ICT Centre 2007 Vacation Scholarship Program

Project 1: Extending the VotApedia Audience Response System
Location: Canberra

For further information please contact the supervisor for this project: ken.taylor@csiro.au

Skills: Skills in some of the following: AJAX, XML, Web Services, JavaScript, Interface Design, Php programming, Flash ActionScript, Usability Analysis Skills.

Prerequisite Criteria
Partially completed degree in Engineering or Computer Science

Project description:
Audience Response by Mobile Phone

VotApedia, is an open source audience response application primarily designed for education that uses mobile phones rather than clickers. You will study user behaviour and modify functionality to improve useability and satisfy unmet user requirements for the free audience response system at www.VotApedia.com. You should review current usage, identify an aspect of the service that could be improved, implement your change and review the effectiveness. VotApedia is built as an extension to Mediawiki, the open source software that runs Wikipedia.

CSIRO has released this software as an open source application and is establishing a foundation to promote its use and further development. The student will contribute to the work of the foundation by continuing development work and addressing issues raised by the user community. It is hoped the student will maintain a relationship with the foundation and developer community supporting this software.

There is a considerable body of research work on the effectiveness of audience response systems for education and there is an opportunity to expand on this research by exploring the new approach that this audience response system takes.

The project aims to build a group of users and developers amongst the open source community for a CSIRO initiative that is well liked by the current small but growing user community. The student will develop an idea and evaluate the effectiveness of their solution with an application in regular use and have the opportunity to see their work used.

What is the vacation scholar going to learn through this project?
The student will be developing for an open source community, gaining experience in a Web2.0 application, gain knowledge in interfacing with telecommunications equipment, learn about developing AJAX applications and gain experience in studying internet user behaviour.

Project 2: Rate Control of Video over IP Networks
Location: Sydney

For further information please contact the supervisor for this project: **michael.lee@csiro.au**

Skills: C/C++, TCP/IP.

Project description:
Video communication is one of the most important Internet applications. However, unreliable networks could cause transmission errors of video streams. A dedicated rate-control technique can guarantee a certain level of video quality with graceful degradation of the data according to the available network bandwidth. The project aims to develop a TFRC-based rate control tool for video transmission over the Internet.

MJPEG2000-based HD video techniques have intensively been studied as part of the Virtual Tearoom (VT) project in the Networking Technologies Lab at CSIRO ICT Centre. As an excellent outcome, MJPEG2000 stream scaler was developed and has been presented at a number of conferences, including IEEE Broadband Multimedia in 2007. This vacation project will aim to develop a rate-control technique using the MJPEG2000 stream scaler which could guarantee video quality over the Internet with bandwidth fluctuation.

Rate control has been an important issue in video communication as it can offer a great adaptable solution to guarantee a certain level of video quality in the network condition with bandwidth fluctuation. The TFRC protocol, which is now part of NS2, can be used as a base method for a further development of rate-controlled video transmission technique.

The project aims to offer a good solution for rate-controlled video transmission over the Internet. The student is expected to develop a software tool which adaptively controls the rates of video streams. The student may also need to create some new concepts in the project.

What is the vacation scholar going to learn through this project?
As rate control is one of important techniques in video communication, there are a number of research issues that have to be solved theoretically as well as practically. It will be a good subject especially for a scholar who wants to pursue a higher degree, such as PhD.

Project 3: Security Exposure of Virtual Machines
Location: Sydney

For further information please contact the supervisor for this project: jonathan.chan@csiro.au

Skills:
- Firm understanding of Windows Operating System
- Knowledge of virtual machine emulators such as QEMU, VMware and Xen
- Familiar with C and C++ languages
- Good initiative and self motivated

Prerequisite Criteria:
Completed computer Operating System subject and optional Computer Security subject

Project description:
Machine virtualisation has been widely used in industry due to its potential to offer significant savings through server consolidation and hosting of customised services. Isolation is one of the fundamental concepts of virtualisation, but most virtual machine emulators are not built to be completely isolated. They are only "good enough" so that typical software applications can be fooled to run inside them.

To clarify this issue, this project will investigate the security issues related to isolation of virtual machine emulators in a hostile environment, such as the presence of key loggers, screen loggers or other form of malware. The student will gain valuable experience in using/analysing virtual machine and malware technologies, and the opportunity to contribute to the security upgrade of those virtual machines under investigation.

This student project is closely related to the continuous development of Trust Extension Device (TED) within our Trusted Services Project. Since the current software-based TED architecture is heavily relying on a virtual machine to isolate the activities between the trusted (i.e. within TED) and untrusted (i.e. the hosting machine) environment, the outcomes of this project will definitely contribute to the design of a better TED prototype to be demonstrated to our industrial partners.

The project aims to produce a basic testing platform through which CSIRO researchers can utilise to investigate TED related security issues and possibly a development platform for the next generation TED. The student's creativity is essential to resemble possible attacks from a hostile environment.

What is the vacation scholar going to learn through this project?
The student will gain valuable experience in using/analysing virtual machine and malware technologies, and the opportunity to contribute to the security upgrade of those virtual machines under investigation.

Project 4: **Development of a key management service on a portable Trust Extension Device (TED) for trust enhanced SOA applications.**
Location: **Sydney**

For further information please contact the supervisor for this project: **julian.jang-jaccard@csiro.au**

Skills:
C++ AND
Either Java or C# (Good use of Security Package from either technologies required)

Prerequisite Criteria:
Though it is optional, it's preferable the student to have the good knowledge in the domain: Service Oriented Architecture (SOA), Web Services, and security issues (such as authentication, authorisation, trust etc.)

Project description:
One method for establishing a trust relationship between remote servers in collaborating web applications is to use a mutual attestation protocol based on hardware solution, such as one proposed by Trusted Platform Module (TPM) specification.

During the trust relationship is in effect, dynamic collaboration can freely happen among the participants on each trusted server by exchanging sensitive data, such as medical records or financial data. However, the shared sensitive data must be controlled in a way to prevent them from being misused even after the trusted relationship has ended.

We propose a novel approach to solve this problem by using a key management service based on the concept of "Ephemerizer" to monitor and manage the lifetime of the shared sensitive data.

The next logical step is to develop a demonstrator which incorporates Ephemerizer into a trusted system such as one developed by our group TED. The aim of the demonstrator is to show it is feasible trust enhanced applications can be built using today's proven technologies such as Java or C#.

This project is one of the core activities within the Trusted Services research and its predecessor projects Virtualization. We are especially focusing on the security problems in enhancing trust among participants of SOA applications.

An exciting trend in enterprise computing lies in the integration of applications developed by multiple enterprises. The best successes in this type of large-scale Internet-based web applications come through use of SOA and Web Services, which allow interoperation between loosely coupled applications, through open standards based on XML and SOAP.

One of the difficult security problems in this new architecture is to establish a trust relationship between collaborating web applications (by means of web servers). This is a hot issue in the Web Services Security community, many researchers and practitioners have been working on devising standards such as WS-Security, WS-Trust, and WS-SecureConversation. Our proposed solution to

approach this problem is summarized as a mutual attestation protocol where two remote servers can mutually authenticate each other to trust each other. The mutual attestation protocol is based on hardware solution proposed by TPM which can toughen the accessibility of the key storage and key management of secret keys compare to general software based counterparts.

Once a trust relationship has been established between interacting web servers, the system must also guarantee the end-to-end security solution for the sensitive data that has been exchanged. The solution should provide a mechanism which to prevent the participants at each trusted server do not misuse the shared sensitive data for malicious purpose. One such solution would be to make the shared data to disappear when the trust relationship ended. Our ongoing research has been investigating ways to corporate a key management service (such as Ephemerizer) to control the lifetime of the shared data.

The aim of the project for the vacation student is to develop a proof-of-concept demonstrator (using either Java or C#) which incorporates a key management system on top of existing TED application (written in Java and C++).

The student will take a lead role in designing the implementation architecture of the demonstrator, identifying implementation issues, and develop a running demonstrator. We also want the student to learn the overall research process by asking the student to produce a report on; stating the research problem and approach based on student's own understanding, and addressing design challenges and implementation issues.

What is the vacation scholar going to learn through this project?
The student will have an opportunity to learn the latest hot topics such as Service Oriented Architecture (SOA), Web Services, general Security and Privacy issues, and Web Services Security standards and technologies.

The student will be supported to develop a critical thinking to approach design challenges, identifying implementation issues, and writing a scientific report.

Also, student will learn a practical skill sets for implementing security solutions using today's proven technologies such as working with latest Java Security APIs or .NET Security components in C#.

Project 5: Interference Study in Wireless Sensor Networks
Location: Sydney

For further information please contact the supervisor for this project: ren.liu@csiro.au

Skills:
- C programming
- Linux environment
- Embedded system (desirable)

Prerequisite Criteria:
- Networking protocols
- Basic understanding of Radio propagation

Project description:
To the networking research community, Wireless Sensor Network (WSN) is the "next big thing" after the Internet. Recent studies on WSN radio reality provide strong evidence that radio links between low-power sensor devices are extremely unreliable. Interference heavily impacts on the performances. The goal of this vacation project is to systematically measure and study the interference distribution in spatial and temporal scales, and analyse the interference effects on data transmission performance, such as packet loss rate, throughput. The experiments will be conducted in real office environment using state-of-art embedded sensor devices.

In CSIRO we are developing a new cross-layer Wireless Sensor Network framework to support joint optimisation, radio adaptation, distributed multi-radio diversity, security, and statistical reliability. Interference is a big problem to radio reliability. The situation is becoming worse when the next generation sensors such as MICAz, TelosB are hopping into the crowded 2.4 GHz band normally occupied by WiFi. Design and development are underway trying to alleviate the interference effects. Understanding the characteristics of interferences is a key part of the overall development.
- Measure radio strength in WiFi frequency bands
- Measure WiFi interference to MICA motes in real office environment
- Characterise spatial and temporal distributions of the interference
- Measure and characterise sensor network performance under interference
- Develop improved measurement techniques

What is the vacation scholar going to learn through this project?
Many students in this area have good experience in computer simulation and modelling; this project will provide them an opportunity to conduct real-life networking protocol experiments in real office environment using state-of-art embedded sensor devices. It will also allow them to feed back the real measurements into the theory and assist in the development of better algorithms. In working with the CSIRO researchers, the student will see the scope of a complex project and the range of skills required.

Project 6: Visual mark-up and rapid prototyping of tailored information delivery systems
Location: Sydney

For further information please contact the supervisor for this project: shijian.lu@csiro.au

Skills:
- Java 2 SE,
- Java GUI development,
- XML.

Prerequisite Criteria:
- Interest in personalised/tailored/adaptive computing,
- Enthusiasm for developing innovative solutions.

Project description:
The ICT centre has developed an approach for developing tailored information delivery systems. This approach is based on research in computational linguistics and with ongoing international collaboration. At present, the approach relies on expert users to specify a *content prescription*, a declarative specification, which instructs how a communicative goal can be satisfied. At runtime, the *content prescription* is interpreted by the planning engine to produce documents tailored to purpose and context.

This project explores approaches to developing a tool that inverts that process: it will enable a less expert, even naïve user, to infer communicative intents from actual documents that already exist. The tool will allow the user to visually mark up communicative intents and will enable them to produce a re-useable *content prescription* from a specific document rapidly, which can then be generalised or constrained, disassembled or combined with others, to meet a wide variety of needs and contexts.

Delivering tailored information to suit users' special circumstance has many benefits. However, tailored information delivery systems are difficult to develop. In CSIRO ICT Centre, we have developed a delivery platform based on cutting edge research in computational linguistics and with ongoing collaboration with a world-leading global manufacturing company. With such a platform, tailoring system development can be achieved by specifying *content prescriptions* in stead of programming. A *content prescription* specifies communicative intents of different content nodes which relate to points in an information space (document collections, web pages, RSS feeds etc.) through information access components known as *retrieval services*. When interpreted, the information needed is retrieved and a contextualised document is produced through a particular realisation strategy. Currently, *content prescriptions* can be authored by an expert using Constructor. Building on top of Constructor, the work proposed in this project is to enable a less expert, even naïve user, to infer possible communicative intents from actual documents (in PDF, HTML, or txt format) that already exist. The new capability would allow a designer to visually annotate sample document instances, and *content prescriptions* as well as *retrieval services* could be automatically get generated. These *content prescriptions* could then be repurposed for generating adaptive documents to suit different user needs. The long term goal of the tailored information delivery research is to make

tailored information delivery system easy to develop and cost effective to deploy in a wide variety of situations.

The project provides the opportunity for the student to investigate innovative approaches to enable rapid prototyping of tailored information delivery systems by leveraging on existing sample documents. By the end of the project, a software prototype is expected which would demonstrate that tailored documents can be produced by utilising sample documents.

What is the vacation scholar going to learn through this project?

- Learn computational linguistic skills,
- Learn user modelling and adaptive application development,
- Learn to address a focused research issue;
- Apply analytic and programming skills to challenging problems for practical solutions,
- Gain first hand experience in a professional research environment.

Project 7: Intelligent support for 'on-the-fly' document tailoring
Location: Sydney

For further information please contact the supervisor for this project: ronnie.ma@csiro.au

Skills:
- Java 2 SE, preferably with experience in Java GUI programming

Prerequisite Criteria:
- Knowledge of the tree data structure and its related traversal algorithms
- Knowledge of parsing algorithms or machine learning
- Knowledge of XML is ideal, but not mandatory

Project description:
The SciFly application ('Science Flyer') demonstrated in the 2007 CeBIT exhibition utilises approaches from computational linguistics to generate coherent and concise CSIRO brochures tailored to the user's interests. SciFly has many complex XML configuration files, one of which is graphically edited with a Java authoring tool. The aim of the project is to improve on this authoring tool by implementing a set of intelligent support extension(s) that would significantly improve on the usability of the tool, such as automatic diagnosis and correction of syntactic and/or semantic errors. The student will be expected to develop an innovative solution by carrying out research, applying quality software engineering skills, and evaluating the significance of their solution.

The tailored document delivery technologies used for SciFly have been developed and applied in projects with international collaborators over several years. The recent work on the authoring tool Constructor has identified many desirable features that will significantly improve utility and reduce cycle-time in document specification.

