

CSIRO ICT Centre – Postgraduate Awards

PhD Project Topics

Wireless Technologies Laboratory

1. Low-cost high-gain steerable millimetre-wave antennas
(oya.sevimli@csiro.au, location Sydney, Non-core Project)

Millimetre-wave communication links (at 60 GHz and above) are gaining interest as the available wide-band spectrum creates opportunity for very high wireless data rates. One of the challenges is to develop very low-cost preferably steerable high gain antennas. Some potential examples include reflect-arrays and printed arrays and there is room for creativity for new types.

2. Millimetre-wave temperature measurement for industrial applications
(oya.sevimli@csiro.au, location Sydney, Non-core Project)

Objects between 200 and 5000 K emit a blackbody radiation spectrum that peaks at infrared or visible wavelengths, but also includes significant radiation at millimetre-wavelengths. The ability of millimetre-waves to pass through clothing, fog, dust and smoke, suggests that thermally-generated millimetre-waves could be used to measure temperature in a number of industrial applications where other temperature measurement techniques would not be possible. This project would involve constructing a millimetre-wave radiometer and applying it to a number of industrial scenarios.

3. Absorption of millimetre-waves by raindrops
(oya.sevimli@csiro.au, location Sydney, Non-core Project)

Raindrops absorb and scatter millimetre-waves and hence rainfall leads to severe attenuation of millimetre-wave communication links (at 60 GHz and above). Unfortunately current models are limited to frequencies below 40 GHz and become unreliable when used to predict the performance of communication links at higher frequency. This project would involve taking part in the collection of millimetre-wave attenuation and meteorological data at CSIRO's Marsfield site and analysis of this data to propose new attenuation models that would be suitable at millimetre-wavelengths.

4. Miniature Broadband Antennas for Wireless Applications
(trevor.bird@csiro.au, location Sydney, Core Project)

In many modern applications antennas are required to be small to fit into hand-held devices, incorporated in portable systems or wearable. At the same time the antenna needs to function efficiently, work over significant bandwidths, operate in the presence of other obstacles and sometimes conform to the shape of a person or an animal. In recent years, a variety of optimisation methods combined with accurate computational methods have been successful in designing new antennas. Improvements in materials technologies have also resulted in better small antennas than in the past. The purpose will be to investigate some of these techniques to design new integrated antennas that will be suitable for UWB, multiband communications or sensor networks.

5. Near-field Imaging Techniques Using Metamaterials
(trevor.bird@csiro.au, location Sydney, Non-core Project)

The purpose will be to investigate image resolution below the diffraction limit. One way to do this is through the use of negative refractive index materials or more generally metamaterials (ref. J.B.

Pendry, Phys. Rev. Lett., vol. 85, pp. 3966-3969, 2000). We would investigate the electromagnetics of suitable materials and devise ways of converting relatively wide antenna beams into narrower beams. Possible solutions will have application in millimetre and submillimetre-wave imaging for security or medical applications and for antenna arrays to achieve close overlapping beams.

6. Wideband 3-dimensional antenna-array structures
(john.kot@csiro.au, location Sydney, Non-core Project)

This project would conduct research into 3-dimensional antenna array structures with inherent frequency independence, such as multiple self-complementary screens. Structures of this form combined with emerging beam-forming techniques may provide solutions for conformal, integrated and adaptive wideband antennas for applications in communications and imaging. There would be strong commonalities between this research and research into photonic band gap structures and metamaterials.

7. 'All-electronic' Antennas for THz Imaging Applications
(john.kot@csiro.au, location Sydney, Core Project)

Monolithic non-linear transmission lines have been proposed as ultra-fast voltage step generators for both generating picosecond pulses and driving monolithically integrated diode samplers for the detection of these pulses' (Ref: Bostak et al, 'All Electronic Terahertz Spectroscopy System with THz Free-space Pulses', J. Opt. Soc. Am. B Vol 11, #12, Dec 1994 p. 2561). See also: van der Welde 'Planar Antennas for All-electronic Terahertz Systems', *ibid*, p. 2553. This would enable THz pulses to be generated directly for wide band spectroscopy.

8. Computational modelling of large, wideband antenna arrays using domain decomposition techniques
(john.kot@csiro.au, location Sydney, Non-core Project)

Increasingly, antennas are realized as closely packed arrays of small antenna elements, giving many potential advantages over traditional antenna types. The electromagnetic analysis of such antennas is very challenging, especially for wide band operation. Domain decomposition methods are "divide-and-conquer" strategies for the analysis of this type of structure. The aim of the project is to use this approach to develop computational electromagnetism techniques on single and cluster computers, and to apply them to antenna arrays in communications and radioastronomy.

