NUCA Collaborative Research Projects

Project Descriptions
TABLE OF CONTENTS

Australian National University ........................................................................................... 5
Riemannian Geometry in Computer Vision (variation) ......................................................... 6
Distributed Control and Estimation in Networked Environments ...................................... 7
Machine Learning ................................................................................................................. 9
Principles and Applications of Compositional Machine Learning ................................... 10
Multimedia in Online Social Communities ......................................................................... 11
Machine Learning for Computer Vision ............................................................................... 12
Optimisation for Energy Systems ....................................................................................... 13
Research Group Leader Computer Vision ......................................................................... 14
Optimisation ......................................................................................................................... 15
Computational Social Science for Optimisation ................................................................ 17
Computer Vision and Optimisation on Manifolds ............................................................... 19
Deakin University ................................................................................................................. 20
   Heath Data Analytics - Pervasive Cardiac Monitoring and Mental Health Data Mining in Social Media .......................................................... 21
   Assistive Bionics for Physiotherapy and Respiratory Analysis ....................................... 22
Griffith University ................................................................................................................ 23
   Advanced Search and Optimisation .................................................................................. 24
La Trobe University .............................................................................................................. 26
   Virtual Speech Pathologist ............................................................................................. 27
Macquarie University ........................................................................................................... 28
   Deep Learning for Text ................................................................................................... 29
Monash University ................................................................................................................ 30
   Constraint Modelling Platform ...................................................................................... 31
   Improved Statistical Models of Document Corpora and User-Click Behaviour with Application to Personalised Patent Search .......................................................... 33
   Noise in Voice: Cascaded Speech Recognition and Information Extraction for Automated Form Filling in Hospitals ............................................................. 35
   Macromolecular Informatics ............................................................................................ 37
   Scalable Semi-supervised Learning for Structured Prediction ....................................... 39
Queensland University of Technology ............................................................................... 40
   Adaptive Enterprises ...................................................................................................... 41
   Environmental Computer Vision ..................................................................................... 42
   Refactoring Security Critical Program Code to Restrict Data Flow ................................ 43
Royal Melbourne Institute of Technology ............................................................................. 45
Modelling human behaviour in transportation simulation for disaster management ................................................................. 46
Data Analytics over Social and Spatial Data .......................................................... 47
The 3T-HEALTH Project Framework .................................................................. 49
Machine Learning for Intelligence Networks and Signal Processing for Humour Detection .................................................. 50
Swinburne University of Technology ................................................................. 52
Victoria Software Systems .................................................................................. 53
University of Adelaide .......................................................................................... 55
Dynamic scene understanding with applications to traffic monitoring ............. 56
Assessment and OS-Level Mitigation of Timing Channels .................................. 57
University of Canberra ........................................................................................ 58
Health Living Lab .................................................................................................. 59
University of Melbourne ......................................................................................... 60
Machine Learning .................................................................................................. 61
NICTA Victoria Deputy Director and Education Director ...................................... 64
Future Grid .............................................................................................................. 65
Constraint programming platform: solving technology ........................................ 66
BiomRKRS: A Biomarker Retrieval and Knowledge Reasoning System ................ 67
Learning Analytics related to MOOCs ................................................................. 68
Mechanism Design and Game Theory for Optimisation ...................................... 69
Systems Biology .................................................................................................... 70
Computational Neuroscience ............................................................................... 71
Signals and Systems: Industrial Applications ...................................................... 72
Diagnosis and Planning: Decentralised optimisation ............................................ 73
University of New South Wales ............................................................................. 74
Indexing and Analysis of Large Spatiotemporal Data Repositories ....................... 75
Protecting User Privacy via Obfuscation ............................................................... 76
File System Synthesis (extended) (VARIATION) .................................................. 77
Trustworthy Systems ............................................................................................. 78
Blue Iris .................................................................................................................. 79
Trustworthy Systems, Verification ....................................................................... 80
Computational Complexity of Resource Allocation Problems ............................ 81
UNSW Research Student Administration .............................................................. 82
Improving Authentication and Network Security with Privacy Preserving Voice Biometrics .......................................................... 83
Analysis of Mobile Phone Privacy Risks ............................................................... 84
Autonomous Personal Indoor Localisation Using Smartphone Sensors ................ 86
Location-based Authentication in Wireless Networks ........................................... 88
Mapping the Brain: The Arcanum of Deep Brain Stimulation ............................................. 89
Data-centric Groundwater Modelling ............................................................................. 90
Cross-layer security in wireless networks ............................................................. 91
Understanding the Accuracy of Traffic Estimation, Monitoring and Incident Detection through Wireless Vehicular Communications ............................................. 92
Associate Director of Education ............................................................................ 94
University of Queensland ......................................................................................... 95
Context-Awareness in Dynamic, Mobile Environments ........................................... 96
University of South Australia .................................................................................... 97
Mobile Computing/Augmented Reality Hardware .................................................. 98
University of Sydney ................................................................................................. 99
USyd NICTA Research Student Administration .................................................. 100
Consumer-run Operation of Cloud Computing Platforms ....................................... 101
Research Leader ................................................................................................ 102
Associate Director of Education .......................................................................... 103
Approximation algorithms for voting scenarios and cost allocation of vehicle routing games ............................................................................................................................. 104
Machine learning for air pollution monitoring ...................................................... 105
Data Mining Techniques for Network Security and Optimisation ........................ 106
Crack Detection In Steel Reinforced Concrete Beams based on Vibration Analysis and Guided Waves ............................................................................................. 107
University of Tasmania ........................................................................................... 108
SenseT Freight and Logistics Lab ...................................................................... 109
University of Technology Sydney ........................................................................... 110
Investigation of Effective Damage Detection Algorithms for Structural Health Monitoring of Large Iconic Bridges Using Vibration Measurements .............................. 111
University of Wollongong ........................................................................................ 112
Sample-wise Learning and its Application .......................................................... 113
Australian National University
**Riemannian Geometry in Computer Vision (variation)**

**Description:**

**Project Title:** Riemannian Geometry in Computer Vision (variation to CRP executed on 13 July 2013)

**Research Group Association:** Computer Vision

**University Group Association(s):** ANU, College of Engineering and Computer Science, Research School of Engineering

**Project Description:** The use of Riemannian geometry in Computer Vision problems has been shown to lead to improved results in many problems. Riemannian manifolds come up in many contexts, such as Structure from Motion, pedestrian and face recognition, tracking and other applications of Machine Learning in Vision. The type of manifolds that can occur include the space of rotations (SO3), the Essential manifold, Grassman manifolds, and Kendall’s shape manifolds. Typically, measurements or features extracted from images reside in some manifold, either mathematically defined by a model, or empirically by the distribution of data. By observing the manifold geometry, questions such as separation of different data sets (classification), the mean of a data set, and mean-shift tracking become more accurate.

I propose to further this field in the following areas:

1. Investigate the existence and definitions of kernels on Riemannian Manifolds. Defining a kernel allows one to apply kernel techniques to classification (support vector machines, Fisher Discriminant Analysis) and data modelling (Kernel PCA).
2. Explore the geometry and Riemannian structure of Kendall’s shape manifolds. Extension of the techniques to continuous curves, and shapes in 3D seems promising and useful. This leads to the exploration of Riemann manifolds based on a Hilbert space model.
3. Possibly complete a book (underway) on discrete optimisation methods, including pseudo-boolean optimisation and graph algorithms.
4. Contribute expertise in this area (and more generally) towards the research and commercialisation goals of the Computer Vision group in NICTA.

**Project Duration:** 1 Jan 2012 - 31 Dec 2014. This CRP covers the period 1 Jan 2013 until 31 Dec 2014.

**Benefits:** Riemannian methods are becoming increasingly popular in Computer Vision. This project will establish NICTA as a leader in this area. Particular benefits will include achieving real-time and optimal performance of many tasks. Several of my graduate students both in NICTA and ANU are involved in related research, which will benefit the knowledge base in Australia in this area, and will further NICTA’s commercial goals.
Distributed Control and Estimation in Networked Environments

Description:
Project Title: Distributed Control and Estimation in Networked Environments
Research Group Association: Networks Research Group

Lead Investigator: Brian Anderson

Other Investigators: Guoqiang Mao (UTS, Changbin Yu (ANU, ARC QEII), Zihuai Lin (USyd), Adrian Bishop (NICTA)

University Group Association(s):
The ANU, Research School of Engineering (for Brian Anderson and Changbin Yu)
The University of Technology Sydney, School of Computing and Communications (for Guoqiang Mao), University of Sydney, School of Electrical and Information Engineering (for student Jing Yue)

Project Description: A key research challenge is to develop theoretical tools for the design and analysis of distributed estimation and control schemes suitable for distributed dynamical systems with network connected sensors and actuators. On occasions these can be very large scale and/or nonlinear, and the sensors may be moving, e.g. as a formation of UAVs. This project examines a number of key research problems within this field typically related to the control and estimation of distributed sensor systems. Collaboration with Australian Defence is also undertaken throughout this project with a number of key collaborators within DSTO, and these collaborators specify subprojects derived from particular scenarios from time to time, the latest of which is in software radio and its possible application to target localisation.

This is a continuation of a pre-NUCA project. The standard NICTA IP agreement applies for all NICTA affiliated partners. DSTO affiliated partners are covered under an existing NICTA/DSTO umbrella agreement.

Project Duration: 1 September 2011 - 31 December 2014. This particular CRP spans the period from 1 February 2014 until 31 December 2014.

Benefits: This project delivers numerous benefits through:
• The development of internationally recognised world-leading research in distributed control and estimation of large-scale systems. Such benefits are evidenced by plenary and invited lectures and a number of best-paper (or finalist) awards achieved by the project team, and a number of publications in top tier journals.
• The training of postgraduate students and early career researchers. This project currently involves a large number of research students, many of whom receive PhD Scholarships funded by NICTA (see budget for details). It supports one early career researcher (ECR) employed by NICTA with adjunct status, and it has as a long-term collaborator - a second ECR who holds an ARC Queen Elizabeth II Fellowship at ANU (Changbin Yu). Many short-term visitors come from leading institutions worldwide.
• Collaboration in the national interest with DSTO, leading to the solution of particular problems posed by them, and the facilitation of world-leading basic research within the Australian Defence community. Further prospective individual benefits (all achieved in the past) with DSTO include provision of software, analysis of trial data, and joint patents.
Machine Learning

Description:
Project Title: Machine Learning
Research Group Association: Machine Learning
University Group Association(s): ANU, CECS, Computer Science

Project Description:
The aim of the project is to drive fundamental and applied machine learning research across NICTA and across NICTA’s partner universities, building new machine learning capabilities of critical future relevance to Australian industry. The objectives of this project are to:

- Develop core research strengths around Bayesian statistics, transfer learning, structured prediction, graphical models, parametric and non-parametric learning and optimisation.
- Turn machine learning into an engineering discipline, by developing a composable framework for machine learning methods and algorithms, and by building technologies for the software engineering of machine learning.
- Address major application challenges of machine learning especially in areas such as health, environment and infrastructure; key application areas for Australia.

The initial group of researchers identified in this CRP will grow to include groups across NICTA and across other partner universities. The project is expected to drive fundamental and applied machine learning research within the ANU, NICTA and the various partner universities that are part of NUCA. This will include hosting national summer schools and internship programs relating to machine learning, preparing and delivering machine learning outreach material into schools with the aim of attracting undergraduates into computer science programs, the generation of significant additional funds that enable this project to grow to the direct benefit of each member of this CRP.

Project Duration: 1 January 2012 to 30 June 2015. The previously executed Agreement for this CRP covered the period 1 January 2012 to 30 December 2012. This CRP covers the period 1 January 2013 to 30 June 2015.

Benefits:
Machine learning is a fundamental enabling technology across all areas and applications of ICT. Machine learning will have a fundamental impact in areas from banking to geothermal energy and from drug discovery to network content distribution. NICTA continuous to apply machine learning across all of these applications, providing increased machine understanding, customer value, economic and social outcomes. The core research to be developed and built in this project will make machine learning technology more readily applied and more readily reused in a range of projects. The project is expected to draw attention of the international research community and thus build the reputation of the group and the partners. It will provide numerous opportunities for graduate student training. Through the collaborative end-user projects we expect to deliver real value and wealth creation for Australia.
Principles and Applications of Compositional Machine Learning

Description:
Project Title: Principles and Applications of Compositional Machine Learning

Research Group Association: Machine Learning

University Group Association(s): ANU Research School of Computer Science

Project Description: The fruits of machine learning research are quickly becoming sought after commodities in this current era of data-driven industries. To systematically build upon this developing layer of inferential commodities (i.e., data, learning algorithms, and the predictions and models they produce) a theory of how they compose is required: How should we combine predictions from existing models to solve more complex tasks? How can similar tasks best be solved in parallel? This project will examine a number of classical and emerging techniques (e.g., ensemble methods and transfer learning) for the composition of learning algorithms, the tasks they are applied to, and the models and predictors they produce. The aim is to uncover theoretical principles for inferential composition that create a unifying framework for these techniques and investigate their application to prediction from heterogeneous sources of data, such as those found in energy and traffic management.