This vacation student project is offered in the context of SciFly. Upon completion of this project, both the SciFly demonstrator and other applications in Safeguarding Australia will benefit from the project outcomes.

At present, the task of defining a document is carried out through graphical manipulation of a tree-like structure representing the communicative intent or 'content structure' of the document. There is little automated support in this process, leaving the user with the task of ensuring that the specification is well-formed.

The aim of the project is to improve on this authoring tool by implementing a set of intelligent support extension(s) that would significantly improve on the usability of authoring content structures, such as (and not limited to) the following:
- An automated checking and correcting syntactic and/or semantic errors in the content structure.
- An intelligent to-do list reminder that tracks, learns, and warns about missing entities in the content structure.

The improvements of Constructor from this project would also provide a stepping stone towards the long term vision of a simple, easy to use authoring tool that users will no longer be required to understand aspects of computation linguistics to use the authoring tool.

The project aims to significantly improve the capability (and thus improving the usability) of Constructor, which as a result would greatly simplify the task of authoring content structures for any contextualised documents of any application built on top of the Myriad platform. In the context of this project, the application is SciFly.

The creative activities/inputs expected from the student in the project is exploring, implementing, and evaluating different ideas that automatically and intelligently simplify the use of Constructor.

What is the vacation scholar going to learn through this project?

- Acquire an understanding and appreciation of some computational linguistic theories (Rhetorical Structure Theory and Discourse).
- Acquire an appreciation of how cutting-edge research technologies in the fields of computational linguistics is applied to address the problem of "information overload".
- Practical experience in typical activities performed by Scientists, such as conducting research and experiments and/or user evaluations.
- Practical experience in typical activities performed by Engineers, such as designing, engineering, and testing quality software algorithms or components.

Project 8: Declarative program synthesis for the Web
Location: Canberra

For further information please contact the supervisor for this project: **mark.cameron@csiro.au**

Skills:
- Currently undertaking, or have already completed, a Bachelors degree in computer science, software engineering or mathematics.
- Must have completed undergraduate units in basic logic formalisms.
- Experience with one or more programming languages like Prolog, Java, etc.
- Strong analytical skills and an interest in logics.

Project description:
Many Web resources have behavioural constraints—forms-based Web sites are one example of this class of resources. In this project, the student will use a modal logic to declaratively model three different form-based Web sites—each site having different behavioural constraints and different but overlapping information and data processing services. Using a reasoner, the student will synthesize controller programs from a client's data and information processing specification together with these site models. Generated controller programs will enable automated or semi-automated interaction with a series of Web sites and Web services to achieve the specified goals. At the end of the project, students will demonstrate a prototype of the program synthesis module against a variety of different client specifications. If time permits, the student will also develop and demonstrate a basic execution environment for synthesized programs.

Services and web-sites with behavioural constraints are an important class of resources that are beyond the current scope of the Semantic Services Architecture platform.

This project is an early investigation of a very desirable automated composition capability—being able to synthesize a control program to mediate interactions between a client and a set of resources that have behavioural constraints (forms-based web sites in this instance).

The outcomes will be applied in the Semantic Services Architecture project in the Safeguarding Australia theme and in the Semantic Data Integration project in the WRON theme.

During this project, the student will have an opportunity to learn about application of modal logics to resource and client behaviour specifications; using and applying a logic reasoner; and developing rules for controller synthesis reasoning.

Tangible outcomes will include:
- An academic prototype of the control program synthesis module.
- A short report describing the rules used/developed for controller synthesis.
- Controller synthesis for a number of different client goals.

Creative activities or inputs include:
- The application of modal logics to modelling and specifying requirements in the context of a 'real world' scenario.

- There is significant scope for developing novel ideas with respect to developing and applying rules for the reasoner.

What is the vacation scholar going to learn through this project?
During this project, the student will have an opportunity to learn about application of modal logics to resource and client behaviour specifications; using and applying a logic reasoner; and developing reasoning rules for controller synthesis.

These skills would be invaluable for a student seeking to pursue an honours year topic with ANU/CSIRO co-supervision (see http://cs.anu.edu.au/honours/topics.html for example topics)

Project 9: Semantic Security Views
Location: Canberra

For further information please contact the supervisor for this project: peter.lamb@csiro.au

Skills:
- Currently undertaking, or have already completed, a Bachelors degree in computer science, software engineering or mathematics.
- Experience with at least one programming language like Java, etc.
- Must have completed undergraduate units in basic logic formalisms.
- Experience with one or more programming languages like Prolog, Java, etc.
- An interest in logic and/or security.

Project description:
Semantic Data integration allows the description and querying of data from diverse sources through a high-level domain-oriented description of the data. The data is described in an ontology whose terms and relationships come from the problem domain and are an abstraction and unification of the underlying schema of the databases being described.

When access control is applied by the data custodians in a distributed Semantic Data Integration system, parts of the underlying schema are no longer accessible to a user, and it is desirable that these restrictions are reflected in a view of the complete schema that reflects the fact that some of the classes, terms and relationships in the schema no longer have supporting data. The project aims to calculate the semantic security view from the complete ontology, the full schema, and the security view of the schema that the access control system allows the user to view.

The project would be a key to the proper integration of schema-based access control into the Semantic Data Integration system developed in the ICT Centre Information Engineering Laboratory. Without the reflection of the access control restrictions at schema level into the ontology, understanding that data available to a user, and framing queries over the data is complicated by the fact that the full ontology describing the integrated data may not be supported by the data actually available through the access control system.

The student will be required to develop an understanding of how the ontology structures are mapped into the data schemas, and apply this to make changes in the ontology driven by restrictions on the schemas.

What is the vacation scholar going to learn through this project?
The student should develop a strong understanding of the use of semantic descriptions of data that are close to a data use domain as a tool for understanding and accessing complex integrated data.

Project 10: Change management in Composed Web Services
Location: Canberra

For further information please contact the supervisor for this project: athman.bouguettaya@csiro.au

Skills: C++/Java

Prerequisite Criteria: Ability to think outside the box

Project description:
This project aims at designing and implementing a set of experiments that test and validate a change management model for composed Web services. The focus will be on top-down changes initiated by changes in the goals of the composed Web services. The simulation will identify the important parameters and implement a set of scenarios to test the performance of the proposed change model.

This project is directly related to the P-health flagship that focuses on the prevention of colorectal cancer.

This project will provide an evaluation of the proposed change management framework for composed Web services. It is expected that the student will use both their computing and analytical skills to design and implement the simulation model. The outcome will be a set of simulations that validate the proposed approach.

What is the vacation scholar going to learn through this project?
The vacation scholar will learn about the emerging technology of Web services. The scholar will also acquire a deeper understanding of how simulations can be used to ascertain the advantage of the change management approach in composed Web services.

Project 11: Web Service Mining
Location: Canberra

For further information please contact the supervisor for this project: **athman.bouguettaya@csiro.au**

Skills: C++/Java

Prerequisite Criteria: Ability to think outside the box.

Project description:
This project aims at conducting a proof-of-concept of an algorithm that mines Web services. The mining process involves the discovery of "interesting" Web service compositions that would represent new biological pathways that for example, would show how a drug works on a certain disease.

This project is directly related to the P-health flagship that focuses on the prevention of colorectal cancer.

This project will provide a proof of concept for the effective use of an algorithm to mine Web services. The student will use both their computing and analytical skills to design and implement a web service mining algorithm. The outcome will be a demonstration of the implementation of the algorithm.

What is the vacation scholar going to learn through this project?
The vacation scholar will learn about the emerging technology around Web services. The scholar will also acquire a deeper understanding of the application domain, ie, biological pathways and how some the biology problems can be solved using ICT techniques.

Project 12: Bootstrapping Reputation in Web Service Environments
Location: Canberra

For further information please contact the supervisor for this project athman.bouguettaya@csiro.au

Skills: C++/Java

Prerequisite Criteria: Ability to think outside the box.

Project description:
This project aims at providing a reputation model where new Web services can bootstrap their reputation in a fair and accurate fashion. Reputation will be used as measurement to implement trust among Web services. The implementation of this model will involve experimenting with 2 approaches: 1. community-based bootstrapping and 2. hidden markov models as a prediction mechanism for bootstrapping.

This project is directly related to the P-health flagship that focuses on the prevention of colorectal cancer.

This project will provide a proof of concept for modelling of the bootstrapping of Reputations among Web services. It is expected that the student will use both their computing and analytical skills to design and implement the bootstrapping model and conduct a comparative analysis. The outcome will be a demonstration of the implementation of the algorithm.

What is the vacation scholar going to learn through this project?
The vacation scholar will learn about the emerging technology of Web services. The scholar will also acquire a deeper understanding of trust in P2P Web services.

Project 13: Automatic creation of overview pages for science communicators
Location: Canberra

For further information please contact the supervisor for this project:
peter.bailey@csiro.au

Skills:
Perl (preferred); C, C# or Java; general programming skills; and Web standards experience (HTML, XML, HTTP)

Prerequisite Criteria:
Communication skills (oral, written); programming skills (see above)

Project description:
CSIRO has played a major role in the creation of a new collection for the TREC Enterprise track 2007. This collection uses a crawl of public csiro.au websites, and is based on the task of a science communicator finding resources for the creation of an overview page. The availability of relevance judgements for 50 topics provides us with an opportunity to carry out an evaluation experiment. This experiment will determine whether science communicators would prefer to receive an "answer" for a topic of interest as an automatically created overview page (from the known highly relevant resources) vs standard ranked result lists of documents. The current www.csiro.au website contains examples of overview pages already; the project will mimic the creation of these pages from the relevant documents. An experiment will be conducted to compare the two techniques for returning "answers", and test it with science communicators to determine real preference in the task context.

Task-based search is an example of the use of specific context which could be used to move away from classic ranked lists of results as the outcome of information retrieval activities. TREC Enterprise 2007 provides a framework of experimental data in the form of an IR test collection, which has been formulated specifically around a real world task of CSIRO science communicators. Determining if differentiated delivery of results may be used to improve performance or user satisfaction in task-based search is a major long term science goal of the Search and Delivery project. This experiment can be carried out without having to solve the harder problem of finding the "perfect" set of documents for each topic, since the highly relevant documents and experts will already have been identified in the creation of the collection.

The project is part of the broader set of science goals being considered by the combined strengths of the Search and Delivery project. The student will be expected to provide substantial contributions to creating a facility to generate an overview page from the known relevant documents on a per topic basis, and setting up and conducting the comparative experiment. The research is real, and should lead directly to a joint publication to be submitted to SIGIR or equivalent. The student will be involved in all activities associated with the project, and be mentored accordingly.

What is the vacation scholar going to learn through this project?
The student will have exposure to a number of new skills, such as applied information retrieval research methods and user-based comparative evaluations. They will gain an appreciation for experimental methods in the IR field, and the

conduct of user evaluations. In addition, they will be tightly involved in the process of writing up experiments for publication in a leading venue.

Project 14: Improving search algorithms for better health information
Location: Canberra

For further information please contact the supervisor for this project: peter.bailey@csiro.au

Skills: Perl (preferred); C, C# or Java; general programming skills; and Web standards experience (HTML, XML, HTTP)

Prerequisite Criteria:
Communication skills (oral, written); programming skills (see above)

Project description:
Health search is increasingly important on the Web. However, using medical evidence as a quality-basis for guiding search ranking is so far uncommon, challenging, and important to achieve. A classifier algorithm determining assessments of the information quality regarding medical evidence for use in re-ranking by filtering, evidence combination, and focused crawling needs to be learned for the subject of obesity. This must then be applied and compared to alternative techniques for common search queries on the topic. Comparison to human expert judgements for relevance and quality will be used as the benchmark for performance. Analysis of results will yield correlation data that can be used to confirm or deny the hypothesis.

Health search is a burgeoning area of research both within the academic research community and amongst major search engine companies such as Google, Yahoo, and Microsoft. CSIRO and ANU have had a multi-year history investigating this problem in the context of mental health, resulting in a number of high quality publications and improved outcomes for depression search. CSIRO and ANU are currently embarked on a new study part-funded by a grant from Microsoft Research Asia to investigate the extension of the research to the subject of obesity, and to explore whether the techniques pioneered extend from specific health subjects to general health topics. The investigations of topical search lie within the spectrum of information retrieval that is influenced by the context of the information seeking task being carried out – in this case, finding evidence-based medical information on specific health topics. Finding where information context may be used to improve generic search results is a major long term science goal of the Search and Delivery project.

The project is part of the larger grant activities being undertaken by David Hawking, Peter Bailey and ANU researchers. The student will be expected to provide substantial contributions to investigating the application of prior techniques to a new health domain, and will entail significant programming, experiments, and analysis. The research is real, and should lead directly to a joint publication to be submitted to SIGIR. The student will be involved in all activities associated with the project, and be mentored accordingly.

What is the vacation scholar going to learn through this project?
The student will have exposure to a number of new skills, such as applied information retrieval research methods, information retrieval ranking algorithms, Web search engine result manipulation and Web crawler technologies. They will gain an appreciation for experimental methods in the IR field, and how these methods are used to improve search relevance and quality. In addition, they will

be tightly involved in the process of writing up experiments for publication in a leading venue.

Project 15: Correction of intensity inhomogeneity of Magnetic Resonance images in 3D
Location: Brisbane

For further information please contact the supervisor for this project: olivier.salvado@csiro.au

Skills:
C++, Matlab, and Linux skills.

Prerequisite Criteria:
Must be familiar with Matlab and be able to program C++. Other disciplines: image processing, numerical methods, Linux.

Project description:
Magnetic resonance images suffer from a shading artefact: areas closer to the receiver antenna received more signal than the ones far away from it. This intensity inhomogeneity induces two problems: the images are more difficult to interpret by human, and more importantly for us, many computer methods assume that a tissue has a constant intensity across the data which is not true. Several methods exist to correct for this problem and we would like to implement a very accurate correction as part of our image analysis pipeline to diagnose Alzheimer's disease patients where an accurate image correction is needed to estimate brain tissue parameters. This problem is also very important for small animal imaging. A new method has been developed for 2D images by the supervisor (Salvado et al. IEEE TMI 2006 25(5)) and we would like to implement this method in 3D and validate it on our datasets. This tool will be used by many researchers in our team and has the potential to yield a scientific publication.

