A/Prof Tim French, Prof Mark Reynolds
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A hybrid automata framework
Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

Hybrid automata of formal models of complex systems that have both a discrete and continuous part. For example a motor may have the discrete states of *off*, *idling* or *in gear*, and the continuous variables of *temperature*, *rpm*, and *power*. A hybrid automata is able to specify such a system so that it may be verified to ensure that a critical property is always true. This project would use existing implementations of hybrid automata, to specify and verify a complex hybrid system, noting the advantages and limitations of the approach.

A/Prof Tim French
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Optimizing material transportation with non-linear constraints.
Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

A material transportation network has material (such as minerals) moving from a source (e.g. a mine) to a sink (e.g. a port) through various processes and pathways. Optimizing the flow of these materials is an important problem to solve. There are efficient algorithms that can handle these systems when they have linear constraints, but the situation is more difficult when there are non-linear constraints on the way material can move. This project would examine some common problems in this area, and investigate algorithms and heuristic solutions.

A/Prof Tim French
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Information flow in bargaining scenarios
Discipline: Computer Science, Software Engineering

A bargaining scenario is a multi-agent system with two or more agents. Agents exchange bids, counter bids and information in an attempt reach a mutually agreeable price. This project would investigate and extend formal models for how agents exchange information, and increase their knowledge base in these scenarios.

A/Prof Tim French
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Fractal document formats
Discipline: Computer Science, Software Engineering

As more and more people use mobile devices to replace their interaction with paper documents, there are less constraints on the printed word. Particularly, a reader can

magnify a page at the press of a button, and there is no reason why this magnification should be limited to a fixed percentage. This project will examine challenges and potential of representing fractal documents to arbitrary precision. The project will examine existing document formats (such as pdf and ps), and consider an architecture for allow users to edit and interact with fractal documents.

Prof Mark Reynolds, A/Prof Tim French
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Simulation and exploration of hybrid systems via automata
Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

Hybrid systems are dynamical systems that have both discrete and continuous components. A simple example might be a thermostat which has discrete aspects (whether the heater is on or off) and continuous aspects (the current temperature). Hybrid systems can be used to formally model the way a discrete controller interacts with a continuous environment, and formally verify certain safety properties of that system. This project will look at modelling hybrid systems from various domains, using automata, and formulating and checking basic safety properties. Suitable domains could include mechatronic systems (such as cruise control, or anti-lock brakes), fluid systems (such as batch plant control), or discrete event systems (such as train gate controllers). A successful project will build one or more such models, and assess the feasibility of verifying several important safety properties of the system.
This project template can be taken by more than one student each doing their own individual version.

Prof Mark Reynolds, A/Prof Tim French
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Title: Automated modelling, derivation and evaluation for efficient scheduling in industrial processes
Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

This project is to make and/or use an abstracted automata-like model of a an industrial process, such as mine trucks being dispatched to shovels, to reason about the optimum scheduling controller. A successful project will build one or more such models, and assess the feasibility of verifying optimum throughput properties of the system.
This project template can be taken by more than one student each doing their own individual version.

Prof Mark Reynolds
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Automatic Scene Measurements using a Video Camera with Partial Calibration (with Dr Arif Mahmood)

Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

Automatic scene measurements have wide range of applications including computation of 3D scene structure, autonomous robot navigation, and human activity recognition. Some recent work have proposed techniques for estimating heights and lengths from video without any camera calibration information. We think that estimates can be improved greatly by using, in addition, some quick and easy (pre or post) calibration techniques such as measuring a few lengths in the background scene. This project is to develop and test some basic approaches using different combinations. Experience with Matlab and/or C++ beneficial. The project will use Linear Algebra, Analysis of Vector Geometry and standard image processing functions.

Prof Mark Reynolds, Dr Arif Mahmood
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Mobile Phone Based Hand Held Scanner

Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

Most of the high end mobiles have a built in camera. In this project student will develop an application to use the mobile phone camera as a document scanner. Commonly used document scanners are a separate hardware customized for normally used page sizes. For larger pages, larger scanners are required which are much more costly. Also many documents of historic importance cannot be handled or even touched. This project will enable scanning page of any size without physically touching the documents. This is a research and development based project. Experience with Matlab and/or C++ beneficial. The project will use Linear Algebra, Analysis of Vector Geometry and standard image processing functions.