Project Duration: 1 February 2013 – 30 June 2016

Benefits: This project delivers numerous benefits through:
- The development of high-quality research that has the potential to influence future machine learning practice. Existing work related to this project on the structure of loss functions and prediction markets by the lead investigator has already been published in top conferences and journals.
- The training of post-graduate students from the ANU.
- Interaction with international visitors and institutions. Collaborative visits to Microsoft Research, the University of Edinburgh, and Tsinghua University are planned.
Multimedia in Online Social Communities

Description:
Project Title: Multimedia in Online Social Communities
Research Group Association: Machine Learning
University Group Association(s): Australian National University, College of Engineering and Computer Science, Research School of Computer Science.

Project Description:
Online multimedia content is taking up a significant portion of all bits being exchanged. Notably, videos account for 37% of peak hour web traffic in 2010 [2], growing to over 50% in the next two years [1]. Online social networks, on the other hand, have become the largest virtual meeting places. With 91% of online adults accessing social media in a typical month, it has become a platform for sharing experiences, germinating ideas, as well as building and maintaining relationships. A large share of messages being communicated on social media platforms contains or points to multimedia content.

This project will focus on two main themes where multimedia meets social networks. On one hand, community-based intelligence will help tackle some of the most challenging problems in artificially intelligence and multimedia understanding, such as using microblogs, folksonomy tags and user comments to understand the meanings of an image or video. On the other hand, tracking multimedia messages as they propagate through the social web will help understand the structure and dynamics of online information network at large.

Project Duration: This CRP covers the period 1 January 2013 – 31 December 2015. An earlier CRP covers the period 1 January – 31 December 2012.

Benefits:
- The problem area at the intersection of multimedia and social networks is new and emerging. Understanding large-scale media semantics in a social context, and understanding large-scale social interactions in media have not been achieved before. We anticipate disseminating our finding in top conferences and journals, such as WWW, ACM Multimedia, ICWSM, ACM Trans. Web.
- We will provide world-class research training for PhD students. Graduates from this research program will have sufficient skills, experience and research vision to be employed in top industry or academic research jobs. In addition, we will facilitate exchange visits from top multimedia and social media researchers, especially our colleagues and collaborators from Columbia University, Google, Rutgers University, and others.
Machine Learning for Computer Vision

Description:
Project Title: Machine Learning for Computer Vision
Research Group Association: NICTA’s Machine Learning Research Group
University Group Association(s): Research School of Computer Science, College of Engineering and Computer Science, Australian National University.

Project Description:
The purpose of this project is to facilitate closer engagement between Stephen Gould and the NICTA Machine Learning group. As such the project covers three collaborative efforts. First, Stephen Gould is involved in the Solar Prediction project (led by Bob Williamson and Chris Webers) where he is providing computer vision expertise. Second, Stephen is involved in the teaching efforts of the NICTA ML group. In particular, he has delivered lectures and prepared online teaching modules for NICTA short courses (with Chris Webers). Third, Stephen is actively supervising NICTA ML PhD students. Specifically, Stephen is co-supervising Netanel Ratner (with Bob Williamson) on the Solar Prediction project, and Paul Rivera (with Tiberio Caetano) on life-long learning with real-world data. Paul is currently on leave, but will be resuming his PhD in August 2013.

Project Duration: 1 May 2012 - 30 April 2015. This CRP specifically covers the period from 1 May 2013 until 30 April 2015.

Benefits:
Stephen Gould is an expert in the application to machine learning techniques to computer vision problems. His existing relationship with members of the NICTA Machine Learning group and proximity to CRL makes collaboration natural and mutually beneficial. This collaboration delivers significant ICT outcomes. Specifically, Stephen Gould's supervision of NICTA PhD students and delivery of NICTA short courses is helping to increase the availability within Australia of world-class ICT research skills. Moreover, his involvement in the Solar Prediction project is likely to result in research outcomes of significant commercial value as well as social and environmental benefit.
Optimisation for Energy Systems

Description:
Project Title: Optimisation for Energy Systems
Research Group Association: Optimisation
University Group Association(s): ANU Research School of Computer Science

Project Description:
The project studies the optimisation techniques necessary to support the energy systems of tomorrow, including smart grids and smart buildings. The integration of distributed generation through renewable energy fundamentally challenges the structure of the existing grid and calls for a paradigm shift in the way energy systems are planned and operated. Quoting the PSERC white paper from 2010, “to seamlessly integrate renewable resources in the grid, research and development must address challenges that high penetration level will have in power system planning and operations” which already use sophisticated optimisation algorithms. A detailed project description (25 pages) can be found in the Optimisation Research Group Strategic plan.

Project Duration: 1 Jan 2012 to 30 June 2015. This CRP covers the period 1 Jan 2013 to 30 June 2015 and replaces the previously approved CRP (which had a budget for 2012 only) from 1 Jan 2013.

Benefits:
NICTA is creating a world class research group in Optimisation for energy systems, with a focus on the planning and operations of smart grids and smart buildings. This complements the expertise available in Australia (e.g. ANU Energy Change Institute, CSIRO, utilities and vendors) whose focus is traditionally lower down the stack. NICTA as a whole is very well placed to make a major contribution in this area, with its expertise in Control, Machine Learning, Network Systems and Optimisation.
Regarding training of postgraduate students and early career researchers, four new students will start in this area in 2013, adding to the five students and three postdoctoral researchers recruited in 2012. This number is expected to rise further in later years of the project.
Regarding commercialisation for the national benefit, appropriate subprojects within the NICTA Infrastructure, Transport and Logistics and Security and Environment business teams, or via ARC linkage and ARENA grants will be established as the research matures. Within the scope of this agreement, they are more likely to concern the automation of the operations of conventional grids and microgrids, as well as the incorporation of renewable energy generation on the grid.
Research Group Leader Computer Vision

Description:
Project Title: Research Group Leader, Computer Vision Research Group
Research Group Association: Computer Vision Research Group
University Group Association(s): Australian National University, College of Engineering and Computer Science, Research School of Engineering

Project Description: Professor Porikli will be involved in the leadership of the Computer Vision Research Group in NICTA, of which a primary responsibility is developing CVRG into one of the top 5 groups in computer vision worldwide. This includes:
• Providing research leadership in activities in the group in areas such as:
  - Continental-Scale 3D Dynamic Scene Understanding
  - Spectral Imaging
  - Optimisation and Geometry
• Developing new research directions arising from:
  - Engagement with NICTA’s business teams and other NICTA research groups
  - Collaboration with world-leading research groups
  - The pursuit of excellence in computer vision
• Conducting research at the highest international level in computer vision. Initial discussions included topics of Riemannian geometry and sparse representations on shape spaces
• Supervising and mentoring CVRG staff and PhD students
• Other duties relating to the research excellence KPIs as specified in the Research Group Leader position description.

The more detailed focus of this CRP will be updated within 3 months after Professor Porikli joins ANU/NICTA, to allow for more detailed discussions and planning.

This CRP accounts for 50% (0.5FTE) of Professor Porikli’s time. This CRP is one of three agreements that together comprise Professor Porikli’s employment arrangement (the other two are an employment and secondment agreements). Professor Porikli will be on a 30% ANU and 70% NICTA employment arrangement. For the first 5 years of appointment, the University will pay 30% of his University salary and NICTA will pay 70%. He will be 20% seconded to NICTA and 50% on this Collaborative Research Agreement. Travel costs will be shared pro-rata between the ANU and NICTA, with NICTA being responsible for travel costs directly related to his NICTA secondment and CRP project.


Benefits: To be completed within 3 months of the start date.
Optimisation

Description:
Project Title: Optimisation
Research Group Association: Optimisation Research Group
University Group Association(s): Australian National University, College of Engineering and Computer Science, Research School of Computer Science

Project Description: The aim of the project is to carry out fundamental and applied research across NICTA and its university partners, building new optimisation capabilities of critical future relevance to Australian industry. The key research themes under this project are:

- Disaster Management: to mitigate the consequences and the costs of natural disasters through advanced optimisation and simulation technology, data and network science, and 3D visualisation
- Future Energy Systems: to build new optimisation technologies required to support the future of energy systems and the transition from today’s power systems to renewable energy sources
- Next Generation Optimisation Platform: to build an optimisation platform that will dramatically simplify the solving of complex optimisation applications by supporting rapid prototyping, deep solver hybridization, data intensive optimisation, and decision making under uncertainty
- Logistics and Supply Chains: to produce solutions to problems affecting supply chains in Australia such as efficiencies in routing and scheduling in fleet management, simulate and optimise port operations, maximise utility in rail operations, look at innovative public transport systems and applications in disaster management
- Algorithmic Decision Theory: to develop optimisation tools and technologies to exploit user's preferences using knowledge of artificial intelligence, operations research, social choice, game theory, and machine learning.

The initial group of researchers identified in this CRP will grow to include groups across NICTA and across other partner universities. The project is expected to drive fundamental and applied optimisation research within the ANU, NICTA and the various partner universities that are part of the NUCA. This will include: hosting visiting researchers and internship programs relating to optimisation; preparing and delivering optimisation educational materials such as Coursera, with the aim of reaching a wider cohort of students to develop optimisation skills and potentially interest them in pursuing postgraduate careers in optimisation and ICT; and, the generation of significant additional funds that will enable this project to grow to benefit members of this CRP.

Project Duration: 25 November 2013 to 30 June 2015

Benefits: Optimisation is a fundamental enabling technology across all areas and applications of ICT. The core research to be developed in this project will be state-of-the-art, innovative optimisation methodologies that will be applied to grand societal challenges such as disaster management, supply chain and logistics, and future energy systems. The benefits include applications that will allow faster response and recovery from disasters, improved decision making under uncertainty, increased
productivity and resource planning, and smarter energy systems including future renewable energy integration. The project will develop the skills and reputation of the group and its partners in the international community. It will provide numerous opportunities for graduate student training and visiting researchers and student internships and exchanges thus building skills and capabilities in the ICT sector. The project is expected to deliver real value and wealth creation for Australia and the global community.
Computational Social Science for Optimisation

Description:
Project Title: Computational Social Science for Optimisation
Research Group Association: Optimisation
University Group Association(s): Australian National University, College of Engineering and Computer Science, Research School of Computer Science

Project Description:
This project will model dynamics of social media and other behavioural traces, using statistical models to predict user behaviour, and devise optimisation strategies to improve processes of individuals and cities. This project will advance computational social science via novel methods and publicly released tools for analysing large amounts of online messages and behavioural traces. These methods and tools will improve information dissemination capabilities, provide new insights into many-to-many communication patterns in social media during real-world events, and provide tools to optimise decision-making in developing and managing cities.

This research will help answer questions such as: Which users should be targeted in order to convey information about traffic conditions in a hurricane? How much public attention will a new climate change bill garner, if its introduction coincides with other major events (e.g. the football finals or the Nobel Prize announcements)? How popular will a new catchphrase or idea become? More broadly, computational social science has emerged as a very active research area across several traditional disciplines – including sociology, computer science, statistical physics and economics. This project presents a unique contribution to computational social science, providing new methods and tools for analysing large amounts of social message data, improved understanding of many-to-many communication dynamics in social media, and approaches for applying these insights to plan better actions.

This innovative interdisciplinary project seeks to advance both computer science and social science, and is significant in three ways. The intellectual contribution will be in both methodology and understanding: we design automated methods to predict social message popularity and user actions, which will result in observations and understanding of how users act and how information propagates in real-world events. The practical benefits of our project will include predictive models for information dissemination (such as a ranking of users for broadcasting status updates in a hurricane), and better situation awareness (e.g. what are prevention measures already in place for a flu outbreak, will it be safe to do air travel during the epidemic, and so on) – these improvements will empower citizen users and government agencies alike. In the long-term, we anticipate societal impact: that better tools and understanding of social media communication will lead to novel optimisation strategies for urban planning, healthcare, and other policy decisions. These challenges can only be tackled by machine learning, optimisation and social science researchers working in close collaboration.