Reducing intensity inhomogeneity of magnetic resonance images is a hot topic always present at international scientific conferences. There is currently no universal method and the potential to implement a novel state of the art algorithm is very strong with involvement in many projects in our group. Furthermore, the final product of this stage will be a plug-in of our software platform that will be sold or distributed to our collaborators but also to the research community for comparisons and tests. Successful completion and good results will certainly yield to international exposure to the best image processing international research teams and pave the way to doctoral research.

We expect the student to integrate quickly our team of scientists (~18 persons). He should be able to communicate and be very pro-active. Strong scientific and programming support will be available, but the student is expected to be motivated to learn complex software and perform validation experiments. The student should expect to write professional reports and present his work to team meetings. Improvement of the current technique is open and creative student will be able to make a significant impact. The student is also expected to create a user friendly interface and work closely with users.

What is the vacation scholar going to learn through this project?
The student will be exposed to cutting edge medical imaging technology beyond what is taught in class. He or she will learn MR physics, numerical optimization methods, B-splines properties and several image processing methods. The research environment is very rewarding with a large team of international researchers motivated to produce results and a final product.

Project 16: Design of 3D Visualization tools for brain surface information analysis for Alzheimer's disease diagnosis.
Location: Brisbane

For further information please contact the supervisor for this project: oscar.acostatamayo@csiro.au

Skills:
- C++, Computer Graphics, Linux
- Physics, Mathematics.
- Image Processing concepts would be appreciated.

Project description:
Several methods exist to visualize information from the gray matter in a user friendly 3D environment, however they all have specific drawbacks that the student will have to identify. The BioMedIA Lab has developed a cross-platform Medical Image Viewer (MixView), which allows for extensibility through a plugin interface. The goal of this project is to implement the selected method on a graphical user interface to be integrated into MixView. As a practical example, thickness of the gray matter will be visualized for Alzheimer's disease diagnosis.

At BioMedIA Lab - eHRC in Brisbane, researchers are developing new tools for analysing and extracting valuable information from medical images of brain, such as magnetic resonance imaging (MRI) or positron emission tomography (PET). This information can be combined and used for diagnosis of multiple neurodegenerative diseases. In alignment with the Preventative Health Flagship, the long term purpose of the current project is the early diagnosis of Alzheimer's disease.

There are many challenges associated to this project. One of them is the extraction and visualization of quantitative information from a large amount of data (coming from control subjects or patients with different degrees of dementia).

This specific project is aimed at the visualization of quantitative data on a surface representing the main cortical structures of the brain. The outcomes of this project will be a demonstration of the developed tool as plugin for the MixView Cross-platform medical image viewer. The demonstration will show the loading of a plugin, selection of a binary-segmented image, the visualisation and the rendering of different data within MixView. The student will have the opportunity to design the plugin Gaphical User Interface (GUI) and selection of parameters for visualization.

What is the vacation scholar going to learn through this project?
The student will learn about visualisation techniques of structures of the brain. The student will also develop Software Engineering skills in requirements, design and testing in a cross-platform environment for Medical Image processing. The student will be involved in a team working on a clinical problem which is the early detection of Alzheimer's disease.

Project 17: Live-wire based semi-automatic segmentation of Medical images
Location: Brisbane

For further information please contact the supervisor for this project: pierrick.bourgeat@csiro.au

Skills:
C++, wxWidget, Linux, Computer Graphics,

Project description:
Summary: The BioMedIA Lab has developed a cross-platform Medical Image Viewer (MixView). The viewer allows for extensibility through a plugin interface. The goals of this project is to develop a plugin to integrate live-wire segmentation capability into MixView.

Manual segmentation is required in many projects of the BioMedIA Lab, to establish the ground truth, which is then used as a base for comparison with automatic segmentation approaches. Manual segmentation is a tedious and time consuming task, and semi-automated techniques are usually required. The Live-wire algorithm is commonly used in semi-automated image segmentation to increase segmentation speed, while improving repeatability. It allows connecting two user-placed seeds with a curve (live-wire) that automatically clings to object boundaries in the image.

The contour fitting process of the live-wire approach is guided by several parameters, such as the medium grey level inside the object which should be segmented as well as the gradient along the edge. The idea is to build a cost image which is minimal along the edges of the image (eg. using an edge detector). The live wire is defined as the path with minimal cost between two seeds points. Therefore, only a few seeds points are required to generate an accurate segmentation.

The student will implement the live-wire plugin within the CSIRO BioMedIA Lab cross-platform Medical Imaging Library (MILX). This library combines the CSIRO BioMedIA Lab's research and expands on algorithms provided by the Insight Toolkit (ITK), the Visualisation Toolkit (VTK) and other open source tools (e.g. CMake).

The segmentation will be performed within the workspace of the existing cross-platform Medical Image Viewer (MixView). The implementation will make use of MixView's modular plugin architecture, extending its capability for manual segmentation. The implementation will also make use of a Wacom tablet, where the user can directly draw on the screen.

This project aims at designing a plugin which will be used by clinicians to manually segment organs. The 2 main challenges of the project are:

- Real time update of the livewire path when control points are moved/added/removed which will require creative inputs in terms of software engineering.
- Integration of the "continuous drawing" information provided by the Wacom tablet with the livewire constrain which will require creative inputs in terms of the livewire methodology.

The student will also have the opportunity to design the plugin GUI and design strategies for selection of the cost filters.

What is the vacation scholar going to learn through this project?
The student will learn about live-wire, segmentation and filtering. The student will also develop Software Engineering skills in requirements, design and testing in a cross-platform environment for Medical Image processing.

Project 18: Building a case database for the Colonoscopy Simulation Project
Location: Brisbane

For further information please contact the supervisor for this project: josh.passenger@csiro.au

Skills: C++, Linux, XML, 3D image processing and technical writing experience beneficial but not essential.

Prerequisite Criteria:
Excellent written and verbal communication skills and an ability to work in a team environment.

Project description:
The Colonoscopy Simulation Project aims to provide a no-risk-to-patient, virtual training environment for performing colonoscopy training. We are utilising the latest graphics hardware (NVidia 8800 GTX) to perform real-time realistic simulation and rendering of soft tissue and integration of a custom designed haptic device (force feedback) that accepts a real surgical endoscope to research a complete simulation platform for instruction of colonoscopy.

Through collaboration with EPFL Switzerland, the Royal Brisbane and Women's Hospital and the Queensland Health Skills Development Centre, CSIRO is actively researching development of a cutting edge simulation framework for surgical simulation. The project is wholly funded by the CSIRO Preventative Health Flagship.

Development of a robust mechanism for defining clinical cases within the simulation framework is the first step towards implementation of a clinical curriculum within the simulation framework. The student will be expected to provide realistic and creative case histories for patients, as well as process large quantities of CT data using existing software products and combine this data in a novel data format to create clinical cases for use within the simulation framework.

What is the vacation scholar going to learn through this project?
During the project, the student will have a unique opportunity to assist in the development of a cutting edge surgical simulation system and will gain exposure to OpenGL, medical image processing and real-time 3D programming techniques in C++.

The development of case histories for virtual patients will require medical research leading to a sound understanding of the colonoscopy procedure, symptoms and treatment practices within the Australian medical community.

The colonoscopy simulation framework is well established so prospective students should be able to concentrate on completing the project milestones without complex technical problems.

Project 19: Efficient visualization and multivariate analysis of multiple images
Location: Brisbane

For further information please contact the supervisor for this project: jurgen.fripp@csiro.au

Skills:
Advanced C++
Matlab.
Preferred: Mathematical visualization and statistical analysis.

Project description:
The aim of the project is to develop a software plugin interface that allows the efficient selection and visualization of large number of medical images. This will be implemented in C++ as a plugin for MixView, the BioMedIA labs image viewer. This viewer uses several open source libraries including wxWidgets (www.wxwidgets.org), InsightToolKit (www.itk.org), Visualization ToolKit (www.vtk.org).

In our research into Alzheimers disease, hundreds of images are acquired and processed using various algorithms. Visualizing all these images concurrently is difficult and cumbersome to manage with most medical image visualization software.

The primary aim of this project is to develop a plugin to our existing software which allows the efficient visual scanning of our acquired data (ie in the most simple case, thumbnails of the images), selection and searching of sub groups based on criteria specified in a database, and statistical analysis and comparisons of groups of images (ie mean, variance, t-tests).

In our research into Alzheimers disease, registration/alignment of images is critical which produces transformations and deformation fields. The visualization and statistical analysis of these transformations and deformations can provide important information about disease progression.

Stable software plugin that allows the efficient and responsive visualization of large amounts of images.

What is the vacation scholar going to learn through this project?
Software engineering process.
Some medical image processing and visualization.

Project 20: Post processing techniques to derive and visualize clinically significant information from ambulatory monitoring data.
Location: Brisbane

For further information please contact the supervisor for this project: niranjan.bidargaddi@csiro.au

Skills: Programming knowledge in Java/C++ and Matlab

Project description:
The care assessment platform project carried out at EHRC involves analyzying large amount of signals collected from ambulatory monitoring devices such as accelerometers. These devices are worn by chronic disease patients undergoing rehabilitation. We analyse and process these signals to derive clinically significant information which would assist physicians and nurses to provide better care for the patients. For example, we derive daily activity profile (walking, lying, sitting, standing), energy expenditure, walking speed from accelerometer signals using complex signal processing techniques. Large amount of this sort of information derived from devices needs to be processed further to derive clinically significant information. This would involve applying techniques for reducing the size of data without loosing much information, deriving new formulas to present this information on a webpage/screen with low loading times. To summarize, there is large amounts of human activity/vital signal data which needs to be converted to meaningful clinical measures and presented graphically with increased speed and less memory. Opportunities exist in long term to research into new graphical ways of presenting the clinical information and enhancing the post processing operation for a web based operation.

As described earlier, the care assessment platform project carried out at EHRC involves analysing large amount of signals collected from ambulatory monitoring devices such as accelerometers, heart rate monitors. We test and trial the feasibility of various smart devices for clinical applications. As part of the Care assessment platform project, we are currently conducting clinical trials at Redcliffe/Caboolture hospitals to monitor patients undergoing cardiac rehabilitation. Large amount of sensor data is collected from these trials which are processed using sophisticated techniques to derive activity profile/ vital sign information. This data needs to be converted to meaningful clinical measures and presented graphically with increased speed and less memory. The end users of these processed results will be clinicians. They will use this information to provide better care to patients. This also provide the students a means to research into new graphical ways of presenting the clinical information and enhancing the post processing operation for a web based operation. The presentation and processing should be acceptable and easy to use for clinicians.

This project would suit an undergraduate student currently pursuing computer science courses. The project tasks for the student would involve various cycles of a good design practices brainstorming, discussions, programming, testing and even trying new ideas. Assistance will be provided to encourage students think independently to understand and address the problems. The scope of the problem defined eventhough specific to the project will still be broad enough for the student to be creative and address the issues in novel new ways. The student would be encouraged to write a document on his/her work at the end of the program with a presentation.

What is the vacation scholar going to learn through this project?

The student will benefit in numerous ways. In addition to the satisfaction of being involved in a health domain project, there are various other incentives:

- Domain knowledge and the challenges involved in addressing monitoring technologies for community care/chronic disease management.
- Practical skills or know hows in dealing with complex data, signals, computational speed, etc.
- Time management, presentation skills.
- Technical writing skills.
- Challenges/issues involved in addressing the gap between technology and clinical relevance.

Project 21: A web based graphical viewer for biomedical time series signals and hierarchical activity profile visualisation
Location: Brisbane

For further information please contact the supervisor for this project: antti.sarela@csiro.au

Skills: Java and Matlab programming skills

Project description:
The care assessment platform project carried out at EHRC involves analysing large amount of signals collected from ambulatory monitoring devices such as accelerometers. These devices are worn by chronic disease patients undergoing rehabilitation. We analyse and process these signals to derive clinically significant information which would assist physicians and nurses to provide better care for the patients. For example, we derive daily activity profile (walking, lying, sitting, and standing), energy expenditure, and walking speed from accelerometer signals using complex signal processing techniques and store these data in a relational database. The project will extend the existing platform and develop a web based GUI that can be used to access the database remotely over the internet and upload, retrieve, and graphically visualise the signals. The GUI will be developed by using Java Servlet Technology. The use of these measures is new in the practical care environment so there is a need to explore new methods to present the data in a meaningful and user friendly way on the screen. This also involves applying techniques to present the information with low loading times.

As described earlier, the care assessment platform project carried out at EHRC involves analysing large amount of signals collected from ambulatory monitoring devices such as accelerometers, heart rate monitors. We test and trial the feasibility of various smart devices for clinical applications. As part of the Care assessment platform project, we are currently conducting clinical trials at Redcliffe/Caboolture hospitals to monitor patients undergoing cardiac rehabilitation. Large amount of sensor data is collected from these trials which are processed using sophisticated techniques to derive activity profile/ vital sign information. This data needs to be converted to meaningful clinical measures and presented graphically with increased speed and less memory. The end users of these processed results will be clinicians. They will use this information to provide better care to patients. This also provide the students a means to research into new graphical ways of presenting the clinical information and enhancing the post processing operation for a web based operation. The presentation and processing should be acceptable and easy to use for clinicians.

This project would suit an undergraduate student currently pursuing computer science courses. The project tasks for the student would involve various cycles of a good design practices, brainstorming, discussions, programming, testing and even trying new ideas. Assistance will be provided to encourage students think independently to understand and address the problems. The scope of the problem defined even though specific to the project will still be broad enough for the student to be creative and address the issues in novel new ways. The student would be encouraged to write a document on his/her work at the end of the program with a presentation.

What is the vacation scholar going to learn through this project?

