CURTIN UNIVERSITY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

PROJECTS FOR 2011

Prof. Peter Wolfs

Introduction

In each year I attempt to manage a cohort of students to make progress in a few research themes. At any point in time up to 20 projects will be running covering students ranging from Bachelor Degrees to PhDs. The projects below vary enormously in scope and difficulty. Consider your capabilities and skills carefully. Not all projects will be available as students move in and out of topics on nearly a weekly basis.

TRANSMISSION AND DISTRIBUTION TOOLS

These are spreadsheet based design tools to support the transmission line design classes. There are several critical design calculations that require great care and students are prone to frequent errors. The project involves a literature and design standard review to extract key design formulas, their implementation in EXCEL, and the verification of the spreadsheet tool accuracy.

Corona, RFI and EM Field Design Tool

This tool calculates:

- The corona inception voltages and power losses for high and extra high voltage lines from the given conductor spacing and placements. It specifically aims to allow the easy assessment of optimum bundling in EHV lines using Gohar’s method;
- The radio interference levels generated by a given line and compliance with Australian/IEC and IEEE standards;
- Magnetic and electric fields at ground level generated by a given line and compliance with Australian/IEC and IEEE standards. It makes a recommendation on required widths of easements.

A “beta version” is required by the end of week 5 in second semester.

Insulation Co-ordination Tool

This tool calculates:

- The effectiveness of earth wires in shielding phase conductors from direct lightning strikes;
- Feasible insulator strings consider criteria such as specified insulation reliability levels and required mechanical strength.

The spreadsheet will be based on:

A “beta version” is required by the end of week 5 in second semester.

**SMART FEEDER GROUP**

*Smart Meter Laboratory*
Develop a Home Area Network to interface with Smart meters that GEEP

**PV Inverter with Battery Storage – Simulation study**
Develop a Simulink model for a PV inverter with integrated lithium-ion storage

**PV Inverter with Battery Storage – Hardware Development**
Develop hardware for a PV inverter with integrated lithium-ion storage.

Applicants should have strong grades in power electronics and have laboratory skills. At the research masters level you will be required to program embedded processors.

**MAXIMUM POWER TRACKING GROUP**

*Distributed Maximum Power Tracking Models*
Simulink studies of the advantages of distributed maximum power trackers for arrays with partial shadowing.

**Maximum Power Tracking Models**
Development of Simulink models for standard maximum power trackers:

- Voc based methods
- Perturb and Observe
- Incremental Conductance

**Maximum Power Tracking Hardware Development**
Development a hardware system capable of operation in standard maximum power tracker modes:

- Voc based methods
- Perturb and Observe
- Incremental Conductance

Applicants should have strong grades in power electronics, embedded processors and have laboratory skills.
Dr Iain Murray
The projects proposed fall into two groups. The first involves development of systems on embedded or DSP platforms and may include some electronic design. The second includes projects based on standard computing platforms, either Linux/UNIX or Apple Mac OSX/iOS.

The majority of the projects listed are in the area of rehabilitation engineering and assistive technology. If you want a brief outline of those areas go to http://www.cucat.org

This is a particularly useful area of research, with most projects based around building real products (not simulation) that may benefit disadvantaged members of the community. Students interested in these projects should have a good understanding of digital design and C/ Objective C/ Assembler programming. The current projects are listed below, but several others are available and I am happy to discuss any ideas students may have for research in this area.

Customized Linux Kernel development for an embedded system (ARM9)
This project involves the customisation of an embedded linux kernel and associated driver development. The system is to be used in our Braille PDA currently under development (the CUB, see http://www.ece.curtin.edu.au/~iain/CUB)

CCTV System for Vision Impaired
These devices will utilise a rotating camera design that enables people with low vision to perform daily tasks more effectively. By rotating the camera head, the user can read, write, and view magnified images at any distance. This requires the use of a CCD camera, digital zoom and contrast enhance/invert video software. (see also iView in the Apple section)

Speech friendly packet sniffer and/or cable tester
As part of the Cisco Access for the Vision Impaired project, there exists a requirement for a speech friendly packet sniffer and/or cable tester. This could be based on the open source application wireshark or similar.