9. Multi antenna correlation modelling and optimization for future MIMO wireless communications
(iain.collings@csiro.au, location Sydney, Core Project)

Multi-Input Multi-Output data communications are set to revolutionize mobile and wireless communication systems. The potential is to have extra robustness and mobility by making use of (multi) signal diversity, and also to have extra data rates by sending different data streams of the multiple antennas. This project addresses the important problem of modelling the way in which the antennas interact with each other and with the scattering environment. By understanding these interactions, the data transmission schemes will then be optimized. The project is suited to a student with an interest in applied mathematics and computer simulation, and there is also some scope for hardware implementation and testing.

10. Transmission optimization for distributed ad hoc wireless networks
(iain.collings@csiro.au, location Sydney, Core Project)

A major limitation of current wireless devices is that they are constrained by the cellular architecture of the servicing networks. This includes both WLANs and mobile systems (2G and 3G). The result is limited mobility, limited access, limited data rate flexibility, and limited connectivity. This project will develop signal processing and data transmission techniques which can operate in ad-hoc (non-cellular) networks, and allow users to transmit and be decoded by their intended recipients, simultaneously with other users (rather than current time-division proposals). This will enable increased user mobility and overall network capacity. The project is suited to a student with an interest in applied mathematics and computer simulation, and there is also some scope for hardware implementation and testing.

11. Wireless link adaptation with a limited feedback channel in future WLANs
(ian.collings@csiro.au, location Sydney, Core Project)

This project will develop wireless multi-antenna devices which can adapt between different transmission modes (and even possibly different connection networks) depending on whichever gives the best service at a particular location and time. The focus will be on the performance gains that can be achieved when a feedback channel exists from the receiver to the transmitter. The project is suited to a student with an interest in applied mathematics and computer simulation, and there is also some scope for hardware implementation and testing.

12. Adaptive beamforming for high mobility wireless communications
(ian.collings@csiro.au, location Sydney, Non-core Project)

Multi-Input Multi-Output data communications are set to revolutionize mobile and wireless communication systems. The potential is to have extra robustness and mobility by making use of (multi) signal diversity, and also to have extra data rates by sending different data streams of the multiple antennas. This project addresses the important problem of designing and optimizing adaptive beamforming techniques to address the data communication robustness. The project is suited to a student with an interest in applied mathematics and computer simulation, and there is also some scope for hardware implementation and testing.

13. Crosslayer design for multimode wireless communications
(ian.collings@csiro.au, location Sydney, Non-core Project)

Cross-layer optimization is a current hot area in communication systems design. This project will focus on the interactions between the transmission layer and the ARQ and MAC layers. It will involve proposing and optimizing new coding and modulation schemes for packet transmission over wireless links. The project is suited to a student with an interest in applied mathematics and computer simulation.

14. Resource allocation in high mobility wireless communications
(ian.collings@csiro.au, location Sydney, Non-core Project)

Resource allocation involves optimizing the way in which quantities such as power, bandwidth, and delay, are used in a mobile communication system. This project will focus on future high mobility ad-hoc multi-user networks. New distributed algorithms will be developed and current coding-modulation schemes modified to suit the ad-hoc network structure. The project is suited to a student with an interest in applied mathematics and computer simulation.

Information Engineering Laboratory

15. Information Retrieval

(david.hawking@csiro.au, location Canberra, Core and Non-core Projects)

Possible PhD topics are to be found in many areas of Information Retrieval. Examples include: web search, evaluation methodologies, search context, heterogeneous collections, semi-structured data, email search, distributed and peer-to-peer models, query refinement, question answering and multi-media retrieval. We are particularly interested in lines of enquiry with application to Enterprise Search.

16. Repurposing Text

(cecile.paris@csiro.au, location Sydney, Core Project)

Organisations typically have many data bases which typically contain both well-typed fielded data and free text fields. Often the most useful and interesting information in the database is contained in the free text fields, but this is the most difficult information to search, manipulate and repurpose. The aim of this project is to combine techniques from information extraction and natural language generation to allow the information 'locked-up' in these free text fields to be reused to generate new text, tailored to a new situation and to a user. We propose to do this project in the domain of cultural heritage, in particular using museum data bases (e.g., Power House). These maintain information about the objects in the museum collections. The aim is to be able to repurpose the text contained in the museum database to produce automatically and interactively context-sensitive and user-tailored descriptions of museum objects. The techniques developed should be applicable to other free-text databases, such as documents in enterprises.