The student will benefit in numerous ways. In addition to the satisfaction of being involved in a health domain project, there are various other incentives:

- Domain knowledge and the challenges involved in addressing monitoring technologies for community care/chronic disease management.
- Practical skills or know how in dealing with web interface, usability, complex data, signals, computational speed, etc.
- Time management, presentation skills.
- Technical writing skills.
- Challenges/issues involved in addressing the gap between technology, usability and clinical relevance.

Project 22: Structured Pathology Reporting using Natural Language Input
Location: Brisbane

For further information please contact the supervisor for this project: **iain.mccowan@csiro.au**

Skills: One or more of C++, Python and Java programming skills.

Prerequisite Criteria:
Strong programming skills,
An interest in machine learning and human-computer interaction,
Motivated student capable of exercising initiative.

Project description:
Pathologists communicate their findings to doctors by writing free-text reports. There is a current push from health administrators for this to instead be done via structured forms, to improve consistency and facilitate data analysis. Many pathologists, however, prefer to retain free-text reporting, as it allows them to naturally express complexities of individual cases. This project will develop a software prototype that processes natural language input typed by a pathologist. As each sentence is entered, automatic classifiers will detect if it relates to a set of structured data items. If so, this will be fed back to the pathologist as they type and allow them to validate it. The project will be constrained to reports for lung cancer patients, and will classify factors relevant to the stage of the cancer, such as the tumour size. The classifiers are based on Support Vector Machines, and have already been developed for offline application. This project will involve interface design and implementation as well as the integration of the classifiers into a real-time application.

There is an increasing awareness regarding the importance of human factors in the use of information technology, particularly in the health sector. One key aspect of this is the desire for more natural interaction between humans and IT systems. In complex organisations such as health services, this often conflicts with the need for the collection of structured data items, to provide quality and consistency in information gathering and facilitate data analysis.

This project will develop a proof-of-concept demonstrator to investigate whether state-of-the-art natural language processing and machine learning research can be applied to allow consistent structured data collection while only requiring free text input from a user. The project will build upon research conducted in the ongoing Cancer Stage Interpretation System (CSIS) project at the e-Health Research Centre. While CSIS has shown cancer stage information can successfully be extracted when it exists in stored medical reports, the real need is for the cancer stage to be collected and validated by the pathologist at the point of reporting. This project will investigate to what extent this may be done by applying CSIS in an interactive manner, thereby retaining the current natural language input by pathologists.

The project will produce a demonstration system. The student will have the opportunity to show initiative in designing the interface and functionality of the software, as well as the way in which it is implemented. There will be scope for creativity in designing the interactive component of the interface with the

classifiers to determine the best way for the information to be output to the user in real-time to encourage more consistent and informative reports.

What is the vacation scholar going to learn through this project?
In working closely with a core team of researchers in this area, the vacation scholar will have the opportunity to learn about state-of-the-art techniques in statistical machine learning and natural language processing. They will also gain practical experience in user interface design.

Project 23: Digital Mammogram Class Library
Location: Brisbane

For further information please contact the supervisor for this project: anthony.maeder@csiro.au

Skills: Matlab, basic digital imaging knowledge, Web (html)

Prerequisite Criteria:
Successful use of software tools and techniques to produce an image library

Project description:
Digital Mammogram Class Library – provide access to sets of digital mammograms with similar content characteristics via a web interface.

Breast cancer is one of the highest occurring cancers in women. Presently, early detection is achieved by a national screening program, acquiring X-ray mammograms and inspecting these visually for signs of cancer. The inspection process requires highly skilled and experienced viewers, who must train and quality assure their performance regularly. A digital image library of examples for different types of women and cancers would be useful for this. CSIRO has acquired a high quality collection of digital mammograms with limited patient characteristics and with proven diagnostic results, for use as a gold standard set.

The project will produce a report describing how the classification was done, and a working web interface access to the resulting library galleries.

What is the vacation scholar going to learn through this project?
The student will get a good understanding of how mammograms are used in breast screening, and the types of subtle visual features that occur in medical images.

Project 24: Digital Image Watermarking of Mammograms
Location: Brisbane

For further information please contact the supervisor for this project: anthony.maeder@csiro.au

Skills: Matlab, basic digital imaging knowledge, C++

Prerequisite Criteria:
Successful use of software to produce watermarked images, successful analysis of quantitative and subjective experimental results.

Project description:
Digital Image Watermarking of Mammograms – assess the effects of digital image watermarking on mammograms using existing software and human viewers.

Breast cancer is one of the highest occurring cancers in women. Presently, early detection is achieved by a national screening program, acquiring X-ray mammograms and inspecting these visually for signs of cancer. These images may be transferred between many sites and may be sent outside of the public health system, in which case some care must be taken that they are not altered in any way. Using watermarking to achieve this is only possible if it does not change the appearance of the image as perceived by human viewers. CSIRO has developed a watermarking methodology which includes prediction of visibility of the watermark.

The project will produce a report describing the range of watermark parameters used in the experiments, and the quantitative and subjective testing results for these.

What is the vacation scholar going to learn through this project?
The student will get a good understanding of how mammograms are used in breast screening, and the types of subtle visual features that occur in medical images.

Project 25: Statistical parameter estimators in modelling of high electron mobility transistors (HEMTs)
Location: Sydney

For further information please contact the supervisor for this project: thomas.merkle@csiro.au

Skills:
Good programming skills, esp. in Python and C++, background in computer science or physics with interest in numerical computation, background in linear algebra.

Project description:
Our laboratory works on the design of monolithically integrated circuits at millimetre-wave frequencies (MMICs) up to 100 GHz.

Within this project we want to further quantify the impact of statistical and systematic measurement uncertainties on parameter estimation of high frequency transistor models, especially high electron mobility transistors (HEMTs). Our current measurement software is based on the scripting language Python. In the first part of this work the student will extend the existing software for automatic collection of statistical data used in transistor modelling. In the second part, the student will investigate maximum likelihood estimators and the propagation of measurement uncertainties into the process of parameter extraction. He will also assess error bounds for our current DC and RF measurement equipment.

The understanding in characterization and modelling of modern transistor devices is an excellent starting point for working in one of the exciting fields around MMIC circuit design. Our test and measurement laboratory is well equipped for this purpose and a unique place to get first hands-on experience.

High electron mobility transistors (HEMTs) are the key elements in the design of analog microwave and millimetre-wave integrated circuits (MMICs). The exploitation of quantum effects allows these transistors to reach operating frequencies above 100 GHz and make them the preferred device technology for analog high-frequency radar and data communication circuits. The accurate characterization and modelling of HEMTs is a fundamental prerequisite for successful MMIC designs and thus of great research interest. It is also a large interdisciplinary field that offers plenty of open questions that could be addressed in long-term research topics on a Master or PhD level.

The projects goal is to further investigate the propagation of statistical and systematic measurement errors into the process of model parameter extraction. The student can shed completely new light on the current accuracy limitations in this process. The current information on our lab equipment is partly based on crude assumptions and an actual quantification will support our research greatly.

What is the vacation scholar going to learn through this project?
1. The project offers a good practical and theoretical insight into the DC and RF on-wafer instrumentation used in microwave engineering. Our test and measurement laboratory is well equipped and a unique place to get first hands-on experience.
2. The student will get a broad introduction and overview of parameter estimation problems in the field of microwave engineering. This is an excellent

starting point for working in one of the exciting fields around MMIC circuit design.

Project 26: Characterization and electromagnetic modelling of board connectors for high speed digital applications
Location: Sydney

For further information please contact the supervisor for this project: thomas.merkle@csiro.au

Skills:
Knowledge in MATLAB, background in physics or electrical engineering with interest in electromagnetics and numerical problems, knowledge in linear algebra.

Project description:
This work will support our work in the field of millimetre-wave phased array systems. The student will characterize different board connector types from DC to 6 GHz respectively up to 50 GHz. A method to characterize multiconductor interconnections will be under investigation. The student will support his investigations by electromagnetic field simulations of the connectors under test. A special focus of the work is on the evaluation of the interconnections for use in high speed digital applications. Depending on the progress the implementation of connector models in a circuit simulator can complete the work.

This work will be an excellent starting point in the field of modelling and characterization of microwave components. It is also a good introduction for work further work in one of the exciting fields around MMIC circuit design. Our test and measurement laboratory is well equipped for this purpose and a unique place to get first hands-on experience.

High speed interconnects are one of the bottlenecks in building broad-band millimetre-wave communication systems with data rates of several Gb/s. The accurate characterization and electromagnetic modelling of their impacts on the system performance are of great interest. This work will support our efforts in evaluating several potential solutions found in PCB board design and microwave packaging.

The student will evaluate a method to characterize multiconductor transmission lines and interconnections. This method hasn't been used so far in our lab and it requires the implementation of numerical correction algorithms, likely in MATLAB.

What is the vacation scholar going to learn through this project?
(1) The student will get a good practical and theoretical insight into vectorial network analysers used in microwave engineering. He will also get a general understanding on characterization of microwave components and de-embedding problems. Our test and measurement laboratory is well equipped and a unique place to get first hands-on experience.

(2) The student will get first practical hands-on experience with electromagnetic field simulators. Finally depending on the progress of the project, he will also get some experience with microwave circuit simulators.

Project 27: Electromagnetic modelling of reconfigurable antenna arrays
Location: Sydney

For further information please contact the supervisor for this project: **stuart.hay@csiro.au**

Skills: Mathematical and electromagnetic analysis, computer programming in Matlab.

Prerequisite Criteria:
Successful completion of some undergraduate study in electromagnetics and applied mathematics including numerical analysis.

Project description:
Reconfigurable antenna arrays with the ability to dynamically change their spatial sampling of the electromagnetic field may greatly increase the capability of future radio imaging and communications systems. This project will explore the feasibility of concepts for such systems through the application of recent developments in computational electromagnetics.

ASKAP and other SKA projects are attempting to develop radio imaging systems with wide field-of-view over a wide frequency range and such capabilities are also of interest for future communication systems. Focal-plane or directly-receiving array antennas with digital beamforming have been identified as a promising approach. However, with the existing array concepts, the requirement for operation over a large frequency range sees considerable redundancy in the individual array signals and poor efficiency in the use of beamforming resources. Arrays with the ability to reconfigure their spatial sampling of the electromagnetic field may overcome this limitation and provide significantly expanded capability.

A number of concepts for reconfigurable arrays have been proposed and the student will have the opportunity of adding to these proposals. Detailed electromagnetic modelling is necessary to determine the feasibility of these ideas and becoming familiar with the recent developments in efficient modelling techniques should also be of considerable interest to the student.

What is the vacation scholar going to learn through this project?
About the various challenges of ASKAP and Wireless Lab projects. Principles and techniques in antennas and electromagnetics. Working in CSIRO.

Project 28: Modelling electromagnetic waves in millimetre-wave integrated circuits
Location: Sydney

For further information please contact the supervisor for this project: john.kot@csiro.au

Skills: Matlab programming

Prerequisite Criteria:
Solid grounding in Electromagnetism, Linear Algebra
Understanding of transmission line theory

Project description:
CSIRO is working with Ohio State U. in the USA to develop electromagnetic modelling techniques for composite dielectric structures. The aim of this project is to apply the same methods to microwave integrated circuits, looking at how signals propagate along printed transmission line structures. The project will involve extending some current Matlab software to do the modelling, and hopefully some experimental measurement to verify the results.

Computational modelling has been used as a basic tool for engineering design of electromagnetic systems for many years, but it is still rather limited in its ability to accurately model large, complex systems. The recent developments in this area have concentrated on the development of mathematically rigorous methods, and of special linear algebra methods allowing the development of much larger, more complex models while still using modest computing resources. In partnership with some of the leading international research groups in the field, these new techniques are being applied to several areas in CSIRO, including the development of antennas for the “next generation” radio telescopes, and to highly integrated radio systems for advanced communications. These are long-term research areas with plenty of opportunities for graduate research student projects.

The aim is to develop new methods to the problem of transmission line structures on semiconductor integrated circuits. The student will be expected to try out some different approaches and to develop methods to compare their performance.

What is the vacation scholar going to learn through this project?
The student will extend their knowledge and understanding of applied electromagnetism, and learn how the basic theory applies to real engineering systems. They will also get a basic understanding of some of the methods used in computational electromagnetism, and have the opportunity to use some of the latest methods in this field.

Project 29: Super-resolution terahertz imaging
Location: Sydney

For further information please contact the supervisor for this project: **yue.li@csiro.au**

Skills: Matlab

Prerequisite Criteria:
Digital signal and image processing
Optical or radar imaging

Project description:
CSIRO has built a demonstrator of a THz imaging system. This project is to theoretically and experimentally determine the point-spread function of this system so that it can be used to improve the resolution beyond refraction limit.

Terahertz waves, like mid-infrared and mm-waves in the adjacent bands of the electromagnetic spectrum, offer innovative imaging and sensing technologies for applications in material characterization, microelectronics, medical diagnosis, and chemical and biological identification. Recent advances in THz science and technology make it one of the most promising research areas in the 21st century for sensing and imaging. MIT Technology Review listed THz Technology in "10 Emerging Tech That Will Change World" in its Feb. 2004 issue. In 2003, the journal Nature featured the use of THz waves for defect identification for the NASA Space Shuttle program. NASA has installed six pulsed THz imaging systems for the non-destructive inspection of shuttle insulation foam.

While microwave and X-ray imaging modalities produce density pictures, broadband T-ray imaging provides spectroscopic information in the THz frequency range. The unique rotational and vibrational responses of materials in the THz range provide information that is generally absent in optical, X-ray and NMR images. A THz wave can easily penetrate and inspect the insides of most dielectric materials, which are opaque to visible light and exhibit low contrast to X-rays, making THz imaging a useful complementary technology in this context. Applications including semiconductor and high-temperature superconductor characterization, tomographic imaging, label-free genetic analysis, cellular level imaging, and chemical and biological sensing have thrust THz research into the limelight.