Project Duration: 1 March 2014 to 29 February 2016

Benefits:
We envision the broader benefit of this project to be in three main aspects.
Smart Information Use and Advancing ICT Frontiers: Our proposed advances in the understanding and tools for accessing and organizing large amounts of digital media will help advance key elements of a successful digital economy, including “consumer digital confidence” and “digital media literacy”. Furthermore, Smart Information Use “involves improved data management . . . [which can] provide huge opportunities to improve the performance of key Australian industries”. Understanding and building better tools for social media communication facilitates information exchange in a geographically dispersed land such as Australia. This will help Australia to better connect with neighbouring countries in the Asia-Pacific region such as Indonesia, Japan, South Korea and China, which are embracing the use of social-media.

Safeguarding Australia: Monitoring real-time information flow and archival data has been of key interest to national security, defence and information intelligence. The US Defence and Intelligence Advanced Research Agencies (DARPA and IARPA) have hosted new research programs on social media analysis in 2011. DARPA’s $42-million program on “Social Media in Strategic Communication” aims for “a new science of social networks . . . [including the analysis of] linguistic cues, patterns of information flow . . . [and] emergent communities”. IARPA’s Open Source Indicators (OSI) Program aims to observe “significant societal events [that] are preceded and/or followed by population-level changes in communication, consumption, and movement, . . . [especially those] observable from publicly available data, such as web search queries, blogs, micro-blogs, internet traffic, financial markets, traffic webcams, Wikipedia edits, and many others”. Media monitoring and content filtering applications fit well with the missions of relevant government agencies, such as the Department of Defence, many federal and local departments responsible for emergency-response, and the National Broadband Network (NBN). The aim of this project addresses several pain points of national safety issues; we anticipate its outcome to have wide applicability in improving situation awareness and strategic communication.

Educational and social benefits: The project contributes to the training of one postdoctoral researcher and two PhD students. Once matured, the research results can also be used to construct and update a curriculum of computational social science, the first in Australia. Certain research outcomes, such as the visualisations of event evolution, dynamics of interacting users, or stickiness of messages, also have potential to become public outreach and demonstration pieces. These can stimulate broader interest in STEM (science, technology, engineering and mathematics) research and attract the next generation of computer scientists, as well as computational social scientists.
Computer Vision and Optimisation on Manifolds

**Description:**

**Project Title:** Computer Vision and Optimisation on Manifolds  
**Research Group Association:** Computer Vision  
**University Group Association(s):** ANU, College of Engineering and Computer Science, Research School of Engineering

**Project Description:** The use of Riemannian geometry in Computer Vision problems has been shown to lead to improved results in many problems. Riemannian manifolds come up in many contexts, such as Structure from Motion, pedestrian and face recognition, tracking and other applications of Machine Learning in Vision. The type of manifolds that can occur include the space of rotations (SO3), the Essential manifold, Grassman manifolds, and Kendall’s shape manifolds. Typically, measurements or features extracted from images reside in some manifold, either mathematically defined by a model, or empirically by the distribution of data. By observing the manifold geometry, questions such as separation of different data sets (classification), the mean of a data set, and mean-shift tracking become more accurate.

I propose to further this field in the following areas:

1. Investigate machine learning techniques on Riemannian Manifolds. For instance, defining a kernel on a manifold allows one to apply kernel techniques to classification (support vector machines, Fisher Discriminant Analysis) and data modelling (Kernel PCA).
2. Develop a theory of Iterative Reweighted Least-Squares optimization on manifolds, including manifolds of negative curvature.
3. Explore the geometry and Riemannian structure of Kendall’s shape manifolds. Extension of the techniques to continuous curves, and shapes in 3D seems promising and useful. This leads to the exploration of Riemann manifolds based on a Hilbert space model.
4. Possibly complete a book (underway) on discrete optimisation methods, including pseudo-boolean optimisation and graph algorithms.
5. Contribute expertise in this area (and more generally) towards the research and commercialisation goals of the Computer Vision group in NICTA.

**Project Duration:** 1 July 2014 – 30 June 2017

**Benefits:** Riemannian methods are becoming increasingly popular in Computer Vision. This project will establish NICTA as a leader in this area. Particular benefits will include achieving real-time and optimal performance of many tasks. Several of my graduate students both in NICTA and ANU are involved in related research, which will benefit the knowledge base in Australia in this area, and will further NICTA’s commercial goals.
Deakin University
Heath Data Analytics - Pervasive Cardiac Monitoring and Mental Health Data Mining in Social Media

Description:
Project Title: Heath Data Analytics - Pervasive Cardiac Monitoring and Mental Health Data Mining in Social Media
Research Group Association: Control and Signal Processing
University Group Association(s): Deakin University, Faculty of Science, Engineering and Built Environment, School of Information Technology, Centre for Pattern Recognition and Data Analytics (PRADA)

Project Description:
There is an urgent need to pervasively monitor at-risk cardiac patients for possible onset of stroke and related issues. At present the devices available for this cannot take into account individual differences and how variations of activities affect ECG records. This work addresses these issues. There is a need to pervasively monitor the emergence of issues pertaining to mental illness and, in particular, autism, within the guardians of at-risk cardiac patients, such as parents. This work is developing data mining tools to analyse social media data to detect such issues. Again, early detection of issues will aid in coping and treatment strategies.

Thus, this collaboration is centred around two technical challenges. The first challenge is to develop data modelling and pattern recognition technologies for the monitoring and interpretation of electrocardiography (ECG) activity invariant to human activity via the use of normalisation methods and other sensors such as accelerometers. The second challenge is to investigate new data mining technologies for social media pertaining to autism. This project has one common theme, and that is the development of new data interpretation technologies that will help clinicians pervasively monitor individuals or communities in how they cope with health issues.

Project Duration: 1 May 2013 – 31 December 2015

Benefits: The project outcomes are anticipated to generate new health monitoring technology in the wild that can result in economic savings and improve healthcare at a large scale. This is relevant to technologies targeted by Australian Strategic Research Priority Promoting Population Health and Wellbeing. Methodologies developed in this project targets at the forefront of machine learning and data mining techniques – hence, the project certainly advances the current knowledge base of the field, and train PhD students at the world-class level.
**Assistive Bionics for Physiotherapy and Respiratory Analysis**

**Description:**

**Project Title:** Assistive Bionics for Physiotherapy and Respiratory Analysis  
**Research Group Association:** Networks Research Group  
**University Group Association(s):** Deakin University, Faculty of Science, Engineering and Built Environment, School of Engineering

**Project Description:**  
This project is focused on two areas of Rehabilitation Engineering. The first is focused on developing technologies for improving the ability of clinicians to pervasively assess the degree of motor function in patients and for patients to perform physiotherapy with ICT-enabled assistance – a “Virtual Physiotherapist” (VP). The second is concerned with further developing non-contact Doppler radar for measuring and interpreting respiratory function in patients, that is, non-contact respiratory assessment technologies (RAT). This will be applied to the monitoring of sleep apnea, SIDS and other sleeping disorders as well as respiratory diseases.

**Project Duration:** 1 May 2013 - 31 December 2015

**Benefits:** Both activities are being undertaken in partnership with Barwon Health and, as such, the work is focused on delivering solutions to current clinical challenges. In the VP activity there are plans to deliver technologies for clinicians to accurately measure specific movements of patients using pervasive as well as “in clinic” devices. Secondly, to provide a credible, useful exercise feedback platform so that patients can be sure they are performing their physiotherapy correctly without a physiotherapist being present. At present, muscular dystrophy and stroke patients are involved. The recent RAT activity is being applied to the study of sleep apnoea patients at the Barwon Health Sleep Clinic to compare this non-contact technology with wearable (belt) technologies to measure and assess sleep dysfunction. Ultimately, the aim is to build such systems that can interpret tidal volumes from chest and/or diaphragm movements and to provide respiratory rehabilitation, with biofeedback to patients that can be used without a clinician being present.  
Common to both movement and respiratory studies is the measurement, interpretation and use of biofeedback to help in the rehabilitation processes and, ultimately, the development of specific hardware/software devices, for commercialisation and general use.
Advanced Search and Optimisation

**Description:**

**Project Title:** Advanced Search and Optimisation (Extension)

**Research Group Association:** NICTA’s Optimisation Research Group

**University Group Association(s):** Griffith University; Science, Environment, Engineering and Technology Group; School of Information and Communication Technology

**Project Description:**

Problem solving can be conceptualised as a search for answers within a solution space. When the solution space is exponentially large, the search can become extremely challenging. Such problems are commonly referred to as computationally intractable. There are two classes of methods used to solve these problems: systematic search and stochastic local search. Generally speaking while systematic search is effective for limited size problems, local search becomes more realistic when solving complex and large real world problems.

This project aims to develop advanced stochastic local search and optimisation algorithms, and to build robust and efficient search tools. The project will consist of the following work packages:

- **Platform:** This work package will continue the development of Kangaroo, an efficient constraint-based local search system. The goal is to develop efficient solutions to handle and support different global constraints from various problem domains. Additionally, new adaptive search and portfolios will be investigated to make Kangaroo an effective black-box solution.

- **Vehicle Routing:** This work package will leverage and further develop our Kangaroo platform to find high-quality solutions for the vehicle routing problems with capacity constraints and time-based penalties.

- **Disaster Management:** This work package will leverage and further develop our Kangaroo platform to support decision support system effectively handling resource allocation and planning problems (transportation, power infrastructure, emergency services, etc.) arising due to disastrous situation. We will develop optimisation algorithms for disaster management plan and actions for emergency events in dynamically changing environments.

- **Hard Combinatorial Problems and SAT:** Our team will also continue to maintain and enhance its world leading position in SAT solving, and develop local search algorithms for solving hard open computationally intractable problems in the field.

**Project Duration:** This CRP covers the period 1 Jan 2013 to 31 Dec 2015

**Benefits:**

Optimisation problems are ubiquitous across all areas of science, engineering, business as well as social sciences. Efficient and robust solutions of these problems can have profound socio-economic impact on any society.

This project will maintain and enhance Australia’s international standing in Stochastic Local Search methods for solving hard real world combinatorial and optimisation problems. In particular, NICTA will maintain its world leading position in solving SAT
problems (SAT is the core of all computationally intractable problems). It will leverage off GU’s consolidated experience in the area of knowledge representation and reasoning, model checking and NICTA’s world-class expertise in search and optimisation. If successful, this project will benefit the Australian economy through cost savings in logistics and supply chain managements as well as reducing the carbon footprints. In addition, this project helps safeguarding Australia with robust and resilient plans for preparing and responding to disasters.
Virtual Speech Pathologist

**Description:**

**Project Title:** Virtual Speech Pathologist  
**Research Group Association:** Health and Life Sciences Business Team.  
**University Group Association(s):** La Trobe University, School of Allied Health, Faculty of Health Sciences and Department of Electronic Engineering, School of Engineering and Mathematical Sciences, Faculty of Science, Technology and Engineering.

**Project Description:**

This project is focused on developing ICT-enabled assistive technologies for improving the ability of hearing impaired and, in particular, cochlear implant patients, in speech acquisition and recognition.

This collaborative project specifically covers one element of the broader project via a NICTA supported Ph.D. student at La Trobe University. This standalone CRP, and associated Ph.D. thesis, will investigate and implement optimal methods of matching speech production with speech recognition in recipients of cochlear implants. Solutions to this will enable more pervasive and independent speech theory for the hearing disabled and constitutes a core technology for the larger project.

**Project Duration:** 1 May 2013 to 30 April 2016 (not including a possible 6 month extension).

**Benefits:**

Learning speech recognition and speech production is still not a given for all cochlear implant recipients due to a number of reasons including the inability of the implant to provide adequate stimulation to compensate for the mismatch between normal speech signals and the implanted system. Accordingly, there is a need for implant recipients to learn how to match what is encoded with what is spoken – particularly for specific people, family, carers, etc.

This PhD project is part of a larger project using telehealth delivery methods to provide a virtual speech therapist application. Taking a telehealth approach is particularly applicable to people living in rural Australia where clinician shortages, socio-economic factors and geographic factors such as large distances between townships play a significant role in access to treatment. Even in metropolitan areas accessibility issues are still highly relevant.

Clinician delivered treatment programs place significant strain on the resources of clinics and clinicians and clients face issues relating to lifestyle factors. Such factors include often significant clinic fees and direct and indirect expenses such as transportation, time off work for clients and family members and child care costs.