17. User Profiling for Speech Systems

(cecile.paris@csiro.au, location Canberra, Non-core Project)

There are now a large number of deployed speech recognition systems that are capable of relatively simple information-provision and transaction-based services. To date, the gap between these systems and the spoken language dialog systems developed in research labs is significant. The aim of this project is to narrow this gap considerably by augmenting commercially deployed technologies like VoiceXML and SALT by adding capabilities for user-profiling and user-tailoring in spoken language dialogue; the goal is to take ideas that have so far only surfaced in advanced research systems, and to explore how these concepts can be put to use in the more restricted systems that are likely to be available to the general public for the foreseeable future. This project lies at the intersection of natural language and dialogue systems, user modelling and human-computer interaction. This could also be useful in the context of robots interacting with humans.

18. Intelligent Content Aggregation

(cecile.paris@csiro.au, location Sydney, Core Project)

The aim of this project is to develop a system that carries out sophisticated extraction of information from a variety of online resources (typically web pages or web accessible databases), and then combines and collates this information in novel ways, re-presenting it to users via both speech and text. The goal is to automate the kind of 'consumer choice' data gathering task currently carried out by humans for presentation in, for example, comparison reviews in magazines and web pages. Target domains for the project will be the automatic generation of fact-based comparative reviews of laptop computers and broadband access plans. The work is expected to be applicable in other areas. The project involves the use of techniques in search and information extraction, natural language analysis, natural language generation, user modelling, and spoken language dialogue systems.

19. Email Summarisation

(cecile.paris@csiro.au, location Sydney, Core Project)

Automatic summarisation techniques have been applied to a wide range of document types, but relatively little work has focussed on generating summaries whose input is a collection of documents, as opposed to a single document. Electronic mail constitutes a particularly interesting document collection. The aim of this project is to automatically generate summaries of email messages, looking either to summarise discussion threads (building on the work Stephen Wan has done during his visit to Columbia University last year) or a set of newly arrived messages. The typical use case is where a user wants to catch up on the content of a large number of new email messages or email messages on some specific topic, getting a useful overview of the contents without having to read all the messages.

20. Ontology-based Integration for Geo-spatial Problems

(kerry.taylor@csiro.au, location Canberra, Non-Core Project)

The Semantic Web push has sponsored a revival of interest in ontologies, especially focused around the W3C Web Ontology Language, OWL. However, the usual ontology formalisms are not well-tuned to the representation of spatial information, nor is the reasoning mechanism an obvious match to the needs of traditional spatial reasoning. Meanwhile, spatial interoperability initiatives, such as Open Geospatial Consortium are working towards standards to promote discovery and interoperability of spatial data and geo-processing services. What kind of extension to current description and reasoning technology would serve the needs of problems in data and service integration with a geo-spatial focus?

Networking Technologies Laboratory

21. Deriving location cues from multichannel audio

(silvia.pfeiffer@csiro.au, location Sydney, Core project)

A big challenge in telepresence is the exact representation of the remote end in the local environment. This includes the location of people (and for that matter other sound-emitting objects) in the room. If we can project the people from the remote end into the local room in such a way that it produces one consistent sound scape, we achieve a more integrated perception of presence. This research investigates into the clues that can be extracted out of a multichannel audio recording about the location of people at one end of a remote collaboration. It can further be researched into means of transportation of these clues as metadata to the remote end and the reconstruction of the remote sound scape by mixing it with the local sound scape.

22. Automatic metadata extraction from audio

(silvia.pfeiffer@csiro.au, location Sydney, Core project)

Recording of audio interaction such as telephone calls is a necessity for many businesses to e.g. retain a corporate memory or to retain records of business transaction. During such recordings, many clues can be extracted from the audio and the circumstances that the recording is being undertaken in that can help in creating metadata for later re-discovery and re-use of the content. The real-time automatic extraction of metadata is therefore subject of this research.

23. Automatic metadata extraction from video

(silvia.pfeiffer@csiro.au, location Sydney, Core project)

The discovery of specific events in recordings of business video conferences or of surveillance video is a labour-intensive task. Through automatic extraction of metadata in realtime during recording, the content can be made searchable immediately. The subject of this research is to explore algorithms to automatically extract events and transcribe them into metadata which can then support the search.