CSIRO has a THz imaging project and a demonstrator of a THz imaging system has recently been built. The project *aim* is to investigate the application, design and integration of a terahertz imaging system for imaging applications, in particular, but with the intention of developing capability for new scientific and commercial applications in sensing networks, security, wireless communications and spectroscopy at THz frequencies. The *scope* is to do research, publish the findings, demonstrate operation of 'all-electronic' integrated antenna arrays for terahertz imaging, determine the best applications for this technology and partner with collaborators to realise commercial or public-good benefits. In the longer-term, we will investigate emerging technologies, such as electromagnetic bandgap (EBG) antennas, integrated photonics and catadioptric configurations for more advanced THz array designs.

Imaging processing techniques such as super-resolution algorithms can improve the imaging system's resolution beyond refraction limit. The aim of this particular project is to determine the point-spread function of the built system and use it to achieve super-resolution images.
The creative activities/input expected from the student: from the setup and properties of the source, mirrors and the detector, derive a mathematical expression for the point-spread function of the imaging system and experimentally measure it.

What is the vacation scholar going to learn through this project?
The scholar is going to learn skills in image formation and image processing.

Project 30: Non-linear inverse scattering
Location: Sydney

For further information please contact the supervisor for this project: greg.hislop@csiro.au

Skills:
Programming skills using Matlab, C++ or other suitable programming language of their choice.

- An interest/ experience in implementing complex mathematics in software.
- A basic understanding of electromagnetics, for example Maxwell's equations, Helmholtz wave equation and fundamental electromagnetic wave propagation.
- An interest in electromagnetics.

Project description:
Inverse scattering is a method of obtaining an image of an object's permittivity/conductivity contrast. An object the internal structure of which is unknown is illuminated from multiple directions using electromagnetic waves and the field scattered by the object is measured from numerous positions. With this knowledge of how an object has scattered electromagnetic energy inverse scattering techniques reconstruct the permittivity/conductivity of the object and thus obtain an image of the object's internal structure. The student will implement in software a method known as the "contrast source inversion method" which solves this problem in an accurate but computationally intensive method. The student will then apply this algorithm to data collected from an experiment we will perform prior to their arrival on timber logs. They shall compare in their results, images made by us prior to their arrival using real time but less accurate techniques to their non-real time but more accurate technique.

The work is aligned with an existing activity in log imaging, however the work is in the periphery. The project outcome would be beneficial in directing future effort in this area. Currently within the multi-spectral imaging project we have a contract to investigate the possibility of imaging logs with microwaves for internal defects prior to milling. The approach we are taking is a tomographic approach where we attempt to reconstruct the internal structure of the logs using inverse scattering techniques. This involves illuminating the log with microwave fields from multiple directions and measuring the scattered fields. With this information it is possible via inverse scattering techniques to reconstruct the internal structure of the log. As in a practical scenario the logs will be moving quickly over a conveyor belt we are using very fast and therefore less accurate inverse scattering techniques. The algorithm the student will implement however is much more accurate but also much more computationally intensive. This project will provide CSIRO with the knowledge of how accurate our tomographic images could become. The student will gain the opportunity to develop their skills at implementing complex mathematics in software and will be exposed to an active and important research field in inverse scattering. He/she will be given the opportunity to see how the contrast source inversion method and our real time methods solve the same problem with emphasis on different requirements (ie speed and accuracy). He/she will have the opportunity to see how well these methods solve the inverse scattering problem and by investigating their limitations will potentially be encouraged to pursue a research career.

The aims of this project are clearly outlined above. The student will have the opportunity to learn about a practical and active research application for

electromagnetic theory. They will implement a world class inverse scattering algorithm and see how it performs compared with less accurate and computationally more efficient algorithms. As the algorithm they are implementing is at the forefront of this research field the student will also have the opportunity to contemplate possible advances to the field.

What is the vacation scholar going to learn through this project?
They will learn about a practical research application for their university studies in electromagnetics. Their ability to code complex mathematics in software will be improved. They will also get a first hand view of what life as a researcher is like within our group and have the opportunity to consider improvements to the algorithm they are implementing.

Project 31: Steerable Antenna Design For Future Gigabit Wireless Networks
Location: Sydney

For further information please contact the supervisor for this project: andrew.weily@csiro.au

Skills:
Background knowledge of electromagnetics and transmission line theory required. Knowledge of basic antenna theory and Visual Basic would be an advantage.

Prerequisite Criteria
Student should have successfully completed 3 years of an Electrical Engineering degree, and have an interest in telecommunications.

Some knowledge on the topics of microwave circuits and antenna theory would be beneficial, but not essential.

Project description:
This project is based upon exciting new technology for millimetre wave wireless personal area networks (WPANs). Operating at 60GHz, WPAN technology will give a dramatic increase in wireless data transfer speeds, providing data rates of greater than 1 Gigabit per second for indoor applications such as file transfer, transmission of uncompressed high definition TV signals, wireless Ethernet and the creation of ad-hoc networks. Focusing on the antenna technologies required for WPAN hardware, this project will contribute to the design of a planar phased array antenna suitable for interfacing with MMIC or RF-CMOS transceiver modules. The phased array antenna will have the capability of steering the radiated power to different directions, for the purpose of improving the WPAN system performance, or adapting to changes in the network environment.

WPAN phased array technology fits in very well to the current research of the Wireless Technologies Lab at the ICT Centre, which includes the science areas of Antennas and Propagation and Millimetre Wave Technologies. It is part of the Reconfigurable Radio project, which already has a collaborative project with a prominent overseas electronics company to develop fixed-beam array antennas.

WPAN technology is also receiving a great deal of attention internationally with well-known companies/organisations such as NEC, IBM, Siemens, CRL and Motorola all actively working on research.

The project aims to achieve a theoretical design for a phased-array antenna suitable for millimetre-wave WPAN applications. The tangible outcomes of the project will be a final report giving details of the theoretical design parameters, materials used and final antenna/array performance. If time permits, a prototype will be built and tested (after scaling the operating frequency to the microwave region). The student will provide creative inputs to the type of antenna used, the type of materials used, and new methods for minimising the mutual coupling between elements (possibly using electromagnetic bandgap materials). The student will be encouraged to pursue a new design, instead of simply modifying an existing configuration.

What is the vacation scholar going to learn through this project?

The scholar will learn about new areas of engineering not typically seen in undergraduate studies, such as phased-array antennas and planar millimetre wave technology, two key areas of expertise in the ICT Wireless Technologies Lab. The scholar will acquire skill in using a commercial electromagnetic software package for the design of an antenna, time management skills involved in working on a small project, and will learn about testing the performance of antennas using a spherical near-field antenna measurement range.

Project 32: Improving Performance of Radio Tracking
Location: Sydney

For further information please contact the supervisor for this project: **mark.hedley@csiro.au**

Skills:
- Electronic Engineering Student
- Some knowledge of wireless communications and signal processing
- Good mathematical skills
- Some experience with Matlab preferable

Project description:
Position location technology has been developed within CSIRO which consists of a flexible communication and processing hardware platform and algorithms for communication and localisation. Determining the node location using radio signals usually uses either a measurement of signal times or signal strength. The aim of this project is to improve the accuracy of the tracking algorithms by combining both measures, and verify the algorithm using real data collected by the student.

The project would form part of the Wireless Localisation and Protocols (WLP) project within the Wireless Technologies Laboratory and form an extension on work being currently undertaken. This work is not on the critical path of the WLP project and without a student would not be undertaken until well into 2008, so the WLP project would not depend upon the student, but a good outcome from the vacation student would benefit the WLP project.

Location tracking in sensor networks is an exciting area of research internationally (e.g. see [1]) for which there are many open problems that would be suitable for a PhD program, and a student taking this project would be exposed to this topic.

[1] N. Patwari, J. Ash, S. Kyperountas, A. Hero, R. Moses and N. Correal, “Locating the Nodes”, *IEEE Signal Proc. Mag*, vol. 22, no. 4, pp, 54–69, July 2005.

The project aims to modify existing algorithms to enhance location tracking performance. At the end of the project the student should be able to demonstrate that the modified algorithm provides superior performance over the existing algorithm in a real sensor network. The student will be given the existing algorithms and suggested literature to read, then the student will be free to try his/her own ideas with guidance and support from the supervisor and project staff. There is also scope for flexibility in the project to adjust the goals to suit the student’s abilities and interests.

What is the vacation scholar going to learn through this project?
The student will have the opportunity to learn about:
- Radio localisation (an exciting research area).
- Wireless communication and sensor networks.
- Applied digital signal processing.
- Software defined radios.
- Developing algorithms in Matlab.

The student will be given the opportunity to be involved in other project activities to allow the student to gain exposure to the full range of activities which also

includes system design, communication protocol development and fusion of radio location and inertial data.

Project 33: Multi-user WLAN Downlink Implementation for Dense Networks
Location: Sydney

For further information please contact the supervisor for this project: iain.collings@csiro.au

Skills:
- Signal processing & digital communication systems knowledge
- Some experience in DSP hardware and Matlab programming

Prerequisite Criteria :
- Signal processing & digital communication systems knowledge
- Some experience in DSP hardware and Matlab programming

Project description:
Within the ICT Centre, we are developing techniques to improve the spectrum efficiency and user densities of future WLAN systems. A key aspect of the project is the ability to simultaneously serve multiple users in real environments, at future high data rates and over future bandwidth constrained channels. The goal of this student vacation project is to implement one of the exciting candidate multi-user coding-decoding algorithms, and test its performance over real channels. The project links the theory of advanced digital communication systems to the real-world of RF multipath multiuser communication channels.

This project is a key step in the ICT Centre project on next generation WLAN technology, an area which is attracting major research activity internationally. CSIRO has an excellent reputation in radio system development, and the project offers the chance to work with some leading researchers in the area. Researchers on the Adaptive Wireless Project have published many international journal and conference papers recently, thus confirming the international standing and reputation of the group. The project also allows the student to gain experience with simulation and modelling of systems in real environments with the ICT Centre Adaptive Wireless hardware development platform.

The project will produce:
- A new implementation of an exciting algorithm which will be incorporated into the existing CSIRO Adaptive Wireless WLAN hardware demonstration platform.
- Analysis of the achievable data-rates in different channel environments.
- Proposals for improvements to the algorithm on the basis of the analysis. It may be, for example, that the algorithms need to be tailored to different types of environments. This will involve working with the researchers who have been developing algorithms.
- It is also possible that the student may develop improved measurement techniques and/or improved software for presentation of results.
- The above will be consolidated in a final report and presentation.

What is the vacation scholar going to learn through this project?
Many students in this area have good experience in computer simulation and modelling; this project will allow them to translate that theory to real-world measurements in different typical environments. It will also allow them to feed back the real measurements into the theory and assist in the development of

better algorithms. In working with the CSIRO Adaptive Wireless researchers, the student will see the scope of a complex project and the range of skills required.

Project 34: GPS Reference for Radio Tracking System
Location: Sydney

For further information please contact the supervisor for this project: **mark.johnson@csiro.au**

Skills:
- Electronic Engineering Student
- Some knowledge of computer interfaces and signal processing
- Good mathematical skills
- Some experience with hardware system design preferable

Project description:
Position location technology has been developed within CSIRO which consists of a flexible communication and processing hardware platform and algorithms for communication and localisation. The existing system uses temperature compensated crystal oscillators for the system time reference, but provides for an enhanced external time reference. Additionally the system uses relative positioning, or user supplied positions for its reference nodes. This project will supply absolute GPS positions for the reference nodes, and a GPS referenced time reference as well.

The project would form part of the Wireless Localisation and Protocols (WLP) project within the Wireless Technologies Laboratory and form an extension on work being currently undertaken. This work is not on the critical path of the WLP project and without a student would not be undertaken until well into 2008, so the WLP project would not depend upon the student, but a good outcome from the vacation student would benefit the WLP project.

The additional value of absolute time and positioning information from the GPS modules would enhance the value and ease of setting up of the existing system, in some of its potential applications, especially in emergency sensor, positioning and communications systems.

The project aims to augment existing hardware subsystems to provide absolute position and timing references. At the end of the project the student should be able to demonstrate that the augmented hardware is easier to set up and capable of improved performance. The student will have guidance and support from the supervisor and project staff, and the ability to add significant personal value to the project. There is also scope for some flexibility in the project to adjust the goals to suit the student's abilities and interests. For a suitable student there is an opportunity to consider the application of differential GPS positioning in the references.

What is the vacation scholar going to learn through this project?
The student will have the opportunity to learn about:
- Radio localisation (an exciting research area).
- Timing and positioning within sensor networks.
- Satellite time and position references.
- Hardware system development.

The student will be given the opportunity to be involved in other project activities to allow the student to gain exposure to the full range of activities which also includes system design, interface development, the whole area of satellite navigation, and self positioning sensor networks.

Project 35: Sigma Delta D/A converter using Rocket I/O
Location: Sydney

For further information please contact the supervisor for this project: john.bunton@csiro.au

Skills: Analogue hardware, Digital Signal Processing

Prerequisite Criteria: VHDL

Project description:
Many FPGAs now have high speed serial outputs running at rate of 3Gbit/s or higher. For this project we treat this output as an analogue signal. Within the FPGA a digital representation of a signal is taken and passed through a noise shaping filter and 1 bit digitiser. The 1 bit data stream now contains a representation of the signal plus digitisation noise. The noise is shaped so that it can be removed by an analogue filter without affecting the signal.

The ICT Centre is a leader, within CSIRO, for FPGA hardware and interfaces. One of the more important interfaces is to the analogue domain. This project will be developing a low cost interface which can be used as a digital IF in a radio. The bandpass design will eliminate at least one stage of mixing and filter that is needed with current systems. For low frequency radios a mixing and the attendant IF filters can be completely eliminated.

The major activities will be developing a delta sigma modulate in Matlab and VHDL and the analogue interface to the high speed Rocket I/O signal.

What is the vacation scholar going to learn through this project?
It is expected that the vacation scholar will learn about 1-bit D/A converters and their implementation as well as become familiar with analogue hardware and the measurement of the characteristics of analogue signal.

