2011 Undergraduate Thesis Topics

Here is a list of proposed thesis topics for 2011. My work focuses on finding better ways to compute using ASIC/FPGA/Cluster/GPU technology. Feel free to email me and make an appointment to discuss any ideas for projects within these areas.

PHWL01 Scalable Vision Machines (1 student)

We are exploring the application of functional programming languages to generate parallel implementations from a high level, domain-specific specification of a computer vision problem. A prototype language which can translate a domain-specific language to parallel code suitable for a general purpose graphics processing unit (GPU) has been developed. This project is concerned with using similar techniques to develop new field programmable gate array (FPGA) architectures and tools for accelerating computations on collections of data (i.e. regular shaped polymorphic arrays, see http://research.microsoft.com/en-us/um/people/simonpj/papers/ndp/fsttcs2008.pdf). The project will involve collaboration with Dr Rami Mukhtar at NICTA and is only suitable for someone with strong programming and digital design skills.

PHWL02 Radio Astronomy using FPGAs (1 student)

The Australian Square Kilometer Array Pathfinder (http://www.atnf.csiro.au/projects/askap/) project, a precursor to the Square Kilometer Array is being developed by the CSIRO and FPGA devices are extensively used for signal processing operations such as beamforming, correlation and spectral analysis. This project will explore novel hardware architectures, tools and methodologies for the digital systems and/or computing needs of ASKAP, the aim being to improve the performance and productivity of existing designs. It will be in collaboration with John Bunton at CSIRO and Prof Anne Green from Physics.

PHWL03 Foreign Exchange Hedging Strategies (1 student)

Most major Australian companies require foreign exchange (FX) services for buying and selling services and goods in a foreign currency. This is typically done through a bank which in turn faces the problem of hedging the FX risk, i.e. managing the accumulated positions via transactions with liquidity providers. This project involves exploring new methods of applying cloud computing and machine learning techniques to predict customer flows and exchange rate changes, and will enable them to better manage foreign exchange risk. It will be in collaboration with Dr Barry Flower at Westpac Bank. Possible projects include:
- Develop a software environment for the parallel back-testing of FX hedging strategies.
- Develop improved customer order flow prediction techniques based on machine learning techniques.
- Develop techniques to better understand and model the dynamics of exchange rate variations, particularly the effect of the FX market on the spot price and spread.

PHWL04 Algorithmic Trading using FPGAs (1 student)

A field programmable gate array (FPGA) is an array of logic gates in which the functionality and interconnection can be configured by downloading a bitstream into its memory. They combine the programmability of microprocessors with the speed and flexibility of application specific integrated circuits (ASICs). FPGAs can be used to accelerate problems in areas as diverse as signal processing, networking, scientific computing and financial engineering, this field of research being known as reconfigurable computing.

Low latency is a focus of many trading systems on Wall Street (e.g. see [http://www.informationweek.com/news/infrastructure/showArticle.jhtml?articleID=199200297](http://www.informationweek.com/news/infrastructure/showArticle.jhtml?articleID=199200297)) and their systems use traditional PC technology and have latencies measured in milliseconds. In this project, a prototype single FPGA system in which a network interface controller (NIC) is integrated with trading logic will be developed. Using such an approach, it is expected that latencies can be reduced by an order of magnitude. The NetFPGA board [http://www.NetFPGA.org](http://www.NetFPGA.org) will be used as the hardware platform. A simple algorithmic trading system that accepts stock quotes from a real-time data feed and generates trade actions will be developed. This project will involve FPGA design using VHDL and a strong interest in digital systems design is required.

PHWL05 Causality of Freezing in Parkinson's Disease (1 student)

A common occurrence in people with Parkinson's disease is "freezing," a temporary, involuntary inability to move. Freezing occurs in certain situations, particularly when the patient is distracted, and is a common cause of injuries due to falls. This project is concerned with obtaining a better understanding of this phenomenon and its physiological basis. We will first develop a miniature wireless accelerometer and electromyography (EMG) device. Using the device to record motion and muscle activity at different locations, we will analyse the causality patterns. Through this work we hope to gain new insights into mechanisms for treatment. This research will be in collaboration with Dr Victor Fung at the Movement Disorders Unit at Westmead Hospital and Graham Brooker from the ACFR.
PHWL06 Wireless Localisation (1 student)

This project is in collaboration with Dr Mark Hedley at CSIRO who leads a group of roughly ten staff working within the CSIRO Wireless and Networking Technologies Laboratory to develop systems for accurate indoor localisation and tracking across a wide range of applications including underground mining and indoor sports. A system called WASP (Wireless Ad-hoc System for Positioning) has been developed that uses time-of-arrival localisation on a rugged custom software defined radio platform providing accuracy down to 0.1 m and update rates up to 200 Hz. They have to date built over one hundred nodes and can deploy large networks of WASP nodes in a mobile ad hoc network in field and application trials. This forms the basis for a wide range of research opportunities in wireless localisation with CSIRO. The projects listed below provide examples of potential projects, in addition to these we will consider other project proposals in this area of research.

- Recently MEMS inertial sensors (such as the Analog Devices ADIS16405) have reached the accuracy where they can be used for inertial navigation. The goal of this project is to build a tightly integrated system to improve navigation by fusing data from the inertial sensor and WASP. The work involves measuring and modelling the error characteristics of the sensor, designing algorithms for stabilising the attitude of the platform, designing algorithms for optimal fusion of the sensor data to estimate inertial sensor bias, and efficient real time implementation of the algorithms. This project can leverage prior research in the field of fusion of inertial and GPS sensors.

- Localisation in indoor environments is complicated by the fact that the distribution of range errors is biased and highly non-Gaussian. We have shown that Bayesian algorithms utilising a realistic model of the errors can produce substantially better localisation and tracking results than conventional algorithms, however their computational complexity is a couple of orders of magnitude greater. This project will develop a real-time implementation of an existing localisation algorithm on a DSP/FPGA computational platform.

- Battery life is the limiting factor in reducing the size of high update rate wireless tracking hardware. This project will examine how to substantially reduce the power of WASP using aggressive power management strategies on the existing hardware and media access controller (MAC) by turning off hardware components and FPGA blocks when not required.

PHWL07 Autonomous Solar Powered Kayak (1 student)

The goal of this project is to develop an autonomous kayak for research and teaching in power electronics, sustainable energy and embedded systems. The School has purchased a Hobie Adventure Island kayak
(see [http://www.hobiecat.com.au/sailing/adventure-island/](http://www.hobiecat.com.au/sailing/adventure-island/)) with electric motor. We will equip it with solar panels for charging and a navigation system which can be controlled via a wireless network e.g. a GSM or satellite phone, allowing it to be operated remotely. After that we will include an on-board computer for navigation and measurements, enabling it to operate autonomously and return data.

An example usage scenario might be to automatically take water quality samples which would be useful in monitoring oil spills. Another is exploring for fish stocks and sending back depth sounder plots via a sat phone. Of course, the same equipment could be used with a passenger and sailed, paddled or operated using the motor, greatly improving its range.