The technologies being developed in this project also have far broader applications including (but not limited to) language learning, accent modification, stuttering interventions and the development of augmented speech/sound production and recognition technologies. To date there are very few published studies using computer based assistive technologies in any of these areas.
Macquarie University
Deep Learning for Text

Description:
Project Title: Deep Learning for Text
Research Group Association: Machine Learning Research Group
University Group Association(s): Macquarie University, Faculty of Science, Department of Computing

Project Description:
Deep learning is revolutionising many areas of machine learning and natural language processing. While most of this work has been largely applied to computer vision problems, this project aims to develop deep learning techniques specific for natural language processing (NLP) applications, such as information extraction (IE), sentiment analysis, and summarisation. We believe that the most effective way to do this is to understand the strengths of deep learning in solving NLP problems, leverage existing NLP technologies, and find effective ways to integrate deep learning with these technologies. Furthermore, deep learning benefit from unlabelled data by using unsupervised pre-training techniques. Therefore, we explore also methods to make full use of the available training data. While most deep learning research aims to prove a theoretical point, we focus on producing scalable systems that work as well as possible.

Project Duration: 1 November 2014 – 30 June 2016

Benefits
This project will develop NLP specific deep-learning methods, which will significantly reduce both the amount of labeled training data and the efforts of feature engineering. It aligns well with NICTA’s ongoing efforts in semi-supervised and weakly supervised learning. We will grow deep learning expertise in NICTA. The resulting deep learning techniques will advance i) IE and IE related applications, such as extending knowledge of people’s life stories; ii) text similarity based applications, such as trademark search. The deliverables are:

- A highly extensible deep learning platform to build text representation for capturing application specific text similarities.
- A deep learning system that extracts named entities and their relations.

The deep-learning research results will be released as open source.
Monash University
Constraint Modelling Platform

Description:
Project Title: Constraint Modelling Platform
Research Group Association: Optimisation Research Group
University Group Association(s): Monash University, Faculty of Information Technology, Caulfield School of IT.

Project Description:
The project studies techniques for modelling, analysing and improving models for constraint optimisation problems. The aim is to develop a modelling environment based on the successful MiniZinc project to deliver the next generation of modelling tools that will allow non-experts to model difficult, but practically important, constraint optimisation problems such as those arising in transport and logistics. This requires having an expressive modelling language that allows a non-expert user to naturally describe their problem and then have their models automatically transformed into a model that can be efficiently solved by the NICTA constraint solving platform. The project covers three main areas:

1. *Design and implementation of MiniZinc 2.0*: Extending the modelling capabilities to handle hybrid algorithms and stochastic models by introducing new syntactic features in MiniZinc and improving the interfacing to new and hybrid solving technology (e.g., nonlinear optimisation systems) and developing an architecture that makes it easy to embed MiniZinc into existing software solutions. MiniZinc will have to compete with established solutions from the area of Operations Research such as AMPL.

2. *Development environment*: Developing an easy-to-use IDE and associated visualisations for MiniZinc 2.0 designed for the non-expert modeller. This includes developing extensive tutorial and reference documentation, provision of interactive modelling support, as well as visualisation and statistical performance feedback that helps modellers understand the behaviour of the solving technology for a given model.

3. *Analysis and transformation*: Studying and developing analysis techniques that support and guide modellers, helping them to improve the effectiveness, efficiency, and maintainability of their constraint models. This includes automatic reformulation techniques.

Project Duration: 1 January 2012 to 30 June 2014.

Benefits:
- This CRP will create a world leading research group in Constraint Modelling and Model Analysis. It naturally complements the research already carried out in the Optimisation Group, which is focused on solving technology and applications, and will provide a crucial component of the Optimisation Platform. NICTA is well placed to become the leading provider of modelling and model analysis technology.
- This project will support up to four postgraduate students (one has already started, and we have advertised and secured funding for at least two more
PhD students). There will be at least two postdoctoral researchers in the group (one is already working in our group, the other position will be filled shortly), and one early career researcher.

- Close links with Opturion will provide commercialisation opportunities. MiniZinc has already been used for commercial projects, and the improved modelling, analysis and integration capabilities will make it an even stronger proposition.
Improved Statistical Models of Document Corpora and User-Click Behaviour with Application to Personalised Patent Search

Description:

Project Title: Improved Statistical Models of Document Corpora and User-Click Behaviour with Application to Personalised Patent Search

Research Group Association: Machine Learning Research Group

University Group Association(s): Monash University, Faculty of Information Technology, Caulfield School of IT

Project Description:

This project consists of two parts: (i) an investigation of statistical models (generalisations of the Pitman-Yor process) capable of modelling observed variations in burstiness across terms in a document corpus, and (ii) an analysis of advanced topic modelling techniques for estimating user click probabilities in query logs. The former will result in better theoretical understanding of textual data and improved search algorithms, while the latter will result in improved algorithms for personalising search engine results. Thus the two halves of the project complement each other in terms of the theory developed and represent in our opinion the two areas of Web search where Machine Learning can have significant impact. Moreover, both parts of the project will leverage data from and provide benefit to the NICTA lens.org patent search project.

Part A: Generative Processes for Modelling Variations in Burstiness across Terms

This part aims at a better understanding of the theoretical aspects of top performing text retrieval functions such as BM25, by identifying (i) what model of term distributions are implicitly assumed by this model, and (ii) what the loss function is that is implicitly being optimized. By doing so we aim to not only improve the performance of text retrieval functions, but also to place them on a more solid probabilistic footing.

Part B: Evaluating Latent Variable Models for User-Click Prediction

Many models have been proposed in the past for personalising retrieval based on the profile information present in a query click-through log. None have been particularly successful except for dealing with the “obvious cases” where the user has already submitted the exact same query in the past. We believe the reason is that they were not based on principled statistical modelling of user interests and information needs. Latent topic modelling techniques are now mature and offer a possibility to model the interests and needs in a principled manner. In this proposal we introduce two new generative models for describing users' querying and subsequent click behaviour. The aim of this project is to evaluate the effectiveness of these and other similar personalisation models.

Project Duration: 1 Jan 2014 to 31 Dec 2015

While the CRP is for the period 01 January 2014 to 31 December 2015; the potential student commitment would continue until the end of the candidature up to a maximum of 3.5 years in order to cover the full term of the student scholarship.
Benefits:
The project will provide significant theoretical and practical contributions. On the theory side it will develop coherent statistical models for effective text retrieval that have hitherto been lacking in the Information Retrieval and Machine Learning literature. On the practical side, improvements in retrieval performance that result from better theoretical understandings will have profound influence on the quality of search results provided to users of retrieval systems such as lens.org. Given that search is the dominant paradigm for accessing online content, technology that improves the quality of results can have a significant and possibly disruptive effect on the national and international ICT sector with possible commercialisation opportunities.
Noise in Voice: Cascaded Speech Recognition and Information Extraction for Automated Form Filling in Hospitals

Description:

Project Title: Noise in Voice: Cascaded Speech Recognition and Information Extraction for Automated Form Filling in Hospitals

Research Group Association: Machine Learning

University Group Association(s): Monash University, Faculty of Information Technology

Project Description:

NICTA has
• proposed a semi-automated approach of cascaded speech recognition (SR) and information extraction (IE) for filling clinical handover forms;[1]
• developed a dataset of simulated handover records in English for experiments (the details are given under the section for background IP);
• evaluated the approach on this dataset, showing a high average of correctly recognised and extracted words;[2] and
• demonstrated this release as a technology in NICTA Techfest 2013.

The main factor influencing accuracy in record automation is SR error, which is multiplied when cascaded to a semantic component, such as an IE engine.[1-7] Owing to the considerable implications of errors for clinical decision-making, the automation of this process calls for accurate output, or at least for accuracy in identifying “at risk” sections where the output may be inaccurate.

In this ten-week project, we experiment the challenge of multiplied SR errors in IE. The research questions and suggested approaches include:
• 40% of the ten weeks: How do SR errors affect performance in IE? A performance evaluation and error analysis will be conducted using the data and technologies [6] of the Suominen group at NICTA.
• 60% of the ten weeks: How to detect SR errors automatically? Following the approach [7] of the Zukerman group at Monash, we will develop a classifier that identifies possible erroneous words and evaluate its performance statistically.

References


**Project Duration:** 3 January to 1 April 2014

**Benefits:**
Fluent flow of information is important in any information-intensive area of decision making, but critical in healthcare. Clinicians are responsible for making decisions which have significant impact on their patients’ lives. In Australian healthcare, failures in this flow are associated with over a tenth of preventable adverse events.[1-2] Failures in the flow of information are tangible in clinical handover, that is, the transfer of professional responsibility and accountability when clinicians are changing shifts. Regardless of verbal handover being accurate and comprehensive, from two thirds to all of this information is lost after three to five shifts if no handover notes are taken or they are taken by hand.[3-4]

By addressing its two research questions, this project creates capabilities to improve overall accuracy by developing better methods for SR error correction in general and in particular in the context of capturing information related to clinical handover. More precisely, the project delivers analysis results on the NICTA dataset (the details are given under the section for background IP) without handing over any software/code. That is, assessment of how much the Monash methods (the details are given under the section for background IP) can contribute to correcting the speech recognition errors (on all text and on text relevant to filling in the structured form) and a report that defines the tested methods and reports the analysis outcomes. This report is to be confidential, that is, the project partners may look into co-authoring a paper later, but for the time being, the results should not be published.

**References**
Macromolecular Informatics

Description:
Project Title: Macromolecular Informatics
Research Group Association: Machine Learning Research Group
University Group Association(s): Monash University, Faculty of Information Technology, Clayton School of IT and Caulfield School of IT

Project Description:
Modern biology and medicine are data driven. Remarkable advances in experimental technologies allow us to identify the genetic blueprint of organisms in its entirety, elucidate the three dimensional structures of biomolecules at atomic resolution, interpret the emergence of complexity through the study of interactions of biological objects working in concert, and integrate microscopic and macroscopic information to explain the whole of the life processes in terms of a complex interplay of biological organisms. The potential significance and impact of analysing and interpreting biological data of various descriptions has created an important cross-disciplinary area of modern science, bioinformatics, where computation and biology converge.

This CRP aims to cover support and supervision of the two existing PhD students’ research projects in two key research themes, under the common rubric of computational biology:

Project: Discovery of architectural principles of protein structures
Proteins are macromolecules of life responsible for almost all biological and cellular activities in living organism.
Focus: Research in this area focuses on developing state of the art algorithms to compare, classify, search and elucidate three dimensional (3D) structures of proteins, in addition to discovering foundational principles behind protein 3D architecture.
Environment in which this project is set: This research area is directly aligned with Monash’s key strength in protein structural biology and crystallography. Monash University provides excellent and extensive resources and infrastructure to support a number of research activities in this area. These include: Clive and Vera Ramaciotti Centre for Structural Cryo-Electron Microscopy; Grollo Ruzzene Foundation Centre for Protein Structure, ARC Centre of Excellence in Structural and Functional Microbial Genomics, and the Australian Synchrotron.

Project: Genomics of Disease
The cost-effective next generation nucleotide sequencing technologies provide researchers with genomic data with remarkable precision, at unprecedented rates. For the first time in human history, this has resulted in an ability to investigate at high resolution the molecular mechanisms driving diseases such as cancer among other heritable diseases.
**Focus:** The focus of this area will be to identify the mutations and aberrations in the host genome that drive the disease manifestation and the underlying evolutionary mechanisms responsible for the progression, metastasis (in case of Cancer) and relapse during the life span of the disease.

**Project Duration:** This CRP covers the period 1 February 2012 to 31 January 2016.

**Benefits:**
- Research in protein structural bioinformatics has resulted in ongoing discussion with Biota Pharmaceutical Inc. This has a prospect to provide commercialization opportunities as the collaborative research relationship matures.
- Tools developed for analysis of protein structure, especially MUSTANG and MUSTANG-MR are already employed in commercial macromolecular dynamics and visualisation systems. This current CRP will build on the success of previous research to generate improved methods for structural search, comparison and analysis.
Scalable Semi-supervised Learning for Structured Prediction

Description:
Project Title: Scalable Semi-supervised Learning for Structured Prediction
Research Group Association: Machine Learning
University Group Association(s): Monash University, Faculty of Information Technology, Clayton School of Computer Science

Project Description: In the semi-supervised setting we are given labelled and unlabelled data in training. To make full use of the available training data, we consider two semi-supervised learning methods that exploit a form of information theoretic regularisation on the unlabelled data: minimum entropy and minimum mutual information which we have proposed previously and shown is grounded on the rate distortion theory in information theory. We will investigate dual and primal-dual methods for both non-convex entropy-based and rate distortion approaches where the dual method is fully distributed, in the sense that both optimisation and feature expectation are performed at local machines. Furthermore, we investigate structured label propagation methods for semi-supervised learning in structured prediction in the context of graph-based semi-supervised learning framework.