Project 36: Communicating agents for self-repairing power grids
Location: Sydney

For further information please contact the supervisor for this project: geoff.james@csiro.au

Skills:
- Experience in programming with MatLab or another scientific language
- Familiarity with a/c circuit theory concepts and calculations
- Interest in adaptive and intelligent systems

Prerequisite Criteria :
- Electrical engineering or physics at least to second-year level
- Computer science desirable (Double degree ideal)

Project description:
As our electricity demand increases and becomes peakier it is more difficult to maintain stability of the power grid. Transmission and distribution networks already have many safety features but can we make them more intelligent and capable of repairing themselves after extreme events? In this project we join the sciences of multi-agent systems (for strategic response) and power engineering (for real-time response) to explore new control strategies in a simple simulated network. Undergraduate circuit theory, MatLab programming, an interest in adaptive systems, and a good dose of imagination are all that are needed to start work – and this could develop into a substantial new research area with important applications.

We have in CSIRO a significant project in agent-based control of distributed loads, generators, and storage devices. Up to this time, our agents have access only to average power consumption or production of the devices under their control, and their responses are on time scales much longer than those required for real-time response to sudden network events. Such events are handled by power-engineering technology that includes relatively simple automated responses aimed at maintaining safe operation.

This project is a first step towards bridging these two domains of control, one sub-second and the other multi-second, and a simple numerical experiment should suffice to demonstrate some interesting effects and to explore the benefits that may be obtained through more intelligent agent-based control operating at sub-second time scales.

It is reasonable to expect this work to develop into a substantial research area in collaboration with power engineering experts such as those at UQ.

The anticipated project outputs are listed in the table above. Following the exploration stage, during which a simple simulator will be written, the student will need to provide significant creative input to develop examples showing interaction between loads, to propose measures of network stability, and to invent new intelligent responses that benefit from interactions. Our approach to mentoring will include lots of stimulation of the student's creativity.

What is the vacation scholar going to learn through this project?
To an appropriate level the student will learn about present issues affecting the electricity network, recent advances in smart power grids, agent technology

including multi-agent algorithms, and power electronics – a rounded experience that could lead to several new interests. He or she will also experience simulation techniques, numerical experimental method, technical report authorship, and conversation with some interesting colleagues both within and outside CSIRO.

Project 37: Image processing and streaming over a wireless sensor network
Location: Brisbane

For further information please contact the supervisor for this project: tim.wark@csiro.au

Skills: C/C++, DSP, Linux, some basic image processing knowledge

Prerequisite Criteria:
Completed third or fourth year electrical/electronic/computer engineering (or equivalent)
Must have demonstrated programming experience in C (or similar)

Project description:
Wireless sensor networks are rapidly evolving as a new instrument to measure the environment around us at a resolution never previously possible. This project will explore the increasing role of image information in these types of networks to measure new kinds of information. Using CSIRO's own cutting-edge hardware platform "Fleck" you will develop a wireless camera network which can stream real-time, compressed image information over a network when significant events occur near a node. PIR sensors at the node will detect movement, and image processing onboard will determine if an object of interest is in-frame. If so, image compression is undertaken at the node, allowing a compact version of the image to be streamed back to base.

This project forms part of a growing program in the development of real-world sensor networks for measuring and understanding the environment around us. The ICT Centre is currently playing a leading role in CSIRO's creation of a large, cross-cutting program into wireless sensor networks with a large number of staff working across a wide range of areas. One of CSIRO's key strengths is the ability to utilise domain expertise in areas such as ecology, animal science and climate change. In particular, the ability to make in-network decisions and select the most relevant information to store and send is seen as a critical step forward in obtaining better quality information for ecological and animal sciences. The opportunity to research core sensor network problems in close collaboration with cross-disciplinary researchers is a unique one, and one that will see CSIRO well-placed in this field for many years to come. This project will fall under one of the key parts of CSIRO's sensor networks program, which is focussing on next-generation platform technologies required to make environmental sensor networks a reality.

This project will result in the implementation and demonstration of a wireless sensor network that combines motion detection, image processing/compression and in-network decision-making. Not only will the project provide the opportunity to work with cutting-edge sensor network hardware and software, but will also provide the opportunity to develop novel techniques and algorithms for making in-network decisions. Successful completion of this project will give a student an excellent exposure to a broad range of current sensor network research problems, as well as providing the foundation for far more in-depth future research into the area of multi-media in sensor networks.

What is the vacation scholar going to learn through this project?

The project will provide the opportunity for the student to learn about many core areas of interest to the sensor networks community. In particular:

- Software development techniques for resource-constrained wireless sensor nodes
- Image processing techniques suited to low-power DSPs
- Latest image compression algorithms suited to sensor networks
- MAC and Routing protocols used in sensor networks
- Operating system principles in low-power devices
- Opportunity to apply creative and lateral problem solving skills
- Hands-on experience with programming of embedded devices

Project 38: Hardware Development of a Small Mobile Robot for Sensor Network Assisted Operations
Location: Brisbane

For further information please contact the supervisor for this project: **paul.flick@csiro.au**

Skills:
Electrical design (protel experience desirable), Mechanical design (3D CAD experience desirable), C microprocessor programming

Prerequisite Criteria:
Third year electrical/ mechatronic/ computer systems student or equivalent.

Project description:
The CSIRO ICT Centre's robotics group currently operates a number of large outdoor industrial Autonomous Ground Vehicles (AGVs) at its Brisbane lab. The group has a new requirement to develop a number of smaller indoor and outdoor AGVs for applications such as an automatic lab tour guide and a mobile sensing device coordinating with a distributed wireless sensor network and other mobile robots. These new AGVs will be based on a low cost commercially available robot base and the successful applicant will be required to instrument and develop a micro-controller based control system.

The Autonomous Ground Vehicles project is advancing its technological foundations in developing core dependable systems for autonomous vehicle operations. Part of creating a dependable system is to utilise available infrastructure to assist with performance. Sensor networks are becoming more predominant in workplaces, and are capable of providing GPS tracking, environmental monitoring, and could be used for localising close-by receivers. Currently, there is little research into using these existing networks for assisting robot operations. They offer the potential for distributed sensing to provide information about the task or environment beyond what the robot is capable of detecting with its onboard sensing. Coordination with sensor networks also offers the potential for tasking the robot based on information obtained from a distant source, e.g. a sensor detects a fire and through the network directs the robot to the area. At QCAT, we have the infrastructure to develop AGV systems that can interface with existing sensor networks. The main problem is that the current AGV fleet consist of large industrial robots which require special licenses to operate and are limited in their area of operations. The goal of this project is to create smaller AGVs that are capable of operating within an environment covered by the QCAT sensor networks. The small robots will act as a research platform and testbed for sensor network-AGV cooperation which is an emerging technology. These smaller robots will be used in future applications to act as mobile sensor network nodes themselves which can supplement larger AGV operations. We believe this is a crucial step towards dependability in autonomous ground vehicle applications.

The project is aimed at developing the hardware components required to remotely control the robot. The students will be involved in planning meetings investigating design options and discussing the pros and cons with experienced team members. This will be done by designing in CAD the placement of components and future expansion into the robot, and designing the wiring diagram to connect all these components. The student will have the opportunity

to demonstrate remote control operations of the vehicle they've helped develop in rough terrain. Once complete the student will also be required to submit a report and present their work.

What is the vacation scholar going to learn through this project?

The student will develop/enhance their skills in:

- System design, of 3D hardware design and placement, electrical design of wiring and power distribution.
- Microprocessor programming for machine control
- The reward of developing a real mobile robot, and seeing it come to life.

Project 39: Software Development of a Small Mobile Robot for Sensor Network Assisted Operations
Location: Brisbane

For further information please contact the supervisor for this project: **polly.alexander@csiro.au**

Skills:
Strong C programming, firmware/microprocessor programming experience, some Linux experience desirable.

Prerequisite Criteria:
Third year Electrical/Mechatronic/Computer Systems Student or equivalent.

Project description:
The CSIRO ICT Centre's robotics group currently operates a number of large outdoor industrial Autonomous Ground Vehicles (AGVs) at its Brisbane lab. The group has a new requirement to develop a number of smaller indoor and outdoor AGVs for applications such as an automatic lab tour guide and a mobile sensing device coordinating with a distributed wireless sensor network and other mobile robots. These new AGVs will be based on a low cost commercially available robot base and the successful applicant will be required to instrument and develop a system of control and communications on a small micro-controller based system**.**

The Autonomous Ground Vehicles project is advancing its technological foundations in developing core dependable systems for autonomous vehicle operations. Part of creating a dependable system is to utilise available infrastructure to assist with performance. Sensor networks are becoming more predominant in workplaces, and are capable of providing GPS tracking, environmental monitoring, and could be used for localising close-by receivers. Currently, there is little research into using these existing networks for assisting robot operations. They offer the potential for distributed sensing to provide information about the task or environment beyond what the robot is capable of detecting with its onboard sensing. Coordination with sensor networks It also offers the potential for tasking the robot based on information obtained from a distant source, e.g. a sensor detects a fire and through the network directs the robot to the area. At QCAT, we have the infrastructure to develop AGV systems that can interface with existing sensor networks. The main problem is that the current AGV fleet consist of large industrial robots which require special licenses to operate and are limited in their area of operations. The goal of this project is to create smaller AGVs that are capable of operating within an environment covered by the QCAT sensor networks. The small robots will act as a research platform and testbed for sensor network-AGV cooperation which is an emerging technology. These smaller robots will be used in future applications to act as mobile sensor network nodes themselves which can supplement larger AGV operations. We believe this is a crucial step towards dependability in autonomous ground vehicle applications.

The student will be involved in design and planning meetings for the project, investigating design options and discussing the pros and cons of different options with experienced team members. The student will be expected to think creatively while researching different design solutions and think critically to assess the implications of their designs. The project will culminate with a demonstration of

basic remote control functionality, involving control of a small robot from a USB joystick connected to a desktop.

What is the vacation scholar going to learn through this project?

The project will allow a student to develop and enhance a large range of skills including:

- Software and system design, involving the creation of communications protocols
- Programming of embedded processors
- Programming using the laboratory's core software modules
- Hands on testing and involvement in a full software design cycle
- Teamwork (dealing with the lab's technicians, programmers and with other students)
- Fieldwork (Testing the robots)

This project will provide inspiration for a student by allowing them the chance to make their own design become an active and mobile reality.

Project 40: Simulation and Visualization Optimization
Location: Brisbane

For further information please contact the supervisor for this project: **mike.bosse@csiro.au**

Skills:
C++ and OpenGL.
Linux Platform is desirable.

Prerequisite Criteria:
Partially completed degree in Engineering or Computer Science

Project description:
The primary aim of this project is to make significant improvements to the performance of Gazebo simulation engine using GPU (graphics processor unit) optimisation in OpenGL. This is to be demonstrated on Hot Metal Carrier and Rope Shovel platforms. If time permits, the second aim of this project is to improve the usability of X3D visualization software through porting of FLUX code to OpenGL.

Several project in the Autonomous System Lab (for MICTA & e-Technology theme) require physical simulation of sensors (lasers and cameras) on various hardware platforms (Rope Shovel, Rock Breaker, Starbug, Helicopter and HMC). Although Gazebo is the most appropriate open source simulation package, its performance is limited by its inefficient use of OpenGL. This project aims to take advantage of the current generation of GPU's and in so doing make a contribution back to the open source community.

Similarly, several projects require 3D visualization of robot state and digital terrain maps. Although there are a number of 3D visualization packages (such as VTK) they are not designed to support dynamic content over the Internet (an essential requirement for TeleRobotics). AJAX3D is an emerging standard that combines X3D (ISO standard for real-time computer graphics) with cross-platform AJAX techniques (*Asynchronous JavaScript and XML)*. Although X3D is an open standard, its support under Llinux is very limited – particularly with the choice of user interaction. A popular X3D viewer, called FLUX, has just recently been open sourced but only has DirectX support. The secondary aim of this project is to port this viewer to Linux using OpenGL and investigate improved viewing modalities for robot visualization and control.

We would like to be able to “fold” the optimised Gazebo and X3D visualization back into our standard DDX toolkit. This would enhance our ability to rapidly prototype and test new robotic platforms and user interfaces. It is hoped that that the student will provide unique solutions to the issue, and thus provide realistic and realtime simulation and visualization technology to CSIRO.

What is the vacation scholar going to learn through this project?
It is hoped that the student will gain a detailed understanding of OpenGL and the interaction with the GPU. And through interaction with our robotic platforms gain an appreciation of the issue surrounding real-world and real-time control. Coding and documentation standards will also be applied.

Project 41: Use of Gaming Engines for Telerobotics
Location: Canberra

For further information please contact the supervisor for this project: **chris.gunn@csiro.au**

Skills:
Experience with the Second Life Environment
Experience with scripting in Second Life, programming skills.

Prerequisite Criteria:
Partially completed degree in Engineering or Computer Science.

Project description:
Controlling the real world from Second Life
The aim of this project is to explore the use of Second Life as a platform for teleoperating real world devices. Second Life provides a sophisticated gaming environment that can be used for interacting with real world devices. You will control a robotic device by manipulating a model of the device you create in Second Life, then investigate the suitability of gaming environments for a teleoperating real world equipment. Your teleoperated device can remain as a permanent demonstration on the Second Life CSIRO island.

Within the telerobotics project there is a Mirror World activity and this vacation project is intended to be an integral part of this activity. Gaming environments provide sophisticated three dimensional worlds that could be much more effective for teleoperating equipment than existing alternatives. The use of gaming environments for teleoperation is a new idea that may expand the reach of teleoperation to applications where teleoperation is in its infancy. The application domain in which we are particularly interested is remote mining. Currently information services are outsourced to call centres and teleoperation provides the opportunity to extend the concept to physical services.

There will be a demonstrator developed that will reside permanently on the CSIRO island in Second Life. The student will apply their gaming skills to controlling a device in the real world from a virtual world. The student will evaluate the effectiveness of the teleoperating from a virtual world.

What is the vacation scholar going to learn through this project?
The student will learn about immersive environments, teleoperation and how to extend a gaming engine to teleoperate a device. They will develop programming skills and skills in evaluating usability.