Prof Mark Reynolds, Dr Christian Nansen
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Tool to assess randomness of activities in a grid

Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

This involves developing and implementing an algorithm to assess the randomness of (small finite) measurements across a rectangular grid by assessing the amount of effort required to change measurements to make them evenly distributed. This has applications in assessing tendencies for pest infestations to be in particular locations in fields of crops, silos or transport containers.
See Sadie here: http://home.cogeco.ca/~sadiespatial/SADIEShell.html

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Prof Mark Reynolds, A/Prof Du Huynh, A/Prof Wei Liu
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Robot to go and have a look

Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

In many security, remote and industrial monitoring situations, successful automation will depend on a smooth combination of sensing, artificial intelligence and robotic investigative action. In order to make progress in integration of these technologies for such applications, this project will consider a fairly simple but typical scenario in which a system will decide when and how to dispatch a robot to investigate problematical sensor data. In this case, a camera vision system will be used to identify problems in terms of the arrangements of objects in a room. The system will use wireless communication with a mobile robot with its own cameras and other sensors to investigate the situation and clearly identify whether there is a serious problem. The student will primarily be involved in designing and implementing a way for the vision, AI, communication and robot movement modules to work together reliably. Skills in Java and/or C++ programming are recommended.

Prof Mark Reynolds, A/Prof Du Huynh

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Combining Kinect and Stereo Depth Measurements

Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

In robot obstacle avoidance and motion planning, we want to use 1) stereo ordinary RGB cameras plus 2) a Kinect (or other short range depth sensor) in combination. The student will investigate how to combine the signals to give the best distance and location information across a wide range of distances. Skills in Java and/or C++ programming are recommended.

Prof Mark Reynolds

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The Not So Smart Grid

Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

In order to alleviate the need for infrastructure to cope with spikes in maximum power delivery via the grid, it has been suggested that power hungry items such as fridges should be made intelligent enough to vary their power usage depending on the current state of the grid. In this project we model a simpler alternative in which the devices have built in, fixed rules for varying their power usage, dependent on the time of day but not requiring detailed knowledge of the actual state of the grid. This is a modelling project. Skills in Java and/or C++ programming are recommended.

A/Prof Bruce Gardiner, Prof David Smith

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Engineering Computational Biology
Discipline: Engineering, Computing, Mathematics

Primarily projects are focussed on using a range of modelling techniques to investigate the behaviour of biological processes such as cell mechanics, cell communication, regulation of cellular environments. All projects have applications to understanding diseases. Example projects include but are not limited to:

- Agent based models of cell behaviour (e.g. migration, proliferation) in colonic cancer and tissue injury
- Modelling tissue remodelling in cartilage, bone and tendon
- Image processing of kidney anatomy and organogenesis

A/Prof Du Huynh
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Human detection: An evaluation of the state-of-art techniques
Discipline: Computer Science

Recent advances in computer vision and machine learning techniques have made it possible to detect pedestrians from images of arbitrary scene. The technique proposed by Dalal and Triggs [1] in 2005 has become the classical human detector. Since then, a few other human detectors have also been proposed (see [2] for a survey) The focus of this project is to evaluate a few human detector techniques described in [2].

References:
[1] N. Dalal and B. Triggs, “Histograms of Oriented Gradients for Human Detection,” IEEE Conference on Computer Vision and Pattern Recognition, vol. 1, pp. 886–893, Jun. 2005.
[2] P. Dollar, C. Wojek, B. Schiele, and P. Perona, "Pedestrian
Detection: An Evaluation of the State of the Art," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 34, no. 4, pp. 743 –761, Apr. 2012.

A/Prof Du Huynh
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Visual tracking using sparse appearance model
Discipline: Computer Science

The aim of this project is to track objects in videos. The focus is on how to represent the target to be tracked so as to better handle partial occlusion and changes in appearance of the target. You will need to have some background in optimization techniques to handle the mathematical aspect of the project.

A/Prof Du Huynh
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Classification of paintings by genre
Discipline: Computer Science

Advances in machine learning algorithms and increase in computing power have opened many possibilities for classification of visual data, such as paintings. The focus of this project is to investigate machine learning algorithms for classifying a collection of paintings (already scanned as colour images) based on their genres. The student should investigate a number of image features suitable for representing the paintings before looking into the literature on classification. Several classification techniques in machine learning relevant to the project include artificial neural network, random forest classifier, and k-nearest neighbours classifier.