Project Duration: 1 May 2014 – 30 April 2015

Benefits (ref: clause 4.8): This project will develop better methods for semi supervised learning, which will contribute to the development of world class ICT research capabilities in Australia. It aligns with NICTA’s ongoing efforts in shaping the frontier of machine learning research, more precisely in structured prediction, large-scale learning and weakly supervised learning. Several projects have benefited or are benefiting from research in these areas (such as the Geothermal project, the SIEF project, the MAGIC project and the Amiata project). Also a number of PhD students have their thesis topics centred around at least one of these research areas.
Queensland University of Technology
Adaptive Enterprises

Description:
Project Title: Adaptive Enterprises (Multiyear Extension)
Research Group Association: Software Systems Research Group
University Group Association(s): BPM Discipline, Information Systems School, Science and Engineering Faculty, Queensland University of Technology

Project Description:
This project aims to enable enterprise systems adaptivity. It will look at two interrelated aspects of adaptivity. The first will investigate how members of a group self-organise their coordination activities using emergent mechanisms, and how this can best be supported by technologies. The second will investigate the design and enactment of flexible business process specifications that are able to change and reconfigure themselves. In both cases the work will take account of the dynamic context in which workers operate, and how best to support this context. The project will consist of the following work packages.

Adaptive process emergence: this work package will develop techniques to support and enhance the many collaborative processes enterprises engage in that are emergent rather than designed. Drawing on principles of cooperation and communication from fields including economics and biology, this work package will introduce low-overhead mechanisms to enhance awareness and cooperation.

Process management: this work package will aim to design and develop techniques and approaches to facilitate the verification, analysis, improvement and maintenance of (large) collections of organizational process models.

Process compliance: this work package will investigate techniques and methodologies to identify whether process specifications are compliant with relevant laws or regulations (expressed as business rules or object lifecycles), and approaches to modify processes to recover from non-compliant situations determined by changes in the regulatory framework governing the affected processes.

Adaptive workflow execution: this work package will study techniques to enable flexible process execution to cope with dynamic, short-term changes of the operational context, while preserving the achievability of the process goals.

Project Duration: This CRP will cover the period 1 Jan 2013 – 31 Dec 2015

Benefits:
This project will enhance the position of Australian academics within the international BPM and CSCW communities, specifically in the emerging field of adaptive enterprises. It will leverage off QUT’s consolidated experience in the area of business process management and NICTA’s world-class expertise in process compliance and complex systems.

The ability to declaratively specify business activities, in conjunction with the enhancement and integration of tools such as Apromore, YAWL and SpiNdle compliance checker, will provide an environment to manage and automate flexible business processes. This in turn is expected to foster the adoption of process technology in the Australian market.

Finally, this project will provide a career development opportunity for three PhD students and two Postdocs.
Environmental Computer Vision

**Description:**

**Project Title:** Environmental Computer Vision

**Research Group Association:** NICTA’s Computer Vision Research Group

**University Group Association(s):** Queensland University of Technology, Science and Engineering Faculty, School of Electrical Engineering and Computer Science.

**Project Description:**

Environmental Computer Vision is the application of advanced computer vision and machine learning techniques to the problems of monitoring the state of the natural world, in particular classifying, counting and measuring micro and macro organisms (e.g., plankton, insects, fish, coral reefs, plants, etc.). Environmental vision systems will be deployed in varied environments (land, air, water surface and under water), may be fixed or carried by robots, and may perform computations locally, remotely or in a distributed fashion.

The initial focus is on classifying and counting fish in video recorded from unattended cameras in natural or baited environments.

**Project Duration:** 1 September 2012 to 31 December 2014.

**Benefits:**

A major benefit of this project will be world class ICT research which automates the analysis of challenging video reflecting the health of an environment, specifically the population of fish in sensitive coastal environments. Currently, underwater video footage is manually examined and used to measure fish abundance and diversity as well as being used to monitor endangered fish species such as the black cod. Due to the challenging conditions that underwater video footage presents, automating this analysis requires the development of state-of-the-art computer vision algorithms and techniques.

Further benefits include training of postgraduate students and early career researchers. This occurs through the involvement of Peter Corke in teaching at the NICTA Computer Vision Summer School as well mentoring one NICTA researcher. As appropriate, developed technologies will be commercialised through the NICTA Security and Environment team. This project has presented results at two NICTA Environmental Analytics Showcase events, and a research collaboration agreement has been established between NICTA, NSW-DPI and UTS to automate the analysis of underwater BRUVS videos.
Refactoring Security Critical Program Code to Restrict Data Flow

Description:

Project Title: Refactoring Security Critical Program Code to Restrict Data Flow


University Group Association(s): Queensland University of Technology, Faculty of Science and Engineering, School of Electrical Engineering and Computer Science.

Project Description:

This project will develop refactoring rules for object-oriented software whose application makes the program code more secure by restricting the potential flow of sensitive data. Although there are already coding guidelines and refactoring rules for security-critical program code, these are generally based around detecting and eliminating source code patterns already known to have exploitable weaknesses. Instead this project will devise rules based around the dataflow characteristics of the code, thus producing a more fundamental set of rules that do not necessarily rely on identifying previously seen vulnerabilities.

The fundamental concern for security-critical software is whether or not the program allows sensitive data to flow inappropriately between “security domains”, ie from a high-security source to a low-security sink. Refactoring is a well-established practice for improving the quality of program code, where “quality” is usually interpreted to mean some general characteristic such as conciseness or maintainability, but “security” is not normally considered as one of these qualities. This project will develop new rules for security-critical refactoring based around the dataflow characteristics of program code, and will demonstrate their application in an existing Interactive Development Environment.

Project Duration: This CRP covers the period 01 July 2014 to 30 June 2015.

Benefits:

The principles developed in this project will benefit programmers of security-critical systems both during initial development of bespoke software and maintenance of existing code. Specific technical outcomes will include:

- Development of a new set of refactoring rules whose application guarantees improvements to the flow of security-critical data through a program.
- A demonstrable prototype showing how such rules can be applied efficiently and effectively within an existing program development environment.

The outcomes of this initial one-year study will engender larger-scale collaborative research between NICTA and QUT on automatic dataflow analysis of program code and tool-supported design of security-critical software. It will also allow us to retain the services of Early Career Researcher Dr Erica Mealy.
Finally, given the broad nature of the research topic there is ample scope to attract new Higher Degree Research students to conduct follow on work in this area. Suitable students could come from either QUT or UNSW.
Royal Melbourne Institute of Technology
Modelling human behaviour in transportation simulation for disaster management

Description:

Project Title: Modelling human behaviour in transportation simulation for disaster management
Research Group Association: Optimisation Research Group, NICTA
University Group Association(s): RMIT University, College of Science, Engineering and Health, School of Computer Science and Information Technology, Intelligent Agents group.

Project Description:
Understanding the effect of human behaviour is an essential aspect of understanding any complex system. Substantial work is being done at NICTA regarding optimisation of various aspects of disaster management. However, it is essential to understand how such constraints might interact with expected or possible human behaviour. To better understand this we can use simulation which integrates constraint optimisation and agent based modelling. A crucial component of this is how to adequately model human behaviour. Existing agent based modelling techniques tend to be too simplistic for this purpose.
This project will take the concrete focus of modelling human behaviour in a disaster situation, with a focus on transport related behaviour, where we will plan to extend and integrate with MATSim, a state of the art transportation simulator which is very efficient and models well a lot of traffic behaviour. Work is underway at RMIT to interface systems with better human modelling to this platform. We will explore and develop representations and a methodology for developing these in consultation with domain experts.

Project Duration: 1 January 2015 to 31 December 2015. (Funding for the student scholarship will be provided for the term of the student candidature up to a maximum of 3.5 years.)

Benefits: We will develop leading edge technology in the representation of human behaviour in simulation systems. The RMIT agents group is already at the forefront of this area. Integrating this with the high impact NICTA project on Disaster Management, a key area both nationally and internationally, will enable both leading edge research and high impact. In the longer term this could be one aspect of a centre of excellence in Disaster Management technology.
The involvement of NICTA and RMIT postdoctoral researchers, as well as PhD students, will ensure that Australia's capacity in this area is increased. As this is an essential component of any simulation that needs to represent human behaviour, these skills are widely needed.
ARC linkage and discovery grants that relate to this project will be sought, and as a result some commercialisation may result. The aim is to develop tools and methodologies that can be widely used by policy and planning bodies within the sector, to allow scientific analysis of potential options and approaches. These could be commercialised if a suitable partner was interested, but they could also be made freely available as open source software, for widespread use.
Data Analytics over Social and Spatial Data

Description:

Project Title: Data Analytics over Social and Spatial Data
Research Group Association: Machine Learning Research Group, NICTA
University Group Association(s): RMIT University, College of Science, Engineering and Health, School of Computer Science and Information Technology.

Project Description:
Big data is a new Computer Science paradigm that is changing the way of solving complex problems or boosting the economy. Global organizations – including governments, industry, and academia – are working towards “unlocking” the potential that underlies Big data. We are focusing on developing technologies and infrastructure platforms to tackle Big data challenges related non-conventional data, in particular social and spatial data.

Sub-Projects Description:

Social Data Analytics
Our work in this area focuses on the need for new data management and query language frameworks that address limitations of existing systems for managing and analyzing big social data repositories. In addition we explore the use of semantic data technologies towards large scale integration of social network data. Innovative research is ranging from data modelling aspects to graph representation and analysis of social data.

Spatial Data Analytics
A key challenge in the research community is how to integrate structured and unstructured information to improve the quality of web search. In our work, we propose new approaches to spatio-textual search. In particular, we combine state-of-the-art research from two domains: spatial keyword search in databases, and ad-hoc search in Information Retrieval to improve the quality of search results. Moreover, we study indexing techniques that allow the efficient search and retrievals of spatio-textual objects.

Project Duration: From 3 March 2014 to 30 June 2016.

Benefits:
With the popularization of geo-tagging an increasing number of applications, in particular in the area of social networks, have flourished providing location-based services with some primitive form of keyword search. In this context, this project will explore novel spatial-keyword queries that are widely applicable in such web-based systems. Hence, the expected benefits include:

- Advancing our state of knowledge on the grand challenge of integrating heterogeneous structured and unstructured data repositories for efficient data analytics. With four strong PhD projects in the above area, the proposed work will increase the availability within Australia of world-class ICT research skills by providing postgraduate training of a high calibre.
• Establishing a strong research team at RMIT in this area. The senior researchers involved have both a strong background on database management and information retrieval; bringing these two worlds together is an important first step to solving more difficult cross-over problems that have plagued the database and information retrieval community for decades. We expect to develop world class ICT research capabilities in existing and emerging fields in Australia, including social and spatial data analytics and the integration of structured and unstructured data.

• A significant number of publications in international journals and conferences will allow for the dissemination of our results to the research community. We are confident that our work will have significant impact on the field of social and spatial data analytics, opening up new research opportunities for combining structured and unstructured information.

• There will also be significant academic benefit from the project. By researching the emerging topic of social and spatial data analytics, this project will further boost the international standing of the RMIT and NICTA research groups, thereby enhancing the reputation of Australian research.
The 3T-HEALTH Project Framework

**Description:**

**Project Title:** The 3T-HEALTH Project Framework  
**Research Group Association:** Machine Learning Research Group, NICTA  
**University Group Association(s):** RMIT University, College of Science, Engineering and Health, School of Electrical and Computer Engineering.

**Project Description:**
The penetration of evolutionary research and development in the health science field for human well-being has been observed over the past several years. The ever evolving information and communications technology (ICT) together with data analytics and signal processing techniques have been the core drivers of such penetration which have overflowed from its respective originating domains to the health science domain. In this context the 3T-HEALTH project provides a core framework for amassing various health related research activities that cognate as Technology, Techniques and Transfer, termed as “the three T’s” (3T). We further describe the three T’s below.

**Sub-Projects Description:**

**T1: Technology in Health**
The ‘technology in health (T1)’ category manifests research efforts related to the development of ICT related technologies and infrastructures in both telecommunications and computing for health and human well-being.

**T2: Techniques in Health**
The ‘techniques in health (T2)’ category manifests research efforts related to the development of biometric data analytical techniques for health and human well-being. The biometric data that we refer to here is broadly defined as (i) biometric information data and (ii) biometric signal data. The biometric information data related research and analyses leads bio-telematics type of research and the biometric signal data related research is about developing novel analytical and processing techniques using realtime and historical bio-sensory level signals (e.g. neural signals) in order to develop prosthetic devices. The analysis and processing of such data concentrates from various fields of research such as data analytics in computer science, signal processing in electrical engineering, together with statistical learning and fundamental information theories.

**T3: Transfer in Health**
The transfer in health (T3) category manifests the development efforts related to the transfer of the research outcomes from T1 and T2 into the health domain. In general all of the research activities in T1 and T2 are expected to be part of T3 in the form of ‘tangible transfers’ or ‘knowledge based transfers’.