Project 42: Laser targeted positioning of a robotic manipulator
Location: Brisbane

For further information please contact the supervisor for this project: kane.usher@csiro.au

Skills:
- C programming
- Basic knowledge of image processing
- Basic knowledge of robot manipulator kinematics and control

Prerequisite Criteria:
- Partially completed degree in Engineering or Computer Science

Project description:
Vision-based, laser targeted positioning for a robot manipulator. The aim of this project is to enable vision-based positioning of a robot manipulator based upon input from an operator using a laser pointer (much in the vein of a 'smart bomb'). The idea is to use a standard imaging device mounted on the end-effecter of the robot, enhanced to highlight the spot produced by a laser pointer. Simple image processing is required to segment the laser spot within the image, following which a set of demands for the robot need to be derived in order to drive the manipulator towards the laser spot.

Autonomous robots and systems perform remarkably well in clearly defined environments. However, truly intelligent autonomous machines, which can robustly deal with unforeseen circumstances and environments, are some way away. The central principle in this project is that of shared autonomy in which humans and 'intelligent' machinery operate in conjunction to achieve a task. This is an area of great interest within the Autonomous Systems Laboratory, and which is seeing wider interest in the international research community.

The project aims to produce a system which can position a robot manipulator based upon input from a human who identifies and points to a target using a laser pointer. The project will culminate with a demonstration of this system on a robot manipulator. There are several areas to be explored in this project including the ideas of 'shared autonomy' and that of visual-servoing both of which are areas of active interest both within the ASL and the wider research community in general.

What is the vacation scholar going to learn through this project?
The project will provide the student with the opportunity to learn about and implement a novel visual servoing method along with the chance to experiment with the idea of shared autonomy in which humans and machines cooperate to achieve complex tasks. It is expected that the student will gain experience in c-programming, robot manipulator kinematics and control, image processing, visual servoing, and in developing systems allowing human and machines to more effectively interact.

Project 43: Real-time hyper-spectral image processing and classification of marine micro-organisms
Location: Brisbane

For further information please contact the supervisor for this project: matthew.dunbabin@csiro.au

Skills:
- C or C++, Matlab

Prerequisite Criteria:
- Partial completion of computer science degree
- Competent in Mathematics

Project description:
This project investigates the feasibility of using advanced vision and image processing techniques to address a common short fall in current sensing systems. Most sensing systems only measure a single parameter using various integrative approaches. With advances in computing and CCD technology, there is a unique opportunity to investigate and develop advanced vision-based monitoring and classification systems for deployment in hostile marine environments. Vision-systems have the potential to simultaneously classify a large number of non-related variables and at greater temporal resolution.

The primary outcome of this project will be the development and evaluation of a real-time image-based hyper-spectral classification system for a set of marine micro-organisms which could eventually be used for in-situ remote monitoring. The system will use hyper-spectral lighting sources to make the various marine organisms in a sample fluoresce. The challenge then is to devise a real-time image processing solution to robustly segment the organisms and classify them, their size and temporal variability using a system such as Support Vector Machines.

CSIRO, through the Wealth from Oceans Flagship, is interested in using advanced ICT technologies and approaches to improve their ability to observe and understand the natural environment. Current technology is relatively expensive and limited to a few specific sites whilst also limited to measuring a few specific variables.

There is a genuine need to improve collection rates, both spatially and temporally, as well as methods to process it. Nearly every marine research, and water resource institution globally require systems to either directly measure or classify their data. In some instances, they are able to collect too much data and never process it.

Vision-based systems offer the potential to radically increase the quantitative aspects of marine classification. However, there are many challenges relating to image processing and robust classification, especially when operating in the real-world scenarios/environments. Development of robust classification technology and schemes is being attempted at various institutions around the world, but their solutions are often generic and can only achieve 70-80% reliability in classification. To become accepted as a valid research tool, these classification rates need to be vastly improved to 95% or more.

This project aims to determine the feasibility of creating a real-time image-based hyper-spectral classification system for marine micro-organisms which could eventually be used for in-situ remote monitoring.

This project requires the student to develop:

- Efficient segmentation and classification algorithms which could eventually be ported to a FPGA for in-situ processing.
- Methods of data representation for correlation with current commercial integration based sensors.
- A process for developing, training, and evaluating the performance of the Support Vector Machine

What is the vacation scholar going to learn through this project?

Through completion of this project, the student will gain knowledge and experience in the following areas:

- Image manipulation and morphological functions for enhancement and segmentation.
- Various colour spaces associated with image processing.
- Support vector machines for classification.
- Real-time image capture and processing.
- GUI development for displaying results and process control.

Project 44: Computer Controllable Power Switching Device for Avionics Systems
Location: Brisbane

For further information please contact the supervisor for this project: torsten.merz@csiro.au

Skills:
Practical experience in:
- Microcontroller application design
- RS232 communication
- Power switching and measurement technology (<15A, <20V)
- C programming (desired)

Prerequisite Criteria:
- Enrolled in Electrical Engineering / Avionics Program (3rd year and above)

Project description:
The goal of this project is to design, build, and test a prototype device for power switching and monitoring of electrical consumers in an avionics system of an autonomous mini-helicopter.

Components shall be switched from a host computer through a RS232 link and manually with toggle switches. The switching state, voltages and currents shall be made available through the serial link. In case a consumer exceeds its power specification (current, voltage) the device shall break the circuit ("smart" fuse).

Working with aerial robots is challenging and exciting and the experience made in such a project is of great value in the growing UAV industry.

The major goal of the "Airborne Inspection Robot" (AIR) project is to demonstrate a dependable, autonomous mini-helicopter prototype for inspection tasks such as power line inspections. Power switching and monitoring is a core functionality of an avionic system. As there is no pilot on-board the helicopter, electrical consumers have to be power switched and monitored from an on-board host computer. Hence, this student project is of great value for the AIR project.

A device like this is useful for any dependable robotic system developed in industry and research laboratories all over the world.

The outcome of the project is to build a prototype device which demonstrates the advantages of computer controlled power switching. A similar device has been realised by the primary supervisor in a previous project which permits to provide helpful advice to the student. The student should be able to solve smaller problems independently by sourcing and reading documentation of electronic components and application notes.

What is the vacation scholar going to learn through this project?
The student learns how to work both independently and as a valuable member of a team in the very challenging field of aviation automation. He or she will go through the whole cycle of building a component in an avionic system: from specification to testing (including documentation). Moreover, the student will learn how to focus on essential problems and will experience the practical side of building dependable electronic systems.

Project 45: Self-assembly Simulator
Location: Sydney

For further information please contact the supervisor for this project: ying.guo@csiro.au

Skills:
The student should have considerable background in applied mathematics and sound programming skills on C++ and Java.

Project description:
This project aims to develop a self-assembly simulator that can simulate interactions among nano-particles in a variety of solutions. One specific interesting problem is to show the drying of individual droplets containing nanoparticles. Drying of individual droplets containing dissolved or suspended solids has been given significant importance due to the increasing popularity of the spray drying operation in the production of various chemicals, ceramics, drugs, food, and dairy powders as well as nanoparticles. The physical and biological qualities of the final products primarily depend on a lot of factors, such as the history experienced by the droplet within the dryer. It is, therefore, desirable to understand and simulate the droplet's behaviour and various characteristics such as moisture content and temperature profiles accurately.

There are existing multi-agent simulators in our group, which may be readily modified to suit the needs of particle based simulation. The student will be expected to extend them to (1) incorporate physics-based fields into particle interaction and (2) enhance their visualisation capabilities. The student can then use the modified simulator to observe the drying of droplets with different nanoparticles.

There is a great deal of interest in making fine scale materials structures. Investigations of nano-structures aim at better understand these properties to both help our basic understanding of materials, and to exploit these properties to solve some practical problems. The self-assembly process of the nano-particles can build structures naturally. The trade off however is that self-assembly is a natural process and may not generate perfect/designed structure. The drying process of the liquid is one of such problems. Hence it would be very useful if a realistic self-assembly simulator can be developed.

Our team has built good collaboration relationship with CSIRO nano-technique experts, such as Lech Wieczorek and Burkhard Raguse of the Nano-technology Team from the CSIRO Industry Physics division (CIP) in last year. They also articulate the need for a high-fidelity simulator. With their support, real experiments and observation results can also be used as the input information and comparison resources for the simulator. Hence the simulator will be of great benefit to both CIP and ICT Centre.

A practical simulator of the multi-agent system that can simulate the nano-particle self-assembly behaviour will be generated. A good understanding and implementing of the drying process of liquid drops using the simulator is also expected to be achieved.

What is the vacation scholar going to learn through this project?

The student will learn in two main areas: (1) to develop a practical simulator using C++/Java. (2) to understand the mathematics behind the liquid drying problem. The student with such knowledge and experience has the potential to continue the research through a PhD study.

Project 46: Low power motion tracking in wireless sensor networks
Location: Brisbane

For further information please contact the supervisor for this project: **lasse.klingbeil@csiro.au**

Skills: C/C++, Assembly, Linux, electronics experience

Prerequisite Criteria:
Completed third or fourth year electrical/electronic/computer engineering (or equivalent).
Must have demonstrated experience with programming microcontrollers.

Project description:
This project explores the use of a mobile sensor networks for monitoring position and motion of humans or animals. Power is a important consideration and with the radio typically accounting for a significant portion of power usage, there is a need for the development of power friendly algorithms for these embedded devices. The project several key aspects. Firstly, the implementation and testing of radio communications on a new low power 'system on chip' (microcontroller + radio). Secondly, the interfacing of useful motion sensors to this chip. Thirdly is the important aspect of this project is the collection, interpretation and classification of motion data for localization algorithms. The final aspect of this project (time permitting) is the visualisation of the motion and localisation data using utilities such as Google maps and Google Earth.

The project is part of a growing program in the development of real-world sensor networks. A particular class of network of interest to us are "mobile networks", where a number of the nodes are moving (e.g attached to humans or animals). The testing of a new embedded radio device is of general interest for all sensor network activities within the Sensor Networks theme, since power and size are both important issues. Tools for collecting, analysing and visualising motion data will be valuable to the existing cross-divisional research projects of cattle monitoring (ICT/CLI) and human ambulatory monitoring together (ICT/eHealth Research Centre).

The main goal of the project is the prototyping of a low power wireless sensor network using a novel radio chip for the collection of motion data of a node moving through the network. The project gives broad experience of the different aspects of wireless sensor networks (from low level embedded programming to the interpretation of gathered data) without the need to delve into high detail in every aspect. However, depending on the interests and abilities of the student, we are happy for any aspect of the project to be explored in more depth. Possible aspects that could be explored in more detail include: local preprocessing of motion data, localization algorithms and data visualization using Google Earth.

What is the vacation scholar going to learn through this project?
- Understanding of power constraints of long term mobile sensing
- Software development for resource constrained wireless sensor nodes
- Low level microcontroller programming
- Low level radio communication protocols
- MAC and routing protocols used in sensor networks
- Methods for RF based localization
- Methods for motion sensing

- Interpretation and visualization of spatio-temporal data

Project 47: On the Reliable Data Transport Protocol in Wireless Sensor Network (WSN)
Location: Brisbane

For further information please contact the supervisor for this project: wen.hu@csiro.au

Skills: C++/C, Operating System, Basic Network Protocols

Project description:
Sensor networks have been envisioned as powerful solutions for many applications, such as monitoring, surveillance, measurement, control and health care. One of the main functionalities of WSNs is to collect and to transmit the sensed data to the gateway. However, ensuring reliable data transport is a challenging task due to limited resources such as energy and memory constraints, and dynamic environment such as high channel error probability. This project aims to implement a reliable data transport protocol and link quality estimation using our outdoor testbed. The approach is to use implicit ARQ (Automatic Repeat Request) for hop-by-hop (HBH) recovery which the sender needs to request for retransmission implicitly if packets are lost. Compared to implicit ARQ, traditional HBH ARQ, which uses explicit Acknowledgement (ACK) messages, consumes much more energy. Explicit ACKs are required for wired links; however, with wireless links, the transmitter can "overhear" the forwarding transmission and interpret it as an implicit ACK.

This project provides the opportunity for the student to keep in touch with cutting edge technologies, and applies the theories learned from networking courses to solve a realistic problem. Delivering data reliably is one of the fundamental requirements for any network. Previous research shows that the yields of sensor networks in harsh outdoor environment are significantly lower than the expectations of sensor network research community. Compared to traditional IP networks, sensor networks have additional resource constraints (energy, memory). Recent studies show that implicit ARQ and link quality estimation are important tools in sensor network transport protocol design. We would like to study/evaluate these reliable data transport protocols in harsh condition, i.e., our outdoor deployment, which is one of the major areas targeted by CSIRO.

- A link quality estimation component for FOS, which is one of the critical components for reliable data communications in FOS.
- A reliable transport protocol for FOS based on implicit ARQ.

What is the vacation scholar going to learn through this project?

- In-depth understanding of the functions of different layer network protocols, i.e., Medium Access Control (MAC), Routing, and Transport layers.
- Problem solving skills (applied existing theory knowledge on new problems)
- Effective communication skills (the vocation scholar will work with a team of 8 researchers who are working on FOS actively)
- Hands-on experience on embedded device programming.

Project 48: Simulation of Self-repairing Modular Robots
Location: Sydney

For further information please contact the supervisor for this project: mikhail.prokopenko@csiro.au

Skills: Delphi or C++; Java3D; Open Dynamics Engine (ODE)

Project description:
The project extends a simulation framework of a modular robotic system: a multi-segment snake-like (salamander) organism, with actuators ("muscles") attached to individual segments ("vertebrae"), capable of robust locomotion in rough terrains. A particular side-winding locomotion, emergent as a result of individual control actions when the actuators are coupled within the system and follow specific evolved rules, may be extended with active vision. There is no global coordinator component in the evolved system, and anomaly and fault detection are addressed in a decentralised way. Self-repairing capability is the focus of the project.

The project will fit into existing CSIRO ICT Centre collaborations with Department of Information Systems Design at Doshisha University, Kyoto, Japan (Dr Ivan Tanev), and Laboratory of Autonomous Robotics and Artificial Life at Consiglio Nazionale delle Ricerche, Roma, Italy (Dr Gianluca Baldassarre). It may develop into a PhD work, relevant to the Adaptive Systems team in the Autonomous Systems Lab, and potentially contribute to a number of themes (e.g. Minerals Down Under).