A/Prof Du Huynh
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Study of energy expenditure in physical activities using Kinect cameras
Discipline: Computer Science / Mechanical Engineering

This project is an extension of a final year's student project in 2013.
We are interested in estimating the energy expenditure on different body parts of humans when they play games in front of the Kinect cameras.
This project will extend our previous work by looking at different models for estimating the work on the body parts and the metabloic energy.
Different machine learning techniques will also be explored and compared for their effectiveness in predicting metabolic energies. This project is in collaboration with the School of SSEH.

Prof Rachel Cardell-Oliver
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Intelligent Analytics using Sensor Data for Water Sensitive Cities (smart meters, water quality, pipe condition assessment)
Disciplines: Computer Science, Environmental Engineering, Civil Engineering

Intelligent Water Systems are systems that provide data monitoring, data analysis, and decision support for making optimal decisions on the management of water in urban and rural environments. State of the art sensors distributed throughout modern water systems collect data about the state of the whole system and its components. The research goal is to develop innovative data processing techniques for utilising sensor data to optimise the efficiency and safety of these water systems.
For students with appropriate backgrounds, there are projects in the following application areas:

(1) smart meters for household water consumption (collaboration with Water Corporation of WA)
(2) water quality in drinking water networks (collaboration with Veolia water)
(3) pipe condition monitoring for predictive asset maintenance (collaboration with PUB Singapore)

This project is part of a larger project funded by the CRC for Water Sensitive Cities

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Prof Rachel Cardell-Oliver
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Underground Sensor Networks with applications for monitoring rammed earth houses

Disciplines: Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Environmental Engineering

This topic researches underground wireless sensor networks in which sensors, radio module and power source are all buried up to one meter underground. Information from distributed sensors is vital for large-scale applications in sustainable agriculture and environmental management. But conventional sensor networks have components exposed above the ground and so they can easily be damaged by machinery, stock, or weather conditions. An invisible underground wireless sensor network would be the ideal solution to these problems. One planned application is to build a novel sensor network for monitoring the thermal performance of a rammed earth house (collaboration with A/Prof Ciancio in Civil Engineering).

For students with appropriate background this topic has scope for work in the following areas:

(1) Radio communication modules for underground transmission;
(2) Novel compression and forward error correction algorithms for energy-efficient data transmission from underground;
(3) Thermal energy harvesting modules for long-lasting, autonomous sensor network operation;

This project is part of an ongoing collaboration with the University of Applied Sciences, Mannheim, Germany.

Dr Kelvin Wong, Prof Bruce Gardiner, Prof David Smith
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Colon Crypt Modeling Based on Discrete Element Method

Disciplines: The approach employed in this project requires modelling (i.e. using computational system biology methods).

Cells are wet 'computers' for processing environmental information and forming appropriate responses. Instead of wire, diodes and capacitors, cells use networks of chemical reactions to transmit and modify environmental signals to the cell nucleus or to neighbouring cells. These signal-transduction pathways should make decisions as to the correct response of the cell. The hallmarks of malignant cancer are inappropriate proliferation, invasion and

metastasis. In order for this to proceed, cancer cells must be capable of switching (deciding) between a quiescent to a proliferation mode and also switching between cell proliferation and an invasive mode. The Wnt signaling pathway is involved in each of these stages of malignant cancer development quiescence, cell proliferation and cell-cell adhesion. Despite being fundamental to cancer cell behaviour, the switching between these various states of the Wnt signaling pathway is still poorly understood, and as such represents a key limitation to future progress in understanding a wide range of cancers. In the colon crypt, the dysfunctional proliferation dynamics could account for the 'offshoots' of cells that can lead to adenomas.

Prerequisites

Ability to program well, plus willingness to rethink how problems should be solved. You do not need any prior experience with parallel computing or supercomputing. As noted above, it is "application neutral" so you don't need a strong background in all of computer science for the parallel computing part of the project.

A/Prof Lyndon While, Prof Melinda Hodkiewicz

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Applying Intelligent Optimization Techniques to Asset Management Problems

Disciplines: Computer Science, Mechanical Engineering, Civil Engineering, Chemical Engineering

Many problems in asset management are operational in nature: they involve optimizing the performance of complex installations at a whole-system level, according to several criteria and within the boundaries of several constraints. You will investigate the application of modern intelligent optimization techniques to such problems.