Currency Identification for the Blind (Dedicated hardware or iOS)
Polymer notes replaced Australia’s decimal paper currency. The denominations of the new notes, while very distinctive in their colour and design, are very difficult to differentiate for a vision-impaired person. All notes are of equal width and increase only slightly in length with increasing value. This project continues the design and development of a prototype device to identify Australian polymer banknotes, which indicates the denomination to a vision impaired person using voice output. Identification is performed by imaging and recognising the contents of the clear window found near the lower corner of each note which is unique for each denomination.
**Braille Keyboard**
This item would replace the standard PC keyboard with a Braille version. Functional compatibility with a standard PC or Mac keyboard is of course necessary but additionally the device must be capable of “forward translation” of Braille codes. Braille uses 7 keys, including the space bar, to form a cell of 6 dots (2 columns of 3 rows). See braille translation project below.

**Braille Translation – Grade 2 forward and back translation.**
Braille is a form of shorthand used by the vision impaired in written communications. It consists of raised dots on paper, in two columns of 3 dots, meaning there are 64 possible combinations that may be represented. Grade two braille uses contractions to represent numbers, common words and letter combinations and some words in an effort to reduce bulk and speed of reading and writing. (64 combinations << 26 upper case + 26 lower case letters + 10 digits + punctuation)

There is, under development within the School, a portable device for the optical recognition of grade one and two braille. The development at this point scans and converts braille cells into a byte, with dot positions represented by bit positions, i.e. \( \text{bit1}=\text{dot 1} \) - \( \text{bit 2}=\text{dot 2} \) etc. The software to translate this binary braille code now needs to be developed. (It should be noted that grade two braille is context-sensitive, i.e. a cell’s meaning is dependant on the preceding and following cells.)

The development platform is the ARM 9 and the application should be developed in ANSI C.

**Translation of sign language to speech**
Communication between the deaf and hearing community can, at times, be difficult and/or embarrassing. A person with a hearing impairment is quite often conscious of the quality of their speech and is therefore happier using sign language. By the use a data glove interfaced to a speech synthesiser, the gestures of the user may be translated to speech. This would mean the hearing impaired would be able to communicate easily and comfortably with persons who do not understand sign language. One interesting issue is the communication between the deaf and the blind as discovered at the paralympic games.

**Optical recognition of embossed Braille.**
A prototype Braille recognition system has been developed. At present this device captures the image of the Braille dots and recognises their position within the Braille cell. A system for decoding grade two Braille has also been developed.

The work required is to complete/improve the recognition, probably with fuzzy logic, and interface the unit to a LCD display. Other improvements to the system are also proposed.
Haptic Displays, Non Visual Representation of Graphical Information, Multimodal Human Computer Interaction, Tactile Graphical Displays

The following applies to several proposed projects.

This project focuses on the design of computer-based haptic (and other) graphs for blind and visually impaired people. Since visual impairment makes data visualisation techniques inappropriate for blind people, we need to develop a system which can make graphs accessible through haptic and audio media. We would like to tackle these problems by using computer technology, such as force feedback devices, 3D sound and computer assistance to help blind and visually impaired people to access graphs and diagrams.

**Ultrasonic White Cane**
The white cane is used by the blind and vision impaired as a mobility aid. It is by far the most economical and efficient method employed to aid users to move about independently. However, it has several drawbacks. Canes make no allowance for overhangs, eg branches hanging over walkways, and is poor at detecting drop offs, eg stairs leading down. By use of either sonar or infra red and audio feedback, the cane may be modified to warn of these obstacles. The device must be integral to the cane, compact and unobtrusive.

**Multichannel Amp**
There is a requirement for a multi channel audio amplifier for blind telephonists. The required amp would have a minimum of 4 channels with independent volume controls. There would need to be software control of mixing, AGC and priority of the fully separated channels.

**iPhone**
There are several projects available in this field. Most form part of a larger project that aims to develop a guidance system for people with disabilities. Some, but by no means all, aspects are listed below;

**Pedometer:** Self calibration using GPS when available, to assist in distance calculation when indoors. Must interact with the compass.