24. Automated, real-time media scaling for M-JPEG2000
(silvia.pfeiffer@csiro.au, location Sydney, Core project)

M-JPEG2000 has been selected as the standard for digital cinema of the future by the Digital Cinema Initiative. Digital movie content will however in the future not only be distributed to cinemas, but also to home entertainment centres (IPTV), desktop computers or mobile phones (3G). M-JPEG2000 is a wavelet-based codec and has media scalability built into it. A network-based service that can dynamically adapt a stream's QoS (and in particular bandwidth and screen-size) requirements to the requirements of the end device is a pre-requisite to integrate the digital content delivery chain of the future. This research will investigate into the issues related to providing such a network-based, real-time media scaling service.

25. Automated creation of Hypermedia: Building Webs of Seminar Presentations and Related Content
(silvia.pfeiffer@csiro.au, location Sydney, Core project)

The Annodex set of technologies allows the extensions of the World Wide Web to an integrated, distributed hypermedia system in which audio and video are as easily searchable and linkable as Web pages. Presentations are time-continuous data that can be turned into Annodex by attaching timed transcripts to the presentation video. Also, the video can be supported with a timed image track to represent the slides typically in use during presentations. The automatic creation of Webs of content from seminar presentations that include such timed text and image tracks is the subject of research of this topic.

26. Trusted Secure Distributed Storage
(john.zic@csiro.au, location Sydney, Core project)

The Secure Distributed Storage (SDS) is a model that relies on separating published, self-describing, self-protecting data objects from the stored information. The information is stored in the storage servers and the data objects are created and distributed among applications that wish to share the information. The consequence of this division is that the secure sharing of information over untrusted infrastructure becomes simple with SDS. The existing SDS model does not have any control over the information that has been shared as the access control mechanism heavily relies on the freely distributed data objects. The aim of the project is to develop a secure trust model for SDS incorporating trusted computing technologies such as sealed storage and attestation, and evaluate it in an electronic medical record application. The major tasks in the project include:

- design and develop an infrastructure for Trusted Secure Distributed Storage (TSDS);
- design and develop a security model for TSDS;
- conduct and report security analysis of the model including attacks, defences, and weaknesses;
- design and implementation of secure electronic medical record application on TSDS.

27. A distributed storage model for virtual collaborative environment
(john.zic@csiro.au, location Sydney, Non-core project)

The Virtual Collaborative Environment (VCE) is an infrastructure that supports inter and intra organisational collaboration for a task. The distributed autonomous organisations participating in

the collaboration share information and resources to complete the given task. The aim of this project is to develop a distributed storage model for virtual collaborative environment where the storage is a shared resource that provides information sharing between participating organisations/applications. The model must support a variety of quality of service parameters such as security, reliability, and performance. That is, a collaborative task may require a secure distributed storage where as another collaborative task may require performance of the storage at the expense of security. The major tasks in the project include

- design and develop a distributed storage model for VCE;
- investigate and define quality of service parameters and their dependencies;
- design and implement the model in the VCE environment for an application domain such as eHealth, postproduction industry or large data sets in astronomy.

28. Performance Modelling and Prediction For Large-Scale Distributed Systems

(john.zic@csiro.au, location Sydney, Non-core project)

Performance is one of core QoS for enterprise systems. Considerable research has been done for system performance modelling and prediction in the past decades. However, little of the work is adopted by Industry due to the complexity of the models and impractical modelling processes. Architects/developers still struggle to wonder how a system would perform before building it and if the design scales well.

This project will explore a new practical approach to modelling and predicting performance for large-scale distributed systems. The approach is not intent to modelling and predicting performance precisely like exiting work, but giving a quick approximate performance estimation based on the high-level design and likely deployment environment. The approach must be simple and general enough to be applicable for most distributed systems. UML, flow control, reasoning and empirical-based knowledge-base may be required to achieve this goal.

29. Multi-Gigabit Wireless Networking and Wireless Mesh Networking

(ren.liu@csiro.au, location Sydney, Core project)

Wireless networking technology has been become more active in the recent decade. With new multi-gigabit technologies (e.g. CSIRO Wireless Technology), and advanced Wireless Mesh Network technologies, new research opportunities are emerging in wireless networking areas such as MAC, scheduling, routing, transporting, and power-conservation. The proposed research focuses on Multi-Gigabit Wireless Networking and/or Wireless Mesh Networking, studies networking implications from the ultra high bandwidth wireless technology and/or advanced wireless mesh network applications, and design new networking protocols/algorithms to meet the new requirements.