The project will produce a number of software routines significantly extending the existing framework, and a paper investigating different ways to detect anomalies and faults in a modular robot, leading to planning of self-repair.

What is the vacation scholar going to learn through this project?
The student will learn:
- how to develop physics-based simulations;
- how to apply genetic algorithms;
- elements of information theory (e.g., mutual information and excess entropy);
- modern anomaly/fault detection techniques.

Project 49: Benthic image analysis
Location: Hobart

For further information please contact the supervisor for this project: **matthew.baker@csiro.au**

Skills: C++

Prerequisite Criteria: Should be doing maths as part of degree

Project description:
The broad aims of the marine observation network project are to deploy a heterogeneous network of sensors in the Derwent, Huon and Channel. Complementary to this, imagery will be captured of the benthos using an autonomous underwater vehicle (AUV) which has been developed in-house. Algorithms will be developed to automatically classify benthic habitats from these data. We will be investigating different wavelengths from UV to IR, potentially polarisation filters and algorithms to improve visibility. As we will own the image capture equipment (or at least plan to), the student will have the rare opportunity to influence the way in which images are captured, based on his or her findings.

The broader aims of the Theme are to support regional multiple use management. This project will support other modelling and decision-making projects focusing on the Derwent/Huon/Channel region. Manual classification of benthic imagery is extremely labourious. In addition, imagery tends to be very poor due to the effects of the water column. Therefore automatic processing methods are desirable. The student's work will assist in the development of such algorithms. There will be potential PhD spin offs, for example counting as sizing squid, automatically determining and quantifying damage to habitats or imaging and classification of phytoplankton.

The student will implement an algorithm, which will be decided after the student begins work. The algorithm will probably be one found in literature, or based on one. He or she will be able to demonstrate the algorithm, evaluate the results and write a report his or her findings, including usefulness of the algorithm, possible enhancements and advise on ways in which the image capture might be improved to make processing more reliable. The student will gain a better understanding of the algorithm and the relationship between it and the images than anyone else on the project so will be in a position to provide valuable input into how the image capture and processing might be improved.

What is the vacation scholar going to learn through this project?
The student will learn the unique issues that make underwater image processing difficult. He or she will learn something about marine animal vision (which in all likelihood will inspire algorithmic development) and image processing in general. He or she will also learn something about the marine environments on our doorstep.

Project 50: Power grid outages and PLC
Location: Hobart

For further information please contact the supervisor for this project: **martin.degroot@csiro.au**

Skills:
Basic understanding of electrical engineering
Familiarity with AI concepts, logic or formal specification would be helpful

Prerequisite Criteria:
Completed a course in computer networks

Project description:
The purpose of this project is to conduct a preliminary investigation of relationships between power grid behaviour and power line communication (PLC) network metrics.

Over the last decade energy has become a focus of scientific activity all over the world. The CSIRO currently has several large projects investigating this critical area. Much of that research is concerned with investigating distributed energy (DE) grids where many management decisions are made by intelligent devices.

Intelligent distributed devices need to communicate with each other to operate effectively. Power line communication (PLC) technology couples digital networks with power grids to allow the exchange of high volume, bi-directional grid management information. This project is an investigation of the relationship between PLC and the health of the underlying power grid.

This project has been structured to lead from simple information gathering, through behaviour characterisation, to automated classification. These tasks are all worthwhile and will impart useful domain knowledge to the student. They are also structured to provide increasingly challenging tasks to a young researcher.

What is the vacation scholar going to learn through this project?
The student will gain an understanding of PLC technology. They will learn about the energy industry and basic aspects power grid technology. The student will also gain experience in developing automated network monitoring and management systems.

Project 51: Online Food Frequency Questionnaire
Location: Hobart

For further information please contact the supervisor for this project: **rebecca.gorton@csiro.au**

Skills: Java, JSP

Prerequisite Criteria:
Should have experience in developing web interfaces

Project description:
The Tailored Diet Information project aims to develop a system that will assist health professionals to combine generic weight management data with their professional knowledge and patient information to generate tailored information for patients that will lead to better weight management.

The Preventative Health Flagship in CSIRO is working on novel methods for preventing and treating obesity in the Australian community. A major requirement of this is good data. This project will directly contribute to this goal by developing a generic food frequency web interface that can be used by many projects to collect information about trial participant dietary habits. The successful completion of this project will save researchers time as they will no longer have to manually enter the results of the paper questionnaire.

The student will develop a web interface that will collect participant diet information which is a requirement variable for successful weight management information tailoring. He or she will be able to demonstrate how the data collected through their interface effects the tailored information delivered.

The questionnaire selected will be one that is recommended by the intuitionalists with CSIRO and there is the potential for the interface to be used by other projects with CISRO.

What is the vacation scholar going to learn through this project?
The student will learn valuable skills in web interface design, database design and web programming. They will also gain an understanding of the process of tailoring generic health information based on patient characteristics such as diet and weight. The student will also gain an insight into the complex nature of preventative health, in particular obesity and diabetes.

Project 52: Sea Sentinel – Propulsion, Steering and Sensor Integration.
Location: Hobart

For further information please contact the supervisor for this project: john.mcculloch@csiro.au

Skills:
C programming, basic electronics, diagnosis, understanding of navigation systems

Prerequisite Criteria:
The candidate must have successfully completed at least three years of an engineering or computing degree, and be eligible for honours.

Project description:
The Tasmanian ICT Centre is developing an exciting autonomous robotic boat (Autonomous Surface Vessel – ASV). A significant amount of work has already been done on the project and the physical platform is almost ready to be deployed, however further work needs to be performed integrating the propulsion, steering and sensor systems with the radio control system and the PC controller. This is a great opportunity for the student to do some cutting edge, real world, engineering. It is planned that the navigation and control systems will be developed in conjunction with this work allowing some initial testing of the platform in the Derwent River.

The ICT Centre has identified that an ASV would be a valuable tool, and has already invested a significant amount in the development of such a system. Several scientific research programs in CSIRO could benefit from the services of an autonomous, surface based, data acquisition platform, and the successful demonstration of the technology would be an excellent way increasing the ICT Centre's public profile. The longer term goal of the project is the development of an ASV that has the required physical and navigational systems to enable safe, long term ocean going missions.

Whilst the requirements of the tasks in the project are reasonably tightly specified, they lend themselves to creative solutions. There is significant scope for the student to apply both current engineering practices and creative solutions. The list of tasks has been conceived to provide a tight list of milestones such as to not overwhelm the student, but does not restrict the methodology required to solve the challenges.

What is the vacation scholar going to learn through this project?
The project will expose the student to several new concepts and skills. They will be exposed to the latest autonomous robotic software platforms, required to learn about industrial safety and design constraints. One of the key outcomes for the student is the experiential learning they will undergo by being involved in such a significant design and build in the real world.

Project 53: Sea Sentinel – Navigation and Control Systems
Location: Hobart

For further information please contact the supervisor for this project: **john.mcculloch@csiro.au**

Skills:
C programming, diagnosis, understanding of control and navigation systems.

Prerequisite Criteria:
The candidate must have successfully completed at least three years of an engineering or computing degree, and be eligible for honours.

Project description:
The Tasmanian ICT Centre is developing an exciting autonomous robotic boat (Autonomous Surface Vessel – ASV). A significant amount of work has already been done on the project and the physical platform is almost ready to be deployed, however the navigation and control systems that will be implemented on a PC controller need to be developed. This is a great opportunity for the student to do some cutting edge, real world, engineering. It is planned that the integration of the propulsion, steering and sensor systems will be developed in conjunction with this work allowing some initial testing of the platform in the Derwent River.

The ICT Centre has identified that an ASV would be a valuable tool, and has already invested a significant amount in the development of such a system. Several scientific research programs in CSIRO could benefit from the services of an autonomous, surface based, data acquisition platform, and the successful demonstration of the technology would be an excellent way increasing the ICT Centre's public profile. The longer term goal of the project is the development of an ASV that has the required physical and navigational systems to enable safe, long term ocean going missions.

Whilst the initial modelling tasks in the project are essentially an implementation of skills obtained, the controller design and higher level navigation systems have will require the student to implement a custom solution. There is significant scope for the student to apply both current engineering practices and creative solutions. The list of tasks has been conceived to provide a tight list of milestones such as to not overwhelm the student, but does not restrict the methodology required to solve the challenges.

What is the vacation scholar going to learn through this project?
The project will expose the student to several new concepts and skills. They will be exposed to the latest autonomous robotic software platforms, required to learn about control and navigation systems. One of the key outcomes for the student is the experiential learning they will undergo by being involved in such a significant real world application.

Project 54: Visualisation of multiple proteomic data sources
Location: Hobart

For further information please contact the supervisor for this project: q.liu@csiro.au

Skills:
Ability to program using at least one of the following language: java/c++, experience with sql and xml, knowledge of a scripting language such as perl or python also desirable

Prerequisite Criteria:
Completed courses in software development

Project description:

The primary goal of this project is to build a web-based component that allows browsing of genomic and proteomic data for a given genome location. This may also involve assisting the researchers with issues involved in integrating data from multiple sources and in different formats.

In the area of colorectal cancer, the project team will work with the biologists and bioinformaticians, under the CSIRO Preventative Health flagship, to provide an infrastructure to facilitate molecular data analysis research and generate biologically meaningful outcomes for better risk profiling and early diagnostics. To build such an infrastructure, many advanced technologies will be investigated such as dataspaces, web services and ontologies, etc. An important aspect of this is visualisation of the disparate data. The project will be involved in this visualisation task.

Data from heterogeneous sources with different data types and formats are normally inter-related. However, the quality of this data is poor. It is imprecise, overlapping, and conflicting. One of the challenges of the project is how to integrate this data together, and how to visualise it in a cohesive manner.

The student will be involved in the design of the visualisation method, and possibly the data integration issues, and will implement a browser-based display component and the supporting server infrastructure.

What is the vacation scholar going to learn through this project?

The student will gain understanding in the bioinformatics domain and explore applying ICT technology to solve the problems in the related area. They will have an opportunity to contribute to the project outcome.

Project 55: Modelling Sensor/Observation Characteristics in SensorML
Location: Hobart

For further information please contact the supervisor for this project: **andrew.terhorst@csiro.au**

Skills: XML, Java

Prerequisite Criteria:
Should be doing a degree in Spatial Information Science/Computer Science

Project description:
The aims of the WRON Sensor Network project are to (a) demonstrate how wireless sensor network (WSN) technology can be applied in area monitoring, (b) investigate how a WSN can interoperate with other sensors/sensor systems in a Sensor Web. With respect to (a) we are using deficit irrigation as our use case. The aim in deficit irrigation is efficient use of water. The Sensor Web being developed in (b) will provide information on water use efficiency – initially at farm level but eventually at a catchment level (also addressing multiple water uses – not just irrigation).

The WRON theme is part of the Water for a Healthy Country Flagship. Our project will contribute to the stream responsible for the WRON Reference Model. The reference model provides a set of design principles for water-related observation systems. The Open Geospatial Consortium (OGC) has recently published a suite of interoperability standards and specifications for Sensor Web Enablement. This will allow sensor observations and measurements to be published directly to the WWW and also allow sensor assets to be controlled via the WWW.

This will revolutionise earth observation stimulating research in various fields of sensor science, engineering and informatics including information security, data fusion, semantic sensor networks, etc.

This project will provide us practical experience in using SensorML to characterise sensors/sensor systems. The SensorML documents will form the basis of a web catalogue of available sensor assets in a Sensor Web. The student will be able to provide us with useful insights in how to populate SensorML documents.

What is the vacation scholar going to learn through this project?
The student will learn about:
- XML schema/metaschema
- OGC/W3C standards and specifications for web services
- Spatial and temporal reference frames
- Hardware characteristics of different sensor systems
- Measurement theory (metrology)
- At-sensor data processing and in-network computation
- Web map services

Project 56: An evaluation of spatial and temporal ontologies
Location: Canberra

For further information please contact the supervisor for this project:
David.ratcliffe@csiro.au

Skills:

- Currently undertaking, or have already completed, a Bachelors degree in computer science, software engineering or mathematics
- Must be familiar with (and have a keen interest in!) basic logic formalisms such as predicate logics
- Experience with at least one programming language like C, C++, Java, etc.
- Strong analytical skills

Prerequisite Criteria:
As above

Project description:

Modelling of spatial and temporal concepts in ontologies is important for describing data collected by sensor networks. We don't know which of the various available ontology languages is best suited to this task.

This project is an investigation and evaluation of some alternative ontology languages such as OWL, EL+, etc. to express spatial models such as region connection calculus (RCC), and/or temporal models such as Allen's Interval Algebra, and the performance of software products such as Racer, Pellet, FaCT++, CEL, etc. that can reason over these ontologies.

The Semantic Services Architecture (SSA) group (in Canberra) has been developing techniques that allow a domain specialist to use ontologies as an abstraction to specify their information requirements (i.e. ontologies for domain specialists, as SQL is for a database administrator), with automated translation to other abstractions.

Important application areas such as sensor networks and water data management involve the modelling of spatial and temporal relationships.

This project is an early investigation of ontology languages that are suitable for spatial/temporal modelling to inform directions for further work next year. The outcomes will be applied within the Sensor Network Workbench project in the Sensor Networks theme and in the Semantic Data Integration and Reference Model projects in the WRON theme.

Tangible outcome will be a technical report covering:

- Ways of representing spatial and/or temporal models using ontologies
- Formalization of some interesting queries over such ontologies

- Evaluation of automated reasoner software performance with respect to query answering (categorizing any trade-off between the modelling language complexity and cost of query answering)

Creative activities/inputs include:

- Application of spatial/temporal model to a scenario in the context of data management for sensor networks

What is the vacation scholar going to learn through this project?

- Ontologies; what they are, and the logic formalisms that underpin them, and their importance with respect to Semantic Web concepts
- Ways of representing time/space using ontologies for the purpose of facilitating automated deduction for query answering
- How such ontologies can be used in ways to make complex tasks easier (e.g. data integration)
- Software products that perform reasoning over ontologies