**Video obstacle detection:** Locates objects in the path of the user and differentiates static (eg a table) object from mobile objects (eg person)

**Mapping:** Locate and display a users position within a building from floorplan loaded from a local server.

**Daisyworm:** Traditionally talking book libraries utilised analogue cassette tapes as the media of choice. These cassettes are now difficult to source and a move to digital formats is underway. The recognised standard for Digital Talking Books (DTBs) is “Daisy” (see http://www.daisy.org). This project aims to develop a full featured DTB player for use on standard hand held devices. Existing Daisy devices are generally custom hardware and therefore expensive and may be used for playback only. By utilising standard devices, a single device may perform many other tasks at a lower cost to the vision device.
impaired user. Daisyworm has been released and is available on the iTunes store but requires many significant features to be added.

iView
iView is a modified camera system for use by vision-impaired students in a classroom situation. Such students often make use of closed circuit television systems (CCTV) to enlarge and enhance textbooks and display them on a TV screen. Whilst of great benefit, such systems are not truly portable. The TV required for display is usually heavy and not easily moved (as it needs to be large so that the text can be magnified). Additionally there is the space requirement for the CCTV system, writing materials, books and often a laptop computer with screen enlargement software for note taking. iView will offer a portable system based on an iSight coupled with a 17” Powerbook (so that vision impaired users may employ zoom features), custom software that will work with iChat AV and also leverage Quicktime technology to enhance and enlarge text. One advantage of this system is that the user may point the iSight at the whiteboard and read the text or swivel the camera toward the desktop and read a textbook or take notes by handwriting. This feature is not commonly available in current CCTV systems. Additionally the students will have all their study needs incorporated into a single package. This will reduce costs to the student as current CCTV systems for this purpose cost in excess of $3500 with screen enlargement software costing $2000. To add to the image enhancement software, we would also integrate the previously developed screen reading software so as to capture events. (This is necessary as with zoom a user must be able to track events such as dialog boxes that occur off the displayed part of the screen.)

Cisco Access for the Vision Impaired (CAVI)
In conjunction with the Association for the Blind W.A (ABWA), a benchmark CCNA course is in the process of being scheduled. This study aims to research two main areas in the fields of rehabilitation engineering and learning environments;
• The human computer interface.
• The effectiveness of e-learning technical and conceptual skills for those with vision impairments.
As a side effect of this research we (Cisco Systems & Curtin University) expect to have a unique program that will teach the vision impaired general IT skills as well as an in depth knowledge of network design.

Music Scanner for the low vision Musician
This software application would allow the low vision user to scan written music (score) into a computer. The PC would the enlarge and display the score bar by bar, enlarged (must use variable magnification) on the monitor. The display of the music must be able to be controlled, ie the score must scan across the screen at the rate the musician is playing.
Dasher for OSX
Dasher is an information-efficient text-entry interface, driven by natural continuous pointing gestures. It is a competitive text-entry system wherever a full-size keyboard cannot be used. Dasher is highly appropriate for computer users who are unable to use a two-handed keyboard. One-handed users and users with no hands love Dasher. The only ability that is required is sight.

Dasher can be driven using a mouse, a trackpad, a touchscreen, a rollerball, or a joystick - any two-dimensional pointing device that can take over the role of a mouse. A foot mouse and a head mouse are additional options.

It can also be driven using an eyetracker, giving a completely-hands-free writing system. After one hour’s practice, some users are able to write at more than 20 words per minute using Dasher with an eyetracker.

This project aims to improve the functionality of Dasher as a keyboard replacement for Apple hardware running OS X.

Haptic Displays, Non Visual Representation of Graphical Information, Multimodal Human Computer Interaction, Tactile Graphical Displays (Note this project covers both sections)
The following applies to several proposed projects.

This project focuses on the design of computer-based haptic (and other) graphs for blind and visually impaired people. Since visual impairment makes data visualisation techniques inappropriate for blind people, we need to develop a system which can make graphs accessible through haptic and audio media. We would like to tackle these problems by using computer technology, such as force feedback devices, 3D sound and computer assistance to help blind and visually impaired people to access graphs and diagrams.