**Project Duration:** From 1 July 2011 to 30 June 2016.

**Benefits:**
Machine Learning for Intelligence Networks and Signal Processing for Humour Detection

Description:

Project Title: Machine Learning for Intelligence Networks and Signal Processing for Humour Detection
Research Group Association: Machine Learning Research Group, NICTA
University Group Association(s): RMIT University, College of Science, Engineering and Health, School of Computer Science and Information Technology.

Project Description:
Developing algorithms and techniques for improved performance is the key for improving the current technologies in communications signal processing and control systems engineering. In this project we broadly cover three major research areas and activities as described below with a common notion of developing sophisticated algorithms and application specific techniques. The three major research areas covered here are (1) cognitive radios for next generation wireless communications, (2) signal processing for advanced image recognition, and (3) intelligent control systems for power converters. The research activities under these broader areas are described further below.

Sub-Projects Description:
The evolution in wireless communications has impacted many technological advances not only in the field of telecommunications and broadband delivery but in various fields such as health, remote monitoring and transport. In this collaborative research project we investigate advanced wireless solutions and techniques for mobile, short/long range wireless communications for various emerging applications with the objectives of delivering high speed communications with optimized usage of the radio resources such as the radio spectrum and the energy consumption. The radio spectrum is a very scarce resource which had become very crowded with the number emerging applications and services that uses the spectrum. Therefore it is eminent that the current usage of the spectrum has to be optimized to obtain a close to 100% spectral efficiency and accommodate the emerging wireless applications and services. The most prominent way to improve the spectral efficiency is to perform dynamic spectrum access with the use of reconfigurable radios leading to the concept of cognitive radio networks. The idea of cognitive radio enables to bring intelligence at the radio level using statistical machine learning techniques to intelligently adopt itself to suit the radio environment in order to maximize the efficiency of the spectrum access.

Once the intelligence is present within the radio it can be then used to improve the energy efficiency of the overall communication system/network, leading to the concept of energy efficient communications or green communications. The energy consumption of both battery operated hand held devices as well as none battery operated devices can reduce their energy consumption by optimally adopting its transmission power by knowing the radio environment.

In this project we consider investigating cognitive radios for both dynamic spectrum access for improved spectral efficiency as well as green communications for improved energy efficiency. Research activities:
1.1.-Machine Learning for Network Resource Allocation: In this research activity some of the most crucial aspects of cognitive radio technology are investigated such as spectrum sensing, secondary user access and reinforcement learning for dynamic spectrum access. Advanced method for intelligently and dynamically accessing the spectrum using reinforcement and game theoretic strategies are investigated.

1.2.-Machine Learning for Improving Energy Efficiency in Networks: In this research activity the intelligence from cognitive radio is utilized to perform energy efficient transmissions and access for short/long range wireless communications. The energy consumption due to transmissions considering the random nature of the wireless channels is optimized to achieve a pre-defined quality of service by means of learning the radio environment. The learning strategies and the corresponding adaptation strategies are investigated here to minimize the energy consumption.

2.-Signal Processing for Scene, Affect and Humour Recognition in Images
The project will address the problem of associating pictures with aesthetics and emotions that they arouse in humans. Given the enormous sizes of many Web-based image repositories, image semantics simply describing the scene can no longer be the sole criterion for image search and organization. Many image hosting and sharing Web sites have expressed the need for introducing some form of categorization that reflects image aesthetic, appeal, emotion or feeling.

Project Duration: From 16 July 2012 to 30 June 2016.

Benefits:
- The outcomes of the Machine Learning for Network Resource Allocation research will enable us to utilize the scarce radio spectrum efficiently without wireless technologies interfering between each other. This is quite crucial given that more and more applications, services and technologies are evolving in the wireless domain and crowding the limited spectrum that we have access to.
- The Machine Learning for Improving Energy Efficiency in Networks research will enable us to reduce the carbon footprint in the environment by reducing the energy consumption in wireless communications. The techniques developed will enable wireless devices to operate at the required quality of service levels whilst consuming minimum energy.
- The Signal Processing for Scene, Affect and Humour Recognition in Images project will research an automated system that can provide feedback about aesthetics or quality based on learned rules. In particular, it will be determined how particular image semantics are correlated with an affect inferred in viewers.
Swinburne University of Technology
Victoria Software Systems

Description:
Project Title: NICTA Victoria Software Systems
Research Group Association: SSRG
University Group Association(s): Swinburne University of Technology co-ordinating, other Victorian Universities on per-project basis

Project Description:

A NICTA Victoria Software Systems initiative will focus on applied Research & Development with predominantly Victorian ICT companies and/or innovative Victorian ICT users. It will draw on Software Systems research expertise of Victorian Universities and NICTA personnel to make a significant impact on industry partner innovation and R&D solutions to challenging Software Systems problems. Expected research expertise is likely to include software engineering, mobile and cloud computing, information visualisation, software security, and HCI. It is likely to include significant collaboration with optimization and data analytics research and R&D in Victoria and other states.

All projects will have one (or more) industry partners contributing cash and in-kind, NICTA R&D Engineers funded under this CRP, one or more Victorian University academic staff contributed cash / in-kind, NICTA researcher(s) contributed in-kind, and some will have student R&D project team members, some paid by a mix of University, NICTA and industry cash. Projects may vary in duration from a few months to multi-year, depending on need. Projects may vary in size form a few thousand dollars to potentially over one hundred thousand dollars, depending on need and likely impact of the R&D.

The initiative will include the formation of a SUT / NICTA Software Engineering and Innovation (SEI) lab at Swinburne University of Technology to lead and co-ordinate the initiative, and to complement other Victorian NICTA/University labs and SUT's existing applied R&D efforts. SUT will match NICTA and industry funding coming to the lab via redirection of existing funding initiatives to better align them to Swinburne and NICTA’s vision for ICT impact in Victoria. Other Victorian Universities will be invited to participate on a per-project basis. Projects will be scoped to include industry, NICTA and University cash and in-kind contributions. Applied R&D will be the over-arching focus of projects, to compliment other basic research and technology transfer initiatives and funding.

Funding from the three sources (industry, NICTA, Universities) will focus on supporting project administration and management, R&D Engineering capability, industry-focused PhD, Masters, Honours, and student team projects, student-staffed R&D company, student-staffed ICT Accelerator project, researcher time on R&D projects, and researcher benefit in third stream income sources.
**Project Duration:** 1 May 2014 – 31 Dec 2015 (TBC)

**Benefits:**

The initiative will focus on delivering high value and impact to Victorian ICT companies and/or innovative users of ICT by running R&D projects drawing primarily on our Victorian software systems research expertise. Projects will require a mix of industry, NICTA and University funding as well as in-kind contributions. R&D undertaken will include technology exploration, development of demonstrators and proof-of-concept platforms, comparative analysis of technology solutions, review and advice on processes, architectures, knowledge management and technology organisational aspects, and feedback of industry needs to Victorian (and wider) University and NICTA researchers.

A key aim is to demonstrate tangible impact and benefit of software systems research by solving challenging industry ICT R&D problems by leveraging University, NICTA and industry expertise in partnership. A key benefit will be that a wider range of researchers will be connected with industry end users and industry end users will be able to influence research (and teaching) of software systems within Victorian Universities. A further benefit will be significant exposure of ICT students to industry R&D project work.
Dynamic scene understanding with applications to traffic monitoring

Description:
Project Title: Dynamic scene understanding with applications to traffic monitoring
Research Group Association: Computer Vision
University Group Association(s): University of Adelaide, Faculty of Engineering, Computer and Mathematical Sciences, School of Computer Science

Project Description: Image and video understanding is effortless and instantaneous for humans but remains a fundamental challenge for machine vision. This project aims to investigate dynamic scene understanding from video. For individual tasks like object recognition/detection, segmentation and tracking, recent progress has been made in improving the scale at which these individual Computer Vision algorithms can be applied.

We want to solve the problem of how to systematically integrate all these vision algorithms for better understanding of dynamic scenes. The problem of scene understanding involves simultaneously solving several sub-tasks including object detection, recognition, segmentation, and 3D reconstruction. Successfully completing these tasks will enable us to interpret the objects of interest within a scene and their spatial extent or 3D layout. Algorithms that capture the correlation among these sub-tasks are desirable, which are likely to provide improved results.

A key aspect of the dynamic scene is its temporal dimension and we would like to study the spatio-temporal models of moving objects, and to reason a variety of object properties based on a principled framework, such as structured probabilistic models. This project is also interested in developing algorithms that are able to detect and recognize activities/events in video. For example, it will be extremely useful in traffic monitoring if we can reliably detect events such as pedestrian/vehicle crossing red lights.

A direct application is to detect and recognize all the objects of interest in street view video, from road signs and cars, to particular iconic buildings. This type of information is extremely helpful to help visually impaired persons to navigate around in outdoor environments.

This project is also aiming to develop a practical road-traffic monitoring system, as an application of the dynamic scene understanding technique. Current techniques for monitoring rely on sensors which have limited capabilities, are inflexible and usually both costly and disruptive to install. The use of video cameras coupled with the Computer Vision techniques developed in this project offers an attractive alternative to current solutions. Intelligent capabilities like real-time detection and tracking of cars and pedestrians, recognition of traffic signs and car license plates, traffic counting and congestion prediction will be made possible.

Project Duration: 1 September 2012 to 30 September 2015. Previously signed CRP covers 1 September 2012 to 31 August 2013. This CRP covers 1 September 2013 to 30 September 2015.

Benefits (ref: clause 4.8): This project will develop first class ICT research in Australia, and its applications are aimed to facilitate commercialisation of research for national benefit through the Infrastructure, Transport and Logistics business area.
Assessment and OS-Level Mitigation of Timing Channels

**Description:**

**Project Title:** Assessment and OS-Level Mitigation of Timing Channels  
**Research Group Association:** Software Systems Research Group  
**University Group Association(s):** The University of Adelaide, School of Computer Science

**Project Description:** The project will survey micro-architectural time-based covert channels and side channels on modern architectures. It will survey existing exploits and mitigation strategies, and attempt to quantify them. It will design, and implement minimal, low-overhead mechanisms for the seL4 microkernel that allow mitigation of those channels, and will analyse their effectiveness, in close collaboration with existing SSRG activities on covert information flow.

**Project Duration:** 15/07/2014 – 14/07/2015

**Benefits** (ref: clause 4.8): The project aims at strengthening Australian cyber security research capabilities by combining the existing activities at The University of Adelaide with those of NICTA’s Trustworthy Systems team. It will strengthen the existing Defence linkages of both teams and help expand the commercial applicability of NICTA’s verified seL4 microkernel.
University of Canberra
Health Living Lab

**Description:**

**Project Title:** Health Living Lab  
**Research Group Association:** Machine Learning RG  
**University Group Association(s):** University of Canberra, Faculty of Health and Faculty of Information Sciences and Engineering

**Project Description:**  
Project as described in Schedule 4, item 4, “Project”  
The Project will establish the eHealth Living Lab at the Premises. The Project includes the development and fit-out of a demonstration space of 36 sqm including telehealth installations (Facilities). The eHealth Living Lab will enable the parties to:  
i) use data and clinical expertise to develop ML + other tools for demonstration of technology in health care setting;  
ii) develop deep engagement with healthcare ecosystem, by facilitating engagement between cluster- and member- organisations;  
iii) build links into research and commercial health care system;  
iv) develop new collaborative projects which may involve either or both of the parties and eHealth Tech Cluster Members.

**Project Duration:**  
Duration as described in Schedule 1, 3, “Term”

**Benefits**

As described in Attachment A, 1.2 “Background Principles”

The National e-Health Living Laboratory is a user-driven open innovation system based on a partnership between industry, citizens, health professionals and government. It enables users to take an active part in the research, development and innovation process to leverage best practice from across Australia to improve national health outcomes through broadband-enabled sites. The objective of the National e-Health Living Lab is to develop a research training environment that integrates electronic health systems and networked education. The living lab will link with several Australian research centres as well as international agencies. The laboratory lead node will be at the University of Canberra, in the new planned Clinical Teaching Building as part of the Health Innovation Precinct. The lab is supported by more than 28 partner organizations including research organizations, consumer health groups, industry groups, health service providers, health technology businesses and ICT vendors. The major benefits of the laboratory include

- Improved workforce productivity and workforce training  
- Catalysis of advanced research in eHealth  
- Platform to drive community engagement in eHealth Research  
- Engagement of small-to-medium enterprises and Health Care providers in eHealth innovation
University of Melbourne
Description:

Project Title: Big data analytics for complex data streams in road traffic management

Research Group Association: Machine Learning Research Group

University Group Association(s): University of Melbourne, School of Engineering, Department of Computing and Information Systems

Project Description:

Our focus in this CRP is to develop data analytics techniques to support spatio-temporal queries in complex road traffic data streams, such as when the data stream is a sequence of time-evolving networks. Networks or graphs provide a natural representation for many types of practical road traffic networks. With the growing volume of data available from such networks, there has been increasing research interest into data mining techniques for analysing networks or graphs. A major focus of graph mining research has been to analyse a static snapshot of the network topology, in order to extract general properties of the topology graph, or to find frequent subgraphs within the graph. However, in many practical applications the underlying networks are not static, but are continuously evolving, such as the traffic congestion patterns in road networks. In this project, we address the challenge of how to support queries for spatio-temporal patterns in complex traffic data streams, such as evolving networks of traffic congestion.