30. High Speed Transport Protocol

(ren.liu@csiro.au, location Sydney, Non-core project)

High Speed TCP is an active research topic with new proposals such as High Speed TCP, Scalable TCP, TCP FAST, etc. Most of these proposals argue that current TCP is unable to handle multi-gigabit throughput, and therefore need to be modified. However modifying TCP may not be the best approach. The existing TCP protocol (after many years of active research) is relatively fair and stable. It can scale from low bandwidth of a few Kbps to 10s Mbps. A lot of new ultra high bandwidth applications have different requirements than that offered by TCP. It can be argued that a new transport protocol should be created to meet the new demands instead of modifying the already heavily patched TCP protocol. This research will study the requirements of new ultra high bandwidth applications such as eVLBI and Super Computing applications running on CeNTIE

networks. A new transport protocol will be designed to satisfy the demand of these new applications. It also needs to be fair and stable in order to coexist with current Internet protocols.

31. Internet Traffic Measurement

(ren.liu@csiro.au, location Sydney, Non-core project)

Since the discovery of self-similarity, Internet traffic measurement research has been active for more than a decade. Huge amount of data has been collected and analysed. With new applications emerging daily from VoIP, peer-to-peer to worm, DoS and virus, Internet traffic is a changing phenomenon, and Internet traffic study is an ongoing research. It is proposed to create new traffic measurement tools based on new peer-to-peer or even worm technologies. These tools are going to be used to study the traffic characteristics of new applications developed in CeNTIE networks and wide area networks.

Autonomous Systems Laboratory

32. Real-time biomechanical models for soft tissue simulation

(sebastien.ourselin@csiro.au, location Sydney, Non-core Project)

The research proposed here is the development of novel patient-specific biomechanical models for real-time soft tissue simulation of the brain. These models could be based on the theory of elasticity, such as the St Venant-Kirchhoff non-linear model, valid for large displacement, and generalise to materials having anisotropic behaviour. These models will combine tissue information from different image modalities, such as MR T1-weighted and T2-weighted, MR angiography, tensor diffusion and MR elastography.

One of the main challenges will be to generalise the biomechanical model to accept change of topology of the virtual organs, due to cutting for example. These new models will be integrated with the current surgical simulator developed within the BioMedIA Lab, Autonomous Systems Laboratory, and will address the problem of real-time interaction with force feedback devices.

Candidates are expected to have a strong background in applied mathematics, good problem solving skills and a high level of motivation. Experience with: mechanics, tensors analysis, elasticity theory and F.E.M. is likely to be advantageous.

33. Spatial transformations for non-rigid registration of 3D medical images

(sebastien.ourselin@csiro.au, location Sydney, Non-core Project)

Determining correspondence of anatomical structures from 3D images is an important area of medical image analysis. This requires a mathematical model of the spatial transformations between images (e.g. rigid, affine, non-linear). A number of such models of non-rigid transformations are proposed in the literature: thin plate splines, interpolating B-splines as well as physically based ones such as fluid flow (c.f. Navier Stokes). However, these models have their own limitations.

This project will focus on determining optimal mathematical models of non-rigid spatial transformations for the accurate registration of medical images.

Candidates are expected to have a strong background in applied mathematics, good problem solving skills and a high level of motivation. Experience with: elasticity, fluid mechanics and splines is likely to be advantageous.

34. Longitudinal study of neurodegenerative disease based on MRI

(sebastien.ourselin@csiro.au, location Sydney, Non-core Project)

Neurodegenerative diseases such as Alzheimer are caused by the gradual death of individual neurons leading to decrements in movement control, memory, and thinking abilities. Most of these neurodegenerative diseases also come with lesions, atrophy or enlargement of different regions of the brain that can be quantified and monitored using MRI. Longitudinal study over a large population requires tools to automatically measure the evolution of the changes over time for each patient, and compare these results between different patients from the MR images. This type of study can help to better understand the evolution of the disease, and can be used to monitor the effects of drugs during clinical trials.

Candidates are expected to have a strong background in applied mathematics, good problem solving skills and a high level of motivation. Candidates can expect strong interaction with a clinical environment. Experience with: segmentation and probabilistic models such as Expectation-Maximization is likely to be advantageous.

35. MR / histology correlation

(sebastien.ourselin@csiro.au, location Sydney, Non-core Project)

To perform clinical diagnosis, such as cancer detection, using non-invasive technique such as MR imaging, it is important to get *prior knowledge* about the correlation between the MR signal and the type of tissue, or the presence/absence of cancer. This prior knowledge can be obtained using the following protocol: the organ is imaged *in-vivo* using MR, then it is extracted from the body (cancer removal) and sliced, then each slice being manually segmented by a histologist to highlight malignant cancer cells on the histology. The correlation between the histologic slices and the MR signal will then be used to perform *in-vivo* diagnosis using MR data only.

One of the main challenges of this topic is to find an optimal way to combine MR data from different modalities (such as MR T1-weighted and T2-weighted, tensor diffusion) to build a strong classifier using histological information.