Only basic programming skills will be required.

Professor Cara MacNish, Winthrop Professor Arcady Dyskin, Ghulam Mubashar Hassan

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Tracking and Analysis of Deformations in Solids

Disciplines: Computer Science, Mining Engineering, Mechanical Engineering, Civil Engineering

Solid objects and structures, such as rock or concrete, are subject to deformation under load. Since deformation may be a precursor to failure, the ability to detect and track changes in solids may have significant safety applications, for example in forewarning and evacuation of underground mines or buildings. Physical measuring devices, such as strain gauges, only give some information at specific sites, provide very restricted coverage, are expensive to deploy widely, and may be obtrusive with respect to other activities such as mining.

The purpose of this research topic is to use camera images to track and analyse deformation in solids under load using surface features. This in turn requires search and optimisation algorithms to reconcile features between images. Because the deformation in

solids may be very small, highly accurate techniques are required. At the same time there may be many difficulties, including adequacy and density of surface features, discontinuities (eg cracks), distinguishing discontinuities from other features (such as lines), and environmental noise (eg dust).
This research topic is suitable for students in civil, mining, mechanical and software engineering.

W/Prof Mohammed Bennamoun, Asst/Prof Dr. Syed M Shamsul Islam
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Design of a multi-biometric security and surveillance system using 3D video cameras.

Biometric based human tracking and recognition systems are rapidly gaining popularity due to breaches of traditional security systems and the lowering cost of sensors. The recently introduced Microsoft Kinect sensor will be used to capture 3D video stream (including the surface depth information). Efficient algorithms will be developed to detect and recognize persons from their 2D/3D gait (walking pattern), ear and face images to be extracted from the 3D video streams. All the software and hardware are available for the completion of the project.

W/Prof Mohammed Bennamoun, Asst/Prof Dr. Syed M Shamsul Islam
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Extraction and classification of Sleep Apnoea Phenotypic features.

The diagnosis of Obstructive Sleep Apnoea (OSA) presents a significant problem to health care systems worldwide. Historically OSA diagnosis has been made with laboratory-based polysomnography (PSG) studies which are very time-consuming and expensive. The overriding aim of this project is to develop a computer assisted technique for classification of features already (or assumed to be) associated with OSA in the literature. This will help to devise a quick, safe and cost-effective screening tool for predicting OSA severity.

The static three-dimensional shape features of the face and neck area as well as anatomical features including airway morphology will be extracted from Cone Beam Computer Tomography (CBCT) images of a group of people whose positive (with levels of severity) or negative status OSA is determined by PSG studies. Machine Learning-based classification algorithms will be developed to link them with moderate to severe level of OSA. All the software and hardware are available for the completion of the project.

W/Prof Mohammed Bennamoun, Asst/Prof Dr. Syed M Shamsul Islam
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Analysis of dento-facial deformities using 3D facial masks.

Dento-facial deformities affect not only the attractiveness of a person but sometimes may be associated with severe syndrome such as diagnosis of Obstructive Sleep Apnoea (OSA). Comparison between such faces with an average or mask face of control group with normal facial structure is important in order to determine unique features associated with the deformities or to define some treatment outcome. In this project, appropriate 3D facial averages or masks of different groups will be constructed from their 3D surface images and then will be compared to localize and quantify the differences. All the software and hardware are available for the completion of the project.

W/Prof Mohammed Bennamoun, Prof Richard Prince - Adding value to imaging studies of the human skeleton using lateral spine low energy X ray imaging.

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Adding value to imaging studies of the human skeleton using lateral spine low energy X ray imaging

The Bone and Vascular Research Group has 2D imaging data files for x-ray studies of the lateral spine in 2000 individuals. These images are available for suitable Hons students in the School of Computer Science and Software Engineering to undertake a project to develop a computer assisted image analysis program supervised by W/Prof Mohammed Bennamoun School of Computer Science and Software Engineering and Prof Richard L Prince of the School of Medicine and Pharmacology.

The project will be to identify calcification in the abdominal aorta the large blood vessel supplying the lower body. ***Increased calcification in this area has been shown in clinical studies to a powerful predictor of heart disease.***

An example AAC-8 score of seven, four on the posterior aortic wall and three on the anterior aortic wall.