As background, NICTA’s Infrastructure and Transport Logistics Business Team and the Machine Learning Research Group have been working to define a set of collaborative projects with road traffic authorities such as VicRoads, including a project with a focus on predicting the impact of unplanned road incidents. In collaboration with this activity, Rao Kotagiri, James Bailey and Chris Leckie at the University of Melbourne have been analysing road traffic data from the VicRoads SCATS system to develop data mining techniques for modelling evolving road network traffic patterns. This activity will provide an application focus for this CRP on big data analytics for complex traffic data streams.

The project will comprise three stages: (1) graph mining algorithms to detect the impact of known events at key locations; (2) efficient indexing and query processing to support more general spatio-temporal queries on complex data streams; (3) query processing and visualisation techniques that can cope with uncertainty.

Stage 1 – Graph mining algorithms to detect the impact of known events at key locations

The aim of the first stage of the project is to predict the impact on road traffic of special events at well-known locations.

For example

- **Well-known location** = sports ground like MCG or Etihad stadium
- **Recurring special event** = AFL matches
- **Predict impact** = what are the road segments that are likely to experience abnormally high congestion
- **Timing of when prediction is made:**
  - In advance of the event – to predict road impact based on features such as the time of day and day of week of the sports event, size of expected crowd
o While the event is unfolding – to detect if road impact is changing in an unexpected way, e.g., is there a secondary congestion problem such as a car breakdown that might otherwise be masked by the congestion due to the sports event

Our approach will be based on analysing a time series of congestion graphs, where we will extract SCATS congestion data for each road segment within a region surrounding the event location of interest. At regular time intervals before, during and after the event of interest, we will construct a network of abnormally congested road segments. We will build on the method in Liu et al [1] for detecting abnormally congested road segments, and will investigate how these unusually congested road segments can be aggregated using methods for modelling evolving networks (e.g., Chan et al. [2]).

We will evaluate our prediction methods on examples of related events at a given location of interest that occur later in the SCATS dataset. We will also examine different approaches to interpreting and visualising the acquired model of low congestion unfolds.

Possible future extensions:
- Can we learn how multiple events interact?
  e.g., events at multiple venues in the same precinct (such as MCG and Rod Laver Arena), taking into consideration their physical separation, the size of each event, and the relative timing of each event.
- Can we learn a model that can generalise to different locations rather than a single location?
  e.g., a model that can be applied to any major intersection in the CBD.
- Can we learn from predictable events to help understand unpredictable events?

Stage 2 – Efficient indexing and query processing for more general spatio-temporal queries

The aim of the second stage of the project is to develop generalised database services that can index high volume road traffic data streams that comprise a range of different data types, and support more general spatio-temporal query processing on these data streams. In particular, we cannot afford to keep a complete history of all data streams in main memory. Hence, we need to develop sampling and compression techniques to support queries on different spatial and temporal scales on historical data. We will also develop services that support distributed database services, e.g., where different parts or layers of the road traffic graph are maintained in different servers in a cloud environment.

Stage 3 – Query processing and visualisation techniques that can cope with uncertainty

The aim of the third stage of the project is to develop generalised highly distributed database services that can provide robust predictions when only a subset of the desired traffic data is available or is inherently uncertain. In particular, we will investigate data stream indexing and distributed query satisfaction techniques that propagate the provenance of data through the query satisfaction process, so that if some data is later found to be erroneous, we can adjust the inferred conclusions. In addition, we will develop consistent visualisation methods so that domain experts can inspect and interpret query results and their associated uncertainty.

Project Duration: 1/7/2013 – 30/6/2016

Benefits:

- Predict the area affected by an event ahead of time, so that appropriate diversions or warning can be put in place. This can potentially reduce the impact of the event on traffic delays.
- Develop scalable and flexible distributed database services that can be used in a variety of road traffic management functions involving large data streams.
**NICTA Victoria Deputy Director and Education Director**

**Description:**

**Project Title:** NICTA Victoria Deputy Director and Education Director  
**Research Group Association:** NICTA Operations  
**University Group Association(s):** University of Melbourne, School of Engineering, Department of Computing and Information Systems

**Project Description:** In order to ensure a productive partnership between NICTA, participating Victorian universities and the Victorian State Government, there is a need for guidance and supervision of the activities within the NICTA Victoria Research Laboratory from a State-wide perspective. This includes two roles covered by this CRP: the Deputy Laboratory Director and the Associate Director of Education.

The role of the Deputy Laboratory Director is to facilitate engagement between NICTA and the Victorian university partners, especially through consultation between the NICTA CEO, relevant NICTA Research Group and Business Team Leaders, and appropriate Deans or their delegates from Victorian partner universities.

The role of the Associate Director of Education is primarily to supervise the allocation of the NICTA scholarship funds in Victoria in accordance with the research priorities of NICTA and the Victorian partner universities, and the performance targets specified by the Victorian state government. Following the Victoria laboratory restructure, this separate role will not be required from 2014 onwards.

**Project Duration:** 1 January 2012 – 30 June 2015

**Benefits:** To assist all parties involved to achieve the strategic goals of NICTA in Victoria.
Future Grid

**Description:**

**Project Title:** Future Grid

**Research Group Association:** Control and Signal Processing Research Group

**University Group Association(s):** University of Melbourne, School of Engineering, Department of Electrical and Electronic Engineering.

**Project Description:**

The electricity sector internationally and in Australia in particular is undergoing a transformation not seen since the early 1930’s. Social and political imperatives have necessitated a global push for reduction in greenhouse gas emissions, which may be achieved by replacing a sizable portion of fossil fuel-based sources of energy with renewable energy sources, such as solar and wind. If the transformation is to be managed smoothly and seamlessly, a few significant technical challenges must be overcome in terms of integration of renewables and their control. The challenges stem from the fact that solar and wind are intermittent sources of energy, as they are weather dependent, and are basically connected to sub-transmission or distribution systems. In this respect, the higher the penetration levels the more acute the technical challenges will become.

The Future Grid project has had a long standing association with the power industry and an excellent appreciation of the technical problems and challenges future power grids will present. In this project, we will explore the technical and practical challenges to help power industry to address problems associated with integration and control of renewable and embedded sources of energy and the impact on voltage levels. We will investigate the optimal utilisation of assets, infrastructure condition monitoring (using sensor networks for example for data acquisition) and placement and control devices.

**Project Duration:** 1 July 2013 – 30 June 2015.

**Benefits:** Work undertaken within the Control and Signal Processing research group will draw on the established research strengths of NICTA and the University of Melbourne. Activities will be focused on applications in areas of national interest such as the electricity sector. NICTA has extensive experience in dynamic fault detection, fault level monitoring, demand side technologies, stability analysis, device and network modelling, smart meters data mining and electricity pricing. Our expertise will help design a future electricity supply system that is generated from the most efficient low impact energy sources using and most effective technology possible.

Students within the activity will work in teams on real world problems with collaborative partners from outside the university system, resulting in graduates who are industry ready. There is a recognised shortage of power system engineers and related skills both in Australia and worldwide.
Constraint programming platform: solving technology

Description:
Project Title: Constraint programming platform: solving technology
Research Group Association: Optimisation Research Group
University Group Association(s): University of Melbourne, School of Engineering, Department of Computing and Information Systems.

Project Description:
The goal of the platform project is to build an optimisation platform that will dramatically simplify the solving of this new generation of complex optimisation applications by supporting rapid prototyping, deep solver hybridisation, data-intensive optimisation, and decision-making under uncertainty. In particular, the platform project will address the following challenges:

- The design and implementation of efficient, highly parallel, optimisation solvers that integrate constraint programming, mixed integer programming, mixed nonlinear programming, local search, dynamic programming, and data-intensive optimisation.
- Developing a suite of optimisation libraries that will serve as the backends for dedicated modeling and programming languages and will give unparalleled control to optimisation developers. A fundamental effort will be devoted to making the kernel of these libraries as small and extensible as possible.
- Critical research to support the solvers in: explanation of solving, hybridisation of solving technologies, data-intensive optimisation, large-scale parallelisation of solving, and generic approaches to stochastic optimisation.

Project Duration: 1 Jan 2012 to 30 June 2016.

Benefits
The CRP will help build NICTA’s and the University of Melbourne’s reputation in complex combinatorial optimisation. The research outcomes will feed directly into the constraint optimisation technology being developed in ORG in the Platform project, helping maintain the world leading status of our optimisation technology.
BiomRKRS: A Biomarker Retrieval and Knowledge Reasoning System

Description:

Project Title: BiomRKRS: A Biomarker Retrieval and Knowledge Reasoning System
University Group Association(s): The University of Melbourne, Faculty of Medicine, Dentistry and Health Sciences, Melbourne Medical School, Health and Biomedical Informatics.

Project Description: The need for a system to effectively manage and retrieve biomarker information has become apparent to medical and biomedical scientists, as evidenced by the recent development of a number of biomarker information systems. To address limitations in existing systems, we will develop a new system we call BiomRKRS: A Biomarker Retrieval and Knowledge Reasoning System. BiomRKRS will build on existing ontologies in the biomedical domain to create a core, integrated ontology for biomarkers as a standard vocabulary set for data storage and retrieval. When fully implemented, BiomRKRS will have functionality and utility that will far exceed that of related existing systems due to the incorporation of a knowledge reasoning system that will make logical and useful inferences in the process of semantically processing end-user queries.

Project Duration: 22 April 2013 until 21 April 2015.

Benefits:
This project will target the development of ICT technologies, specifically knowledge management and information systems, that facilitate improved biomedical research. The collaboration will enable us to contribute significantly to foundational research in semantic inference, information retrieval, and biomedical text mining while simultaneously enabling the development of practical systems that will assist clinical researchers in accessing the latest information relevant to their work. This in turn will result in improved efficiencies to the overall biomedical research endeavour.
Learning Analytics related to MOOCs

Description:
Project Title: Learning Analytics related to MOOCs, with a particular focus on Discrete Optimisation
Research Group Association: Optimisation Research Group
University Group Association(s): University of Melbourne, Melbourne Students and Learning (previously Office of the Provost), Learning Environments Team.

Project Description: The recent interest in MOOCs both from an institution and student perspective has created a new opportunity for understanding how people learn online. The amount of data collected regarding student behaviour in MOOCs is unprecedented in online education but, due to the novelty of MOOCs, it is unclear how to analyse this data. Both an incredible level of detail and noise in raw MOOC data present significant barriers to developing insightful and actionable analytics.

The goal of this research project is to bring together interdisciplinary researchers to develop novel learning analytics on MOOC data. Ideally the project will result in methodologies for filtering and summarising MOOC data, which are informed by state-of-the-art methods in ICT, psychology, and eLearning. The ultimate goal of this work is to provide novel, peer-reviewed, learning analytic methodologies, which can be used by instructors and institutions to better understand student learning process in MOOCs, both live or post-hoc.

In the interest of better understanding the ICT learning process, the learning analytics will focus on the MOOC datasets produced by Pascal Van Hentenryck’s Discrete Optimisation class (and other ICT subject data as they are available), before being generalised to broader subject areas.

Project Duration: 1 September 2013 to 28 February 2014.

Benefits: As Australia’s first University to partner with one of the major MOOC platforms (eg Coursera, Udacity, Edx), the University of Melbourne leads the pack in developing MOOC offerings and collecting MOOC datasets. Furthermore, the University of Melbourne’s Learning Analytics Incubator provides a unique opportunity for interdisciplinary researchers to come together and conduct research on eLearning.

Partnering with the University of Melbourne for Learning Analytics research benefits both organisations. The University of Melbourne will be able to leverage NICTA’s noteworthy ICT expertise in data fusion and analysis. Meanwhile, NICTA will gain access to the domain expertise in Education and Psychology that are necessary for breakthroughs in Learning Analytics research.
Mechanism Design and Game Theory for Optimisation

Description:

Project Title: Mechanism Design and Game Theory for Optimisation.

Research Group Association: NICTA’s Optimisation Research Group

University Group Association(s): University of Melbourne, Faculty of Business and Economics, Melbourne Business School.