Candidates are expected to have a strong background in applied mathematics, good problem solving skills and a high level of motivation. Experience with: data analysis, classifier and MR Physics is likely to be advantageous.

36. MR Spectroscopy for prostate cancer

(sebastien.ourselin@csiro.au, location Sydney, Non-core Project)

MR spectroscopy (MRS) is similar to MR imaging in the way that it uses the same hardware, but with different acquisition protocols to produce a spectrum identifying different chemical compounds in the tissues, giving a broader range of information. MRS information has been shown to improve breast cancer detection, but its efficiency in prostate cancer detection is yet to be proven. It is difficult to obtain the spectrum for each voxel of the image, and therefore, in clinical use, only low resolution images are available.

One of the main challenges of this topic is to reliably extract the chemical profiles of prostate cancer from these low resolution images, where partial volume effects and artefact are very important, and to combine the signal with other MR information (such as MR T1-weighted and T2-weighted, tensor diffusion).

Candidates are expected to have a strong background in applied mathematics, good problem solving skills and a high level of motivation. Experience with: data analysis, signal processing and MR Physics is likely to be advantageous.

37. Biomechanical modelling of the prostate gland

(sebastien.ourselin@csiro.au, location Sydney, Non-core Project)

The research proposed here is the development of a biomechanical model for the prostate gland. Biomechanical parameters of the different zones (define λ & μ) will be measured ex-vivo

on real prostate by applying mechanical deformations on the gland and imaging the gland with different MR modalities such as MR T1-weighted and T2-weighted and tensor diffusion. Then an elastic model of the gland can be constructed, taking into account the biomechanical parameters, and the structure of the gland (*e.g.* a central zone and a peripheral zone with different biomechanical parameters). This model will be used to perform realistic deformation of the prostate, which will be incorporated into novel segmentation and non-rigid registration algorithms.

One of the main challenges will be to get from ex-vivo measurement to a realistic biomechanical model of the gland.

Candidates are expected to have a strong background in applied mathematics, good problem solving skills and a high level of motivation. Experience with: mechanics, tensors analysis, elasticity theory and F.E.M. is likely to be advantageous.

38. Dynamic statistical shape modelling (knee, prostate, soft tissues)
(sebastien.ourselin@csiro.au, location Sydney, Non-core Project)

Statistical shape models (SSM) are used to capture the variation in shape of an object from a set of training examples, and build a model of these variations. SSM add prior knowledge about the mean shape, and the possible variations around the mean shape, that is used in image segmentation to find the most likely shape of the object to be segmented. Dynamic statistical shape modelling intends to embed dynamic deformation inside the model. For example, the flexion of the knee will modify the pressure on the cartilage, and will modify the cartilage shape; internal organs such as the prostate are likely to be deformed if an internal probe is use to image them. Including this information inside the model will allow dynamic segmentation of organs while they are deforming.

Candidates are expected to have a strong background in applied mathematics, good problem solving skills and a high level of motivation. Experience with: SSM and 3D models is likely to be advantageous.

39. Non-rigid registration incorporating a priori knowledge
(sebastien.ourselin@csiro.au, location Sydney, Non-core Project)

Non-rigid registration is usually performed by the mean of local deformations driven by local features on the image. There is no constraint on the expected shape of the organ, which can results in a completely inaccurate registration. The incorporation of a priori knowledge, such as the shape of the organ, can be used to constrain the local deformation and obtain a more robust and accurate registration technique. The incorporation of shape information could be done using Statistical Shape Models (SSM) to capture the variation in shape of the organ and build a model these variations, or using an elastic model of the organ based on its biomechanical properties.

One of the main challenges will be to incorporate constraints that usually require segmented data inside the registration algorithm.

Candidates are expected to have a strong background in applied mathematics, good problem solving skills and a high level of motivation. Experience with: elasticity theory and SSM is likely to be advantageous.

39B. Algorithms for simultaneous registration and segmentation
(sebastien.ourselin@csiro.au, location Sydney, Non-core Project)

Registration and segmentation have traditionally been considered to be distinct processes. They are, however, related. An image can be segmented by propagating an existing segmentation of one subject into the space of another using deformable registration. Furthermore, image segmentation can be considered to be a process which maps an intensity image into a classified one providing information about tissue boundaries and reducing noise. This information is useful for the registration process.

The commonality between the two processes has been recently recognised and this topic is currently at the forefront of research in medical image analysis.