The successful candidate will develop skills necessary to undertake complex image analysis tasks in clinical data and develop skills to understand the biological significance of the work. This will provide a powerful entry into the rapidly developing area of clinical image analysis.

Detection of Abdominal Aortic Calcification with IVA

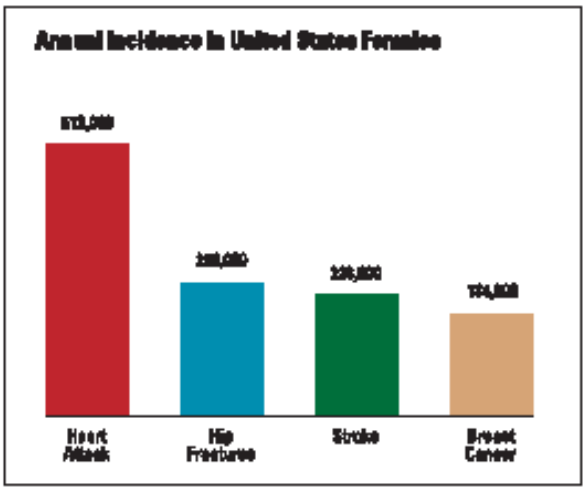
By Kevin E. Wilson, PhD

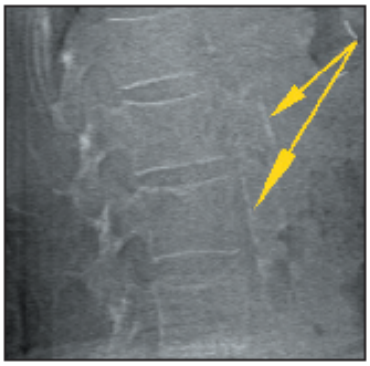
The Scope of the Problem

Heart disease and stroke are the first and third leading causes of death in the United States.[1] Atherosclerosis is the common pathological process underlying myocardial infarction, stroke and other occlusive vascular diseases. Atherosclerosis has a long latent period between early phases of the disease and the manifestation of clinical symptoms. Thus there is an opportunity for primary prevention if patients can be identified before the first clinical event. Unfortunately, for many asymptomatic individuals, the first manifestation of underlying disease is often an unexpected acute myocardial infarction or sudden death.[2, 3] Additionally, there is evidence that in women, coronary heart disease often presents atypically, making clinical recognition difficult.[4] Two-thirds of women who died suddenly of coronary heart disease had no prior symptoms.[5]

> Two-thirds of women who died suddenly of coronary heart disease had no prior symptoms

Traditionally, cardiovascular disease risk stratification has been conducted using risk factors such as cigarette use, diabetes mellitus, systolic blood pressure, dyslipidemia, etc. However, 60% of cardiovascular disease events occur in the population that is at low to intermediate risk by these traditional risk factors.[6] There is thus an urgent need for identifying patients at high risk of cardiovascular events using risk factors that are both strong and independent of the traditional cardiovascular risk factors, and this need is particularly acute in women.





An example of an AAC-8 score of four. Two each on the anterior and posterior walls of the aorta.

Abdominal aortic calcification (AAC), an indication of atherosclerosis, is significantly associated with both cardiovascular heart disease and stroke even after adjustment for the traditional risk factors of age, cigarette use, diabetes mellitus, systolic blood pressure, left ventricular hypertrophy, body mass index, cholesterol, and HDL cholesterol.[7-10] The increased risk of cardiovascular disease mortality associated with moderate to severe AAC is similar to the increased risk of hip fracture in the presence of a moderate to severe vertebral fracture.

AAC and vertebral fractures have similar prevalence and age-related trends in postmenopausal women, though AAC is less well studied. In a study in the Netherlands, the incidence of radiographically detectable AAC in women was approximately 30% at age 67, rising to 75% by age 82.[11] In the Framingham Heart study, the prevalence of AAC in the studied cohort (mean age 61) was 68% in men and 57% in women.[10] While this prevalence is quite high, it is in keeping with the high incidence of cardiovascular disease. Moreover, the studies indicate a graded increase of risk with more severe AAC scores being associated with a higher risk of morbidity and mortality.