Speech Friendly Interface for Packet Tracer
Packet Tracer is a very useful network simulator tool for learning CCNA-level networking concepts and protocols and is extensively used for many networking teaching purposes. However, at present, people with vision impairments can do very little in Packet Tracer as the screen readers cannot read the flash based GUI.

It is extremely difficult for developers to alter PT as the application is not Open Source. Following the release of version 5, several APIs have been exposed for use by 3rd party developers and it is apparent from previous research that an independent, custom built application can be made to interact extensively with Packet Trace through an extension interface using the Packet Tracer messaging Protocol (PTMP) over network sockets.
This project will create such an accessible application that will interact with a running instance of Packet Tracer, allowing vision impaired students to benefit from this simulation package.

**The White Hat Hacker**

One of the best ways to know how to defend a computer network, is knowing how to attack one. By knowing how an attacker will attempt to breach your system, you will be better prepared to defend it.

This project will set up a game environment, like capture the flag, where one team will try to defend their network whilst passing messages to one another (the flag) and attempting to shut down the other team(s) network and capture their message. It will be run on real network hardware in our Cisco labs.

Attacks will include the simple tasks such as DoS, ping attacks, known exploits as well as advanced methods such as packet capture/modification and header/IP masquerading.

**Expected Outcomes:** A set of tools that will allow participants to piece together a strategy for attacking the other teams networks.

**Dr D.G. Myers**

**An educational initiative**

A recent survey of internationally renowned educationalists saw them overwhelmingly endorse the iPad as a technology to revolutionise education. It will enable very different learning paradigms to be investigated that look to be more effective than anything existing now.

I have been thinking of such paradigms for some time now. My concept uses existing iPad features to amongst other things track where a person is located so that if desired they can be easily linked to group members as well as resources such as large screens.

In order to realise this vision, I need to be able to make an iPad into a standard laboratory instrument console. That is, for it to act at least as a CRO, multimeter, voltmeter and ammeter. However, I need other features. For that reason, in the longer term it may be more useful to create a sensor box containing a range of sensors not already part of the iPad. For example:

- Voltage/current sensors
- Infrared sensors
- Sound sensors
- Communications signal sensors other than wi-fi
- Gas sensors

It may also be an idea to duplicate sensors that the iPad already has such as accelerometers. The sensor box would couple to the iPad via USB. It may also have a range of connectors so that it can in turn be used to probe circuit boards or development kits.
There is clearly a possibility here as well to create a universal sensor API to enable any iPad programmer to access any sensor easily. Above that, there could be middleware that locates resources such as screens or data projectors that can be used, or which monitor where other students in the class might be. A question here is whether it is worthwhile doing this in the iPad or farming it off to a cloud system.

Other projects may evolve from this concept in the software domain. For example, tools for the common cartridge format (search the web using IMS-GLC and CC as keywords). The CC format is a new standard for creating multimedia presentations such that elements can be re-used.

OpenCL
About a decade ago, a problem arose with PCs in that the demands for producing GUI screens was soaking up all the computational energy of the CPU. That saw the development of graphics processing chips (GPUs). At first they were hardwired, but for various reasons over time it was more convenient to make them programmable. Then the manufacturers realised that with a few minor changes they could become powerful computing elements in their own right. The latest NVidea chip for example has 512 processors where each can execute a significant thread.

A more recent problem is how to access this computing power? That saw the development of the OpenCL language. It enables a programmer to access any processor in a system including DSP chips, conventional processors and GPUs. Hence there is the potential to turn every PC into a supercomputer. OpenCL is included in all x86 Macintoshes and that is the best option. It can be installed in other Unix systems plus windows, but to do this requires some good computing skills.

The aim of this project would be to use openCL for some application, but I leave that undefined. Some applications are a little too complex. For example, logic verification. Some could be rather challenging such as a parallel hardware design language like System Verilog but this might be tackled by having a high level ‘splitter’ and then compiling the elements with communication primitives. Something relatively simple is the rendering of 3D images. Current renderers only work to first order scattering. That is, after one reflection of the beam off a surface rendering stops. That makes shadows look unnatural and other objects unnaturally ‘clean’. It has long been known that tracing for two, three or even four scatterings gives a much better result. However, that also increases the computational demand factorially. There are public domain packages that could be used where the renderer can be easily replaced, so this might be an interesting topic. Another might be to look at an idea currently being put forward; project an image of a keyboard on a flat surface and then monitor how the user ‘types’ on that keyboard.
Dr Yue Rong
Experience with Matlab is prerequisite for all the projects.

All the projects listed are in the area of underwater acoustic communications. If you want a general idea of this area, please read the following survey paper:

Project 1: Channel equalization for underwater acoustic communication
The underwater acoustic channel has severe multipath interference. In order to achieve high-speed underwater acoustic communication, an efficient channel equalizer should be deployed at the receiver. In this project, the equalizer performance will be studied using the data from a channel simulator developed by Curtin Centre for Marine Science and Technology.

Project 2: OFDM for underwater acoustic communication
The orthogonal frequency-division multiplexing (OFDM) technique can be used to tackle the severe multipath effect of the underwater acoustic channel. This project aims at simulating the performance of underwater OFDM communication system using the data from a channel simulator developed by Curtin Centre for Marine Science and Technology.

Project 3: MIMO communication through underwater acoustic channel
The underwater acoustic channel is extremely band-limited. Multiple-input multiple-output (MIMO) technique can be applied to increase the data rate of underwater communication systems. This project focuses on simulating the MIMO underwater communication system using the data from a channel simulator developed by Curtin Centre for Marine Science and Technology.

Prof. Peter Hall, ECE/Curtin Institute of Radio Astronomy
SOLAR-POWERED ANTENNAS FOR THE SQUARE KILOMETRE ARRAY (SKA)

The SKA (www.skatelescope.org) will use both dish and aperture array antennas. The aperture arrays will operate in the 70-450 MHz region and will consist of many active antennas (e.g. dipole + low-noise amplifier). In total, the number of active elements will be in the region of several hundred thousand and, at the proposed telescope site in WA, there is plenty of sunshine to support a “self-powered” solution, in which each element is energised via its own solar cell and storage arrangement (perhaps a super-capacitor). Such an arrangement may permit just fibre-optic signal connections to be made to the antennas, the resulting galvanic isolation being a great advantage in providing lightning and similar protection to the SKA system.
This project would examine the feasibility of the solar power solution, given a number of SKA design models which produce electrical loads in the range of a few watts per antenna. One particular challenge in the SKA context is the need to produce power systems with very low levels of radio frequency interference (RFI). The project would suit a motivated student with a good understanding of basic physics, an interest in renewable power systems, and a desire to learn more about relevant electro-magnetic compatibility concepts. It will involve design, prototyping and measurement. The project is well-supported financially and topically internationally, offering a good student the opportunity for high visibility in a range of forums.

Interested students should contact Prof Peter Hall (peter.hall@icrar.org or 08 9266 7951) to discuss the project. Note that the emphasis on topics within the project is adjustable to suit the particular interests of individuals.

Prof. Sven Nordholm

**Evaluation and study of time frequency masking algorithms**

Blind signal separation is a popular topic and has developed significantly over the last 10 years. There are a multitude of methods all with somewhat different properties. A large class of such algorithms are related to time frequency masking. In this project we will study methods for doing separation of multiple speakers using two microphones. If time admits we will also do some study of separation of multiple-speakers using a single microphone.

This project is good for an advanced student with good computing skills. The algorithms will be initially developed in Matlab.

**Echo cancellation**

Traditional echo cancellation implementations employ adaptive filters implemented either in time or frequency domain. They are sensitive to non-linear components in the channel. In this study we will study techniques that can be useful for non-linear problems. One of the most commonly used is Volterra filters alternatively neural network processing can be used.

**Speech enhancement**

In this work we are studying methods for speech enhancement depending on the interest of the student it can be single channel techniques based on spectral estimation or microphone array techniques.