The aim of the project is to investigate the use of information between images (provided by registration) and within images (provided by segmentation); propose new algorithms for simultaneous registration and segmentation and demonstrate the use of the algorithm on clinical image datasets.

Candidates are expected to have a strong background in applied mathematics, algorithm design, good problem solving skills and a high level of motivation. Experience with C++, image analysis or image processing would be desirable.

40. Design of network topologies for Artificial Life
(mikhail.prokopenko@csiro.au, location Sydney, Non-core Project)

41. Self-organisation and co-evolution in Multi-Agent Systems
(mikhail.prokopenko@csiro.au, location Sydney, Non-core Project)

42. Physics-based simulation of distributed Multi-Agent Systems
(mikhail.prokopenko@csiro.au, location Sydney, Non-core Project)

43. Projection methods for multi-agent optimisation
(geoff.james@csiro.au, location Sydney, Non-core Project)

44. Real-time network responses for constrained agents
(geoff.james@csiro.au, location Sydney, Non-core Project)

45. Underwater visual navigation
(peter.corke@csiro.au, location Brisbane, Non-core Project)

Autonomous Underwater Vehicles (AUVs) will become a key tool for marine ecosystem management in the future. This project will investigate the use of vision as a means of navigating underwater. The work will include development of underwater visual odometry and the automatic acquisition and tracking of artificial visual beacons that maybe attached to bottom-dwelling science packages, or permanent marker pegs/posts.

46. Outdoor visual navigation
(peter.corke@csiro.au, location Brisbane, Non-core Project)

Animals can recognise places they have visited in the past. This project aims to develop such an ability for an Autonomous Ground Vehicle (AGV) and will create a so-called 'locale recognition' system. A robot would be driven through an environment, recording locales as it goes. The robot should then be able to correctly identify these locales when it revisits them in the future, maybe from a different direction, with different lighting conditions, etc.

47. Inertial/vision integration for mobile robots
(peter.corke@csiro.au, location Brisbane, Non-core Project)

Many animals, including mammals, use their vision systems and their balance system in combination to perform many tasks (e.g. walking). This project will explore the fusion of data from

inertial (balance) sensors with the vision system of a mobile robot. Applications include underwater robots, flying robots and autonomous ground vehicles.

48. Energy efficient path planning of Autonomous Underwater Vehicles (AUVs) accounting for tides and currents

(jonathan.roberts@csiro.au, location Brisbane, Non-core Project)

AUVs have limited stored energy which directly impacts how long a mission may last. This project will explore the area of optimising mission plans to minimise energy expenditure and maximising coverage area. This will be done by modelling and predicting water currents and tides in order to plan. The problem of sensing the currents in the water from the AUV is also an important aspect of the work and will be explored.

49. Underwater terrain mapping from Autonomous Underwater Vehicles (AUVs) using vision

(jonathan.roberts@csiro.au, location Brisbane, Non-core Project)

Shallow water AUV operations, for tasks such as reef monitoring, results in the need for an up-to-date and accurate map of the immediate terrain around and ahead of an AUV. This project will investigate and develop techniques to perform autonomous mapping of underwater terrain using vision as the primary sensor.

50. Framework for intelligent path planning and autonomous operation for Autonomous Ground Vehicles (AGVs)

(jonathan.roberts@csiro.au, location Brisbane, Non-core Project)

This project will develop a framework to bring together existing navigation and obstacle avoidance techniques and combine them into an intelligent system to enable truly autonomous operation over long time scales (hours and days).

51. Visual servoing of autonomous helicopter along power lines

(jonathan.roberts@csiro.au, location Brisbane, Non-core Project)

Unmanned Aerial Vehicles (UAVs) will be a key tool in managing assets such as power lines in the future. GPS cannot be relied on alone to guide a UAV along a power line. Instead, this project will develop a vision system to automatically detect and track the lines in the presence of background clutter in the image and poor lighting conditions. The work will also develop a pole and tower recognition capability.

52. Agent-based frameworks for Sensor Networks

(pavan.sikka@csiro.au, location Brisbane, Non-core Project)

Typically sensor networks are used for environmental monitoring where data is collected from a large number of sensors and transmitted back to a more powerful base station where it is stored and processed. This project aims to explore the agent-based formalisms (both mobile agents from Networking and BDI agents from AI) for solving more complicated problems requiring in-network computing and decision making, for example, localization, control etc.

53. Power aware compiler optimization techniques for sensor networks

(shondip.sen@csiro.au, location Brisbane, Non-core Project)

Typically a compiler is used to optimize code for a purpose such as code size, computational performance or hard real-time constraints. We would like to change the performance metric from

being based on execution speed to watts so that we may generate power efficient code for execution in low power devices.

54. Channel hopping interference avoidance in ad-hoc networks
(shondip.sen@csiro.au, location Brisbane, Non-core Project)

One of the problems with ad hoc wireless networks are that messages sent from non-overlapping terminals can cause interference at intermediate nodes. A channel hopping algorithm is required that works in conjunction with routing to stop messages from colliding in systems without centralized control.

55. Multicasting protocols for code distribution in ad-hoc sensor networks
(shondip.sen@csiro.au, location Brisbane, Non-core Project)

One of the tasks of a sensor network is to efficiently distribute code from a source to a subset of nodes in the network. It is also often the case that messages will be sent to a single sink node. Depending on the underlying routing protocol, there may be a number of different techniques to optimize the sending and receiving of data between multiple nodes while minimizing duplication.

56. Optimizing radio design for sensor networks
(pavan.sikka@csiro.au, location Brisbane, Non-core Project)

Typical sensor network nodes (Mica, Fleck etc) are built from common off-the-shelf components including radio and are therefore constrained by the capabilities provided by these components. These constraints apply on several fronts: communication, power and other capabilities (for example, ranging). This project aims to consider the design of radios for wireless sensor nodes to optimize all three and will require significant input from both Wireless Technologies Lab and the Autonomous Systems Lab.

57. Energy scavenging from mechanical motion for mobile agents
(pavan.sikka@csiro.au, location Brisbane, Non-core Project)

As sensor networks become popular and find many diverse applications, the provision of energy is becoming an important limiting factor. Mobile agents have the potential to provide energy based on their motion but it is very difficult to capture it in a usable form. The aim of this project is to find the ways and means to harness mechanical energy for use by wireless sensor nodes mounted on mobile agents (animals, people, and robots).

58. An exploration of the synergies between robotics and sensor networks
(pavan.sikka@csiro.au, location Brisbane, Non-core Project)

The Autonomous Systems Lab has been exploring the interaction between sensor networks and robots. Robots can be used to deploy sensor networks. They can also be used to connect sensor networks by acting as physical data mules. On the other hand, sensor networks can be used to localize and guide robots. The aim of this project is to further study this interaction in greater detail so as to fully utilize the potential applications of sensor networks to Robotics.

59. Sensor networks, robots and first responders
(pavan.sikka@csiro.au, location Brisbane, Non-core Project)

Since 9/11, there has been significant interest in how to respond to disasters. This problem is special case of the synergies between sensor networks and robots. The aim of this project is to study how sensor networks and robots can aid the task of first responders in the event of a disaster.

60. Sensing, in-network computation and action: An exploration in Distributed Intelligence
(pavan.sikka@csiro.au, location Brisbane, Non-core Project)

Typical sensor network nodes have enough computing power individually to be capable of some limited intelligence. A sensor network as a whole can have significant computing power. This project will consider the problem of distributed intelligence by closing the loop between sensing and action using in-network computation.

61. Sound classification in a sensor network
(pavan.sikka@csiro.au, location Brisbane, Non-core Project)

An application of sensor networks of particular interest is environmental monitoring and the types of animals in the environment is a strong indicator of local ecosystem health. This project is concerned with developing sound classification algorithms for sensor nodes equipped with a microphone and a DSP. Expertise in signal processing and pattern recognition would be advantageous.

e-Health Research Centre (Brisbane)

62. Health data linkage self-auditing system
(anthony.maeder@csiro.au, location Brisbane, Core project)

This project will design and implement tools which allow auditing of the adherence of the EHRCs HDI (Health Data Integration) software package to rules such as data privacy, and access roles. It will provide a means to monitor HDI usage in real time, and allow cumulative reporting as well as immediate alerts. Part of the monitoring may also provide performance and workload details for HDI over a time period.

63. Individualised patient care planning
(anthony.maeder@csiro.au, location Brisbane, Core project)

Tracing the various treatments or interventions applied to an individual patient through successive episodes of care, and modelling the response of that individual relative to anticipated response (using evidence-based data), would allow continuous adjustment of the care plan rather than simply applying a fixed "one size fits all" approach. This project will develop an appropriate Decision Support environment, and user tools, to realise this objective.

64. Medical image smart repository
(anthony.maeder@csiro.au, location Brisbane, Core project)

The ability to access medical images stored across many different image databases (PACS) allows opportunities for content-based search and use of the images. This project will explore some generic methods for content-based image retrieval for medical images generally (possibly over several modalities). The project will demonstrate the effectiveness of the approach by addressing some different needs for clinical applications eg education and training; case comparison and analysis.