University of Melbourne, School of Engineering, Department of Computing and Information Systems.

Project Description: To develop a new class of interdependent games, motivated by applications in large-scale power restoration, humanitarian logistics and integrated supply chains, where different agents have individual utilities, but a social welfare objective must be optimised in a decentralised fashion. The idea is then to design bargaining mechanisms for the agents to interact in order to improve efficiency of the outcome while at the same time preserving their private information.

Another aspect of this project is to analyse the conditions for the existence of a pure Nash equilibrium for a class of two-player scheduling games, where each player’s utility depends on the other one, and then analyse how far away, in terms of efficiency, are those equilibria outcomes compared to the optimal social welfare.

The project will:

- Create a new game theoretic framework for complex problems involving multiple stakeholders that are required to do schedules which are interdependent
- Quantify the importance (or not) of governmental entities in the solution of complex and multi agent challenges such as power restoration after a disaster, via contract enforcement and by the imposition of specific bargaining rules between the stakeholders.

Project Duration: 1 January 2012 to 31 December 2014.

Benefits: The CRP will contribute a new body of work directly relevant to research currently undertaken by the Optimisation Research Group, particularly in disaster management. This will strengthen NICTA’s position as a key innovator in this area by the dissemination of the results in international conferences and peer-reviewed journals.

The funding of a PhD student will also contribute to the development of key ICT research skills in Australia and it will help to attract excellent international students in the future.
Systems Biology

**Description:**

**Project Title:** Systems Biology  
**Research Group Association:** NICTA’s Control and Signal Processing Research Group  
**University Group Association(s):** University of Melbourne, School of Engineering, Department of Electrical and Electronic Engineering

**Project Description:**

To maximise the translational opportunities in biomedical sciences arising from advances in platform technologies such as genomics, metabolomics and proteomics, computational approaches are required to organise, integrate and model these new data sets. Systems biology provides a quantitative and integrative approach with which to understand properties of molecular pathways and networks in relation to cell function. In relation to cancer, these computational technologies enable a new systems-focused approach to a wide variety of challenges associated with understanding the basic cell biology of cancers, the emergence of drug resistance, new therapeutic strategies and improved computational tools for cancer prognosis.

**Project Duration:** 1 February 2013 – 31 December 2015.

**Benefits:** The need for systems approaches in biology and life sciences is recognised across the University of Melbourne and Parkville Precinct, however there is currently a lack of expertise and investment in systems and computational biology in comparison with comparable North American and European universities and, increasingly, our Asian competitors (in particular in Singapore, Japan and China). The breadth and depth of life sciences research and clinical practice in Parkville presents a huge opportunity and demand for computational approaches in biomedicine. NICTA and the University of Melbourne are well positioned to respond to this demand, by forming collaborations and partnerships with life sciences researchers and clinicians across the University, Medical Research Institutes and Clinical centres in Parkville and in Melbourne.

Students within the activity will work in teams on real-world problems with collaborative partners from outside the university system, resulting in graduates who are industry-ready.
Computational Neuroscience

Description:
Project Title: Computational Neuroscience
Research Group Association: Control and Signal Processing
University Group Association(s): University of Melbourne, School of Engineering, Department of Electrical and Electronic Engineering

Project Description: The research goal is to develop mathematical frameworks to understand how neural systems work. This includes: modelling and analysis of learning in the brain; dynamic behaviour in healthy and diseased brains, vision and auditory signal processing; and, the application of control and signal processing tools to neuroimaging.


Benefits: Work undertaken within the Computational Neuroscience project will draw on the established research strengths in NICTA and the University of Melbourne. Activities will be focused on applications in areas of national interest such as prosthetic devices. The project will increase the availability within Australia of world-class ICT research skills including though postgraduate training and attracting international researchers.
Signals and Systems: Industrial Applications

**Description:**

**Project Title:** Signals and Systems: Industrial Applications  
**Research Group Association:** Control and Signal Processing  
**University Group Association(s):** University of Melbourne, School of Engineering, Department of Electrical and Electronic Engineering.

**Project Description:** The research goal is to develop mathematical frameworks for the design and analysis of decentralised estimation and control schemes suitable for very large scale distributed dynamical systems with network connected sensors and actuators. This includes urban transport systems, smart-grid power systems, urban and rural water distribution systems, Defence C4I systems, surveillance systems consisting of large swarms of possibly mobile sensors, and many other applications.

**Project Duration:** 1 January 2012 – 31 December 2014.

**Benefits:** Work undertaken within the Signals and Systems project will draw on the established research strengths in both NICTA and the University of Melbourne. Activities will be focused on applications in areas of national interest such as transport systems, smart-grid power systems, urban and rural water distribution systems and Defence systems. The project will increase the availability within Australia of world-class ICT research skills including though postgraduate training and attracting international researchers.
Diagnosis and Planning: Decentralised optimisation

**Description:**

**Project Title:** Diagnosis and Planning: Decentralised optimisation  
**Research Group Association:** Optimisation Research Group  
**University Group Association(s):** University of Melbourne, School of Engineering, Department of Computing and Information Systems  
**Project Description:** This project falls within the Diagnosis and Planning area of the Optimisation Research Group. It will develop decentralised optimisation solvers capable of handling distributed, fast changing entities, such as: distributed micro-power generation and distribution; emerging healthcare and age care solutions; and even office and retail workspaces of the future involving dynamically reconfigurable furniture and room layouts.

**Project Duration:** 1 Jan 2012 to 30 June 2015 (Funding for student scholarships will be provided for the term of the student candidature up to a maximum of 3.5 years.)

**Benefits**

**Novelty Applications:** The new Decentralised Optimisation techniques will facilitate new solver that can tackle
- Power: generation and distribution of power from multiple, decentralised energy sources
- Workspace: scheduling and planning of work places, critical in healthcare (hospital and age care) and office/retail spaces of the future

**Key Advantage:** Decentralised application requires new optimisation algorithms that can handle the uncertainty and non-determinism that inherently arises due to their distributed functional elements. Under these conditions it is impractical to use centralised optimisation due to the inability to have full control over entities, have complete information, or even delegate with certainty desired actions and outcomes over each and every entity. This project will facilitate the optimisation of multiple, decentralised operational units in the context of incomplete information in dynamic environments.

**New algorithms:** The project will undertake critical research that will result in new algorithms for optimising in the face of uncertainty, and will include new optimisation techniques that can accommodate the necessary decomposition methods required to admit solutions to decentralised problems. Algorithms will include:
- decomposition techniques for handling the complexity of multiple functional and control entities,  
- uncertainty compilation techniques to achieve tractability,  
- exploiting the synergy between mixed integer programming (MIP), constraint programming (CP) and Automated Planning, and  
- the scheduling of asynchronous and concurrent processes.

**National Benefit:** The CRP will help build NICTA’s and the University of Melbourne’s reputation in complex combinatorial optimisation. The research outcomes will work for a wider range of applications, within the Diagnosis and Planning area, and will also feed directly into work on the optimisation Platform project. Such work will help to maintain the world leading status of our optimisation technology.
University of New South Wales
Indexing and Analysis of Large Spatiotemporal Data Repositories

Description:
Project Title: Indexing and Analysis of Large Spatiotemporal Data Repositories
Research Group Association: Machine Learning
University Group Association(s): UNSW Database Research Group

Project Description: Spatiotemporal data sets are usually very large and may contain non-trivial correlation between among the data. This project will first investigate and improve on efficient database indexing support for large amount of spatiotemporal data, in which efficient primitives are key elements for fast data mining on these data sets. For example, effective spatial filters can restrict the search to neighborhood graphs. Based upon some efficient indices and spatiotemporal primitive operators, data mining methods for given water data sets will be benchmarked, compared, and hence improved.

Project Duration: June 2013 to May 2015

Benefits: Water is a critical resource of any country and reliable water supply is important to well developed countries such as Australia. However, water supply is still from time to time interrupted due to various issues, e.g., water pipe ageing, environmental factors. The proposed research will benefit and address the problem of forecasting when and where a critical water main will likely fail. In a water-main system, the status of a water pipe is dependent on the rest of the system within that region. The spatial and temporal correlation can be captured and modelled so as to improve failure prediction (where and when). For example, conditional random fields may be used to model the constraints among neighbouring water pipes within a local area. Furthermore, we aim to develop / optimise techniques for spatiotemporal data such as the water dataset obtained from Sydney Waters.

The benefits in improving the capacity (in terms of timeliness and accuracy) of predicting faulty water pipe network and hence water supply is directly economic to the nation in terms of minimizing the impact of affected businesses and residents, road floods etc.
Protecting User Privacy via Obfuscation

Description:

Project Title: Protecting User Privacy via Obfuscation
Research Group Association: Networks
University Group Association(s): School of Electrical Engineering and Telecommunications, University of New South Wales.

Project Description:

This project will investigate the use of obfuscation techniques to increase the privacy of user’s on-line activities. The first part of this project will develop techniques that allow users to participate in large-scale surveys/polls using their mobile device while maintaining privacy of their responses. The theoretical basis of this obfuscation lies in a technique called randomised response[1] that adds noise to user responses in order to preserve their anonymity while allowing statistically meaningful interpretation of the aggregate responses. This technique has recently been applied to estimate user density[2], and we are developing new extensions that are applicable to large-scale surveying. The second part of the project will extend these techniques more generally to online activities, ranging from online social networks (eg people indicating on OSNs if they like/dislike certain things) to recommendation systems.

It is expected that the outcomes of the first part will be useful in applications ranging from market surveys (eg to obtain statistics on customer purchasing habits without being able to identify any individual’s responses for targeted ads) to obtaining health statistics (eg government agencies can use it to detect an outbreak of influenza without obtaining statistically significant information on any particular individual's condition). The second phase will be contribute to NICTA’s projects on content distribution, for example, by enabling the ability to disseminate opinions/preferences to friends in an OSN while still protecting one’s privacy (from the OSN operator).


Project Duration: The NICTA project runs from January 2011 to December 2014. This CRP covers 1 January 2013 to 31 December 2014.

Benefits:

This project has the ability to develop significant ICT outcomes of national benefit. The tool being developed for privacy-preserving surveys can be used by government agencies for conducting large-scale studies related to healthcare and well-being. It has also commercial potential in market studies. The capabilities developed in this project related to privacy-preserving techniques will be world-leading and published/presented in the premier research venues, increasing our visibility and standing in the research community, and providing advanced training to our post-graduate students.
File System Synthesis (extended) (VARIATION)

**Description:**

**Project Title:** File System Synthesis (extended) (VARIATION)

**Research Group Association:** Software Systems Research Group

**University Group Association(s):** University of New South Wales, Faculty of Engineering, School of Computer Science and Engineering.

**Project Description:**

File systems are a core component of every operating system. They convert logical I/O operations (read/write) into device-driver commands for accessing physical media. File systems for rotating and solid state media (disks) need to carefully choose physical data locations in order to maximise I/O throughput. They therefore tend to be complex pieces of software, incorporating several abstraction layers, and have typically undergone years of manual optimisation.

File systems present a massive legacy issue for new system designs, such as the componentised system architecture envisioned in NICTA's Trustworthy Systems agenda. File systems must either be ported from other environments (such as Linux) or written from scratch. Either approach is expensive and prone to undermine trustworthiness due to bugs in the code.

Based on our experience with the synthesis of device drivers, we will investigate the automated synthesis of file-system code (and matching correctness proofs) from formal specifications. Specifically, a file system will be specified as an OS interface, an on-disk data structure, and a high-level behavioural description matching the two. The specifications will be expressed in domain-specific languages (DSLs) yet to be developed. The project will develop algorithms and tools for synthesising file-system code, and, at a later stage, correctness proofs.

**Project Duration:** Extension to pilot project, for three years 1 July 2012 until 30 June 2015.

**Benefits:**

Success of this project will be a huge step towards realising the microkernel vision of systems organised as mutually-protected servers, able to tolerate failure of individual components. The resulting file systems will also be usable in traditional systems (Linux or Windows) but the biggest benefit will be achieved in combination with the formally-verified seL4 kernel, if correctness proofs can be generated together with the file-system code.
Trustworthy Systems

**Description:**

**Project Title:** Trustworthy Systems  
**Research Group Association:** SSRG  
**University Group Association(s):** UNSW, CSE, Operating Systems

**Project Description:** The Trustworthy Systems project is developing technologies to construct complex embedded systems that have assured guarantees of their behaviour. More specifically, the project aims to further research and develop the technology surrounding the seL4 micro-kernel to enable it to become a foundation for trustworthy embedded systems. Areas of interest include: real-time behaviour, multicore, virtualisation, and component-based systems.

**Project Duration:** