salt solutions. [see: *J. Phys. Chem. B* 113, 9311-9315 (2009).] However, although established in principle, the method used was crude and hence only gave values to about 3% accuracy. There is a need to develop an improved method which will enable new values to be obtained for concentrated electrolyte solutions, above 1M.
2. We previously established that at high salt concentrations, air bubble columns can be produced at high bubble volume fractions without the bubbles coalescing. As they pass through the column, these bubbles pick up water vapour, which can then be condensed to produce drinking quality water. At the same time, solutes in the column are concentrated in a uniform manner, which can be used for the production of controlled particle precipitates, from nano to colloidal sizes. This project would involve the use of SEM and dynamic light scattering (DLS).

The last part of the project is somewhat more speculative. The two main industrial processes for sea water desalination are membrane reverse osmosis (SWRO) and thermal distillation (such as MSF methods). However, both methods have some serious disadvantages. Mixed bed ion exchange resins have been used for many years to remove scale-forming ions such as Ca^{2+} and Mg^{2+} from feed water and to produce distilled quality water from tap water. However, this process could, in principle, also be applied to the desalination of sea water, overcoming the main disadvantages of the current methods. The aim of the project is to develop a specifically designed ion exchange resin suitable for the efficient desalination of sea water and brackish water.

CHEMISTRY/PHYSICS

Project:	***Coherent transients in inorganic crystals by frequency-switching of diode lasers***
Program Code:	*1871, 1892*
Supervisor:	*A/Prof Hans Riesen*

Objectives:
Coherent transient experiments, including optical free induction decay, photon echoes and optical nutation, facilitate an understanding of subtlest details of electronic structures in the solid state. The project aims to investigate the application of coherent transients in chemically interesting systems, such as coordination compounds, by laser-frequency switching of semiconductor (diode) lasers.

Description of Work:

- Establish the facile induction of coherent transients by laser frequency switching of diode lasers by utilizing archetypal materials such as ruby, emerald and the like.
- Transfer the technology to more challenging systems such as coordination compounds.
- Studying the effects of external electric and magnetic fields on the coherent transients.
- Gain a full theoretical understanding of the observed transients.
-

Project:	***Light-driven water flips in crystalline solids: science and applications in optical data storage***
Program Code:	*1871, 1892*
Supervisor:	*A/Prof Hans Riesen*

Objectives:
The project aims to exploit our recent discovery of a thousandfold increase in the efficiency of non-photochemical spectral hole-burning upon partial deuteration of Cr^{3+} doped $NaMgAl(oxalate)_3 \cdot 9H_2O$ with the effect vanishing on complete deuteration. This observation is a significant discovery in hole-burning spectroscopy of inorganic systems in the solid state. The mechanism is based on photoinduced 180° flips of the partially deuterated water molecules of crystallization. Importantly, the non-photochemical holes are stable up to 120 K and hence suitable for applications at liquid nitrogen temperatures.

Description of Work:

- Water flips induced by d-d and f-f transitions of one or more of the transition metal and lanthanide ions in inorganic hydrates will be explored by hole-burning spectroscopy. Because of their low electron-phonon coupling, f-f transitions are prime candidates for higher temperature hole-burning materials.
- The dependence of spectral hole-burning properties, such as quantum efficiency and spontaneous hole-filling on: structural details, the temperature, the potential barrier height, rotational tunnelling splittings, external electric and magnetic fields and the degree of deuteration, will be investigated in a range of selected compounds.
- The potential of the selected materials as the active media in portable frequency standards, in laser stabilization schemes and in optical data storage and signal processing devices will be explored.
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CHEMISTRY/PHYSICS/MATHEMATICS

Project:	***Interactions in Biological Systems***
Program Code:	*1871, 1881*
Supervisor:	*A/Prof Cliff Woodward (c.woodward@adfa.edu.au)*

Objectives:
Molecular interactions, such as the hydrophobic force, van der Waals interactions and electrostatics are of great importance in the study of many biological systems. For example, interactions between proteins are vital for the explanation of many diseases and cures. Furthermore, the interaction of bio-molecules and man-made molecules (such as drugs and polymer) are of great importance to the pharmacy industry. This project uses a range of

theoretical methods to study these interactions. These include mathematical modelling and computer simulation. It involves collaboration between theoreticians and experimentalists in Sweden and Brazil.

Description of Work:

- develop theoretical methods for the description of interactions in bio-systems
- develop computer algorithms for numerical solutions of the theory
- apply the methods to a range of model scenarios including those determined by experimental partners
- Related publication: Lund, Mikael; Jungwirth, Pavel; **Woodward, CE**. *Phys Rev Letts*, 100(25), 258105/1-258105/4, **2008**

Project:	***Study of Ionic Liquids***
Program Code:	*1871, 1881*
Supervisor:	*A/Prof Cliff Woodward (c.woodward@adfa.edu.au)*

Objectives:

Ionic Liquids are a new class of environmentally friendly liquids that are set to revolutionize modern industry. We have begun a study of the properties of ionic liquids, together with researchers in industry in Australia, as well as researchers in Sweden. Our study uses mathematical techniques that we have developed in our group for polymeric fluids, in order to study the equilibrium properties of ionic liquids at charged interfaces and in the presence of nanoparticles. Our work will also investigate the dynamical properties of ionic liquids, especially electro-kinetic phenomena.

Description of Work:

- develop methods, based on density functional theory, suitable for application to ionic liquids
- develop computer algorithms for numerical solutions of the theory
- apply the methods to a range of model scenarios including those determined by industrial partners
- Related publication: **Woodward, CE**.; Forsman, J,. *Phys Rev Letts* 100(9), 098301/1-098301/4,. **2008**

Project:	***Theory of Nanoparticle Polymer Mixtures***
Program Code:	*1871, 1881*
Supervisor:	*A/Prof Cliff Woodward (c.woodward@adfa.edu.au)*

Objectives:

We will use state of the art theoretical methods to study the microscopic structure of nanoparticle/polymer mixtures. These systems are important for many applications in science engineering and medicine. Specific applications include: self-healing materials; detection methods for security applications; drug release; quantum dots etc.
The suitable candidate for this project will be in the area of either mathematics, computer science or chemical/materials engineering. This project will use novel mathematical and computational modelling, so the applicant needs to have a background in these areas.

Description of Work:

- develop methods, based on density functional theory, suitable for application to nanoparticle/polymer mixtures
- develop computer algorithms for numerical solutions of the theory
- apply the methods to a range of model scenarios
- related publication: Forsman, J, **Woodward, C E**, *Phys Rev Letts* 94(11), 118301/1-118301/4, **2005**

GEOGRAPHY

Project:	**Biofuels Research, Policy and Adoption in Agricultural Systems**
Program Code:	*1081*
Supervisor:	*A/Prof Stuart Pearson (stuart.pearson@adfa.edu.au)*

Objectives:
To improve the understanding of the drivers of biofuel research, policy and agricultural adoption in Australia and China.

Description of work:

- Complete an environmental scan to develop a systematic understanding of the drivers of biofuel policy in Australia and China.
- Develop insights into the similarities and differences in the ways biofuel research, policy and adoption occurs in Australia and China.
- Explore the way risk and uncertainty emerge in the way biofuel research, policy and adoption in agriculture occurs.
- Determine the most useful analytical framework for evaluating the impact of biofuel research on policy and agricultural practice.

Project:	**Comparative analysis of Australia and China's marine resources management approaches and scenarios for the future**
Program Code:	*1081*
Supervisor:	*A/Prof Stuart Pearson (stuart.pearson@adfa.edu.au)*

Objectives:
To improve the understanding of the drivers in Australia and China's approaches to Ocean (or Coastal) management and develop credible future scenarios to inform discussion.

Description of Work:

- Complete an environmental scan to develop a systematic understanding of the drivers of ocean (or coastal) policy in Australia and China with a focus on the slow-moving variables and possible triggering events.
- Develop a set of scenarios that are built out of the existing evidence and trends to discuss.
- Interview managers, regulators, investors and other stakeholders about the ways these scenarios interact with current models of change.
- Determine the usefulness of environmental scanning to identify opportunities and threats in Ocean policy.

Project:	***Implications of peak oil (energy stress) on lifestyles in urban and rural environments in Australia***
Program Code:	*1081*
Supervisor:	*Dr Paul Tranter (paul.tranter@adfa.edu.au)* *Dr Scott Sharpe (scott.sharpe@adfa.edu.au)*

Objectives:
Based on recent spikes in global oil prices, this project examines implications for quality of life in urban and rural locations in Australia.

Possible themes:

- Impact of increased oil prices on children's rights and freedoms
- Development of policies to respond to or adapt to increased oil prices
- Impact of oil prices on food production, health, and transport
- Oil alternatives in rural and urban Australia.
- Increased oil price and its affects on community

Project:	***Investigating the use and design of static and interactive cartograms***

Program Code:	*1081*
Supervisor:	*Dr Amy Griffin (a.griffin@adfa.edu.au)*

Objectives:
Static and animated cartograms are becoming more commonly used (and misused) as forms of data visualization in a number of disciplines and in the mass media. The main objectives of this project are to 1) compare the ability of users to understand information in cartograms generated with a variety of different algorithms and 2) to compare the performance of cartograms with other forms of representing thematic information (e.g., choropleth maps).

Description of Work:

- Generate static and interactive cartograms using a number of different algorithms/methodologies.
- Design and carry out user studies that investigate the perceptual and cognitive processes cartogram readers employ when viewing cartograms.
- Develop a series of design guidelines that can be used to help cartogram producers generate cartograms that are effective in representing thematic data.

Project:	***Marina development in Australia and China – organising the knowledge of environmental and economic impacts***
Program Code:	*1081*
Supervisor:	*A/Prof Stuart Pearson (stuart.pearson@adfa.edu.au)*

Objectives:
To improve the understanding of the issues associated with marina developments in Australia and China with the purpose of improving decision-making.

Description of work:

- Complete environmental fieldwork in Australia to describe the current legal, social, economic and environmental impacts
- Integrated this with an understanding of the way these are organised and managed by local and regional governments.
- Identify the opportunities that integrated management provides in change management, development controls, tenure, access, offsets, water quality and safety
- Assess options, including polycentric governance models to provide more adaptive and participative management of coastal zone issues associated with marinas.

Project:	***Marine Parks: Sustainable Growth in Conservation***
Program Code:	*1081*
Supervisor:	*A/Prof Stuart Pearson (stuart.pearson@adfa.edu.au)*

Objectives:
To explore the use of Marine Protected Areas to achieve environmental and political outcomes in Australia and China.

Description of work:

- Develop an understanding of the arrangement of marine parks in Australia and the rationale and process of their declaration.
- Explore the issues associated with marine protected areas from a variety of viewpoints.
- Identify risks and opportunities associated with Marine Protected Areas and how these might be managed.
- Develop an evaluative and knowledge framework for evaluating marine protected areas.

Project:	***Seeing environmental change from tree growth***
Program Code:	*1081*
Supervisor:	*A/Prof Stuart Pearson (stuart.pearson@adfa.edu.au)*

Objectives:

To improve the understanding of the drivers of tree growth in Australia's semi-arid environments using tree rings and correlations to circulation systems.

Description of work:

- Complete environmental fieldwork in semi-arid Australia to recover wood samples with a research team.
- Develop insights into the ocean and atmosphere circulation systems that drive regional climates that are recorded in the trees' growth.
- Collect environmental data and concepts to interpret ring width variations measured using a microscope.
- Analyse the ring widths and other data to identify key drivers of environmental change in Australian semi-arid environments and in surrounding oceans.

OCEANOGRAPHY

Project:	***Nepheloid layers in the Changjiang (Yangtze River) estuary***
Program Code:	*1082*
Supervisor:	*Dr Xiao Hua Wang (hua.wang@adfa.edu.au)*
Co-Supervisor	*Dr Houjie Wang, OUC; Dr Weibin Guan, Second Institute of Oceanography, State Oceanic Administration, China*

Objectives:
This project will characterize the nepheloid layers in the Changjiang estuary and develop new numerical models to investigate these layers. It will examine the role of the nepheloid layers in determining coastal ocean dynamics and in transporting sediments from the river to the East China Sea. A comparison study of the nepheloid layer and sediment processes before and after the construction of the Three Gorges Dam (TGD) will also be conducted in this project.

Description of Work:

- Collect and synthesize pre- and post-TGD sediment, hydrology and meteorology data from the Changjiang estuary and build a multivariate marine and meteorological database for model forcing, validation and calibration;
- Develop high resolution hydrodynamics and sediment transport models that are capable of reproducing nepheloid layer process in Changjiang estuary;
- Combine observations and models of Changjiang estuary to extend our knowledge about the structure and evolution of nepheloid layers and extent to which current theory and models can make reliable and general predictions of these layers pre- and post-TGD.

Project:	***Internal Tides and Waves in the South China Sea***
Program Code:	*1082*
Supervisor:	*Dr Robin Robertson (r.robertson@adfa.edu.au)*

Objectives:

- Learn to use a prominent ocean circulation model
- Investigate internal tides and waves in the South China Sea

Description of Work:
Large internal tides exceeding 50 m have been observed in the South China Sea. These tides generate internal waves and induce mixing on the continental shelf. They also induce non-linear solitons. The goal of this project is to investigate the internal tide and wave fields in the South China Sea using both hydrostatic and non-hydrostatic models. The model results will be compared to observational data. This work has implications for the regional oceanography of the South China Sea and for investigations of internal tides and waves in other active regions, such as Australia's North West Shelf.

Project:	***Nonlinear response of western boundary currents to variable***

	wind forcing
Program Code:	*1082*
Supervisor:	*Dr Andrew Kiss (A.Kiss@adfa.edu.au)* *http://www.unsw.adfa.edu.au/pems/research/kiss/*

Objectives:
This project will investigate the nonlinear response of western boundary currents (WBCs, such as the Kuroshio) to variations in wind forcing. Western boundary currents have intrinsic variability due to their instabilities, but they are also driven (indirectly) by winds which have their own time-dependence, such as an annual cycle. Observed WBC variability may therefore be due to the interaction between intrinsic instabilities and variations in wind forcing. Western boundary currents are nonlinear, and initial investigations (Kiss, 2007) have shown that their response to variable forcing includes nonlinear resonance and chaos, as expected for a driven nonlinear oscillator.

The chaotic response is particularly interesting, because it leads to variability on timescales far longer than either the forcing variability or the intrinsic WBC variability, which may possibly pay a role in climate variability.

Description of Work:
The project will investigate this problem using MITgcm, Q-GCM or a similar model, using a dynamical systems ("chaos theory") approach to analyse the dynamics. Initial experiments will use an idealized "box ocean" to cleanly reveal the physics. Further work could investigate the effects of more realistic bathymetry and boundary shape, and also the effects of two-way ocean-atmosphere coupling.

Reference:
A. E. Kiss (2007) "Nonlinear resonance and chaos in an ocean model", Proc. CSIRO Centre for Complex System Science & COSNet.
Workshop on Turbulence and Coherent Structures in Fluids, Plasmas, and Granular Flows, The Australian National University, 10 - 13 January 2006, World Scientific Lecture Notes in Complex Systems.

Project:	***Sediment transport dynamics in the Great Barrier Reef, Queensland, Australia***
Program Code:	*1082*
Supervisor:	*Dr Xiao Hua Wang (hua.wang@adfa.edu.au)*
Co-Supervisor	*Dr Xueen Chen, OUC*

Objectives:
Due to land clearance and grazing in the catchment areas of the Great Barrier Reef (GBR) rivers, the inshore regions of the GBR are subject to enhanced fluxes of suspended sediments from river runoff, causing bleaching and disappearance of nearshore coral reefs. This project will, for the first time, combine observation and numerical models to investigate the sediment transport dynamics in the GBR region. By quantifying the sediment transport and defining its pathways from rivers to the outer shelf of the GBR, the proposed research will directly address the water quality issues of the GBR, thus help to better evaluate the impact of the land degradation on, and manage and protect the GBR marine ecosystem that offers Australia with tremendous economic, social and cultural values.

Description of Work:
- Collect and synthesise published historic sediment, hydrology and meteorology data from the shelf of the Great Barrier Reef (GBR) and build a multi-variate marine and meteorological database for model forcing, validation and calibration
- Develop high resolution hydrodynamics and sediment transport models that are capable of reproducing nepheloid layer process on the shelf of the GBR;
- Combine observations and models of the GBR shelf to investigate the dynamics of nepheloid layers and extent to which current theory and models can make reliable and

general predictions of nepheloid layers

- Also, sediment transport and pathways from the nearshore zone to the outer shelf of the GBR within and above the nepheloid layers will be investigated. The nepheloid layer effect on the BBL hydrodynamics and coastal ocean circulation will be determined.

Project:	***The Influence of Monsoons and the Southern Oscillation on Transport and Mixing in the Indonesian Seas***
Program Code:	*1082*
Supervisor:	*Dr Robin Robertson (r.robertson@adfa.edu.au)*
Co-Supervisor	*Dr Susan Wijffels, CSIRO, Hobart, Tasmania, Australia*

Objectives:

- Learn to use a prominent ocean circulation model
- Improve transport simulations and estimates of mixing for the Indonesian Seas
- Determine the links between the transport and mixing and monsoons and the Southern Oscillation

Description of Work:
Present estimates of the transport through the Indonesian Seas from simulations fail to correctly estimate the flow. Crude estimates of the tidal currents and mixing have been shown to improve these estimates. By incorporating mean currents into tidal simulations and simulating both the currents and the tides properly, further improvements will be gained. The student will perform simulations using a widely-used ocean model and investigate the dependence of the transport and mixing on the winds and conditions associated with monsoons and El Nino/La Nina. This work has important implications both regionally for climate in the Austral-Asian region and globally for the thermohaline circulation or global conveyor belt.

Project:	***Tidal Influences on the Amundsen Ice Shelf (or other ice shelves)***
Program Code:	*1082*
Supervisor:	*Dr Robin Robertson (r.robertson@adfa.edu.au)*

Objectives:

- Learn to use a prominent ocean circulation model
- Determine the amount of melting of the ice shelf attributable to tides
- Investigate lifting and flexure of the ice shelf by tides.

Description of Work:
Collapse of the West Antarctic Ice Sheet (WAIS) is expected to raise sea level by 6 m, a potentially disastrous event. The Amundsen Ice Shelf, believed to be a key lynchpin for the WAIS, is melting at a rate over 10 times faster than other Antarctic ice shelves. Along with the melt ponds, tides are believed to be a significant factor in ice shelf dynamics and thermodynamics. In this project, the student will simulate tides in the Amundsen Sea, including the ice shelf cavities. Using the model results, the student will quantify tidal effects on the ice shelf, including lifting, flexure, and melting from below.

Project:	***Tides, Sea Ice, and the Thermohaline Circulation***
Program Code:	*1082*
Supervisor:	*Dr Robin Robertson (r.robertson@adfa.edu.au)*

Objectives:

- Learn to use a coupled sea ice-ocean model
- Determine tidal effects on sea ice
- Investigate tidal influences on deep water production

Description of Work:
Tides have been identified as the prominent factor in sea ice dynamics over the continental

shelf in the Weddell Sea. Presently, few sea ice models include tidal dynamics and few tidal models include sea ice, making tidal effects on sea ice difficult to investigate. For this project, the student will investigate tidal effects on sea ice using a coupled sea ice/ocean model. Model output will also be used to determine changes in deep water production, which typically accompany changes in the sea ice cover. This project has obvious implications for climate work not only in the Antarctic and Arctic, but also globally from the connection between deep water production and the global thermohaline circulation.

Project:	***Transport and Mixing in the Straits of the Indonesian Seas***
Program Code:	*1082*
Supervisor:	*Dr Robin Robertson (r.robertson@adfa.edu.au)*

Objectives:

- Learn to use a prominent ocean circulation model
- Perform fine scale simulations of the transport and mixing in the key straits of the Indonesian Seas

Description of Work:

Pacific Water is transformed in localized regions through mixing as it passes through the Indonesian Seas. Due to its localized nature, coarser scale models estimate the mixing poorly, particularly for narrow straits. Finer resolution simulations provide more accurate estimates; however, the entire Indonesian Sea region is too large for the optimal resolution. It is proposed that the student perform a series of fine scale tidal simulations, including mean currents, for key straits in this region: Lombok, Ombai, Makassar, and Timor. These simulations will identify localities of mixing and provide improved estimates of the flows through the straits. Besides being useful for shipping and naval operations, this work has important climate implications, both regionally and globally.

PHYSICS (ADVANCED MATERIALS)

Project:	***Fundamental magnetism and magnetocaloric effects in rare earth alloys and compounds***
Program Code:	*1892*
Supervisor:	*Dr Wayne Hutchison (w.hutchison@adfa.edu.au)*

Objectives:

Rare earth intermetallic alloys such as $RNiAl_4$ (R = rare earth) have fundamentally interesting magnetic properties, including metamagnetism. Additionally, it has been discovered recently that the magnetic transitions in these alloys show large magnetocaloric effects, and could be the basis for refrigeration schemes. Rare earth compounds such as HoF_3, an enhanced nuclear paramagnet also show potential for use in very low temperature refrigeration. This project will involve further fundamental study of such compounds in order to identify potential refrigerants and develop possible schemes for using such alloys.

Description of Work:

- Synthesis of alloys and compounds with characterisation by standard techniques such as x-ray diffraction;
- Carry out measurements to characterise magnet materials using a number of appropriate techniques including heat capacity, magnetisation and susceptibility, neutron diffraction, and low temperature (millikelvin) nuclear orientation;
- Select the most suitable materials for refrigeration in various temperature regimes. Develop and test prototype refrigeration schemes.

Project:	***Magnetic resonance and silicon based quantum computing***
Program Code:	*1892*
Supervisor:	*Dr Wayne Hutchison (w.hutchison@adfa.edu.au)*

Objectives:

The general aim of this project is the use of magnetic resonance, directly, to measurements on spin systems which have application as spin based quantum computers (QC). The technique is also applied to investigations of the principal materials and fabrication processes. The emphasis is on electron spin resonance (ESR) studies of the phosphorus in silicon (Si:P) system. But will also have scope to include low temperature nuclear magnetic resonance applied to radioactive probes.

Description of Work:

- Use of continuous wave and pulsed electron spin resonance techniques to study spin dynamics and materials issues in silicon doped with n - type impurities such as phosphorus;
- The studies will involve both bulk doped and ion implanted samples, as well as the fabrication of devices on a submicron scale;
- Low temperature (millikelvin) nuclear orientation and nuclear magnetic resonance will be applied to beta-ray emitting ^{32}P in these systems to study and manipulate nuclear spin polarisation.

STATISTICS

Project:	***Analysis of recovery/recapture data for Short-tailed Shearwaters Puffinus tenuirostris***
Program Code:	*1881*
Supervisor:	*Dr Leesa Sidhu (L.Sidhu@adfa.edu.au)*

Description of project: Short-tailed Shearwaters have been studied continuously on Fisher Island, Tasmania since 1946, making this one of the longest continuous studies of any wildlife population in the world. Although life-history data have been collected sporadically over this time period, a detailed mark-recapture-recovery analysis has not yet been conducted. This study will produce age- and time-varying survival estimates for Short-tailed Shearwaters, and examine the effect of individual covariates such as egg size on first year survival.

Project:	***Frailty Model Misspecification***
Program Code:	*1881*
Supervisor:	*Dr Joanne Chapman (j.chapman@adfa.edu.au*

Objectives:

Errors in survival models caused by missing information or unknown covariates cannot be assumed to be Normally distributed because of the selection effect that is induced. Standard frailty models assume one of several common probability distributions. Little or no research has been done into the effect of model misspecification. This project will investigate the affect of this misspecification for the standard survival models, and find or develop the most robust frailty model.

Description of Work:

- Develop computer programmes to simulate survival data with frailty from a variety of distributions;
- Develop computer programmes to fit parametric and non-parametric survival models with frailty;
- Quantify the affect of frailty model misspecification for each model type, and each combination of simulated and fitted frailty distribution;
- Determine the affect of choice of frailty distribution on real data;
- Select the most robust model/frailty distribution combination for future use or develop a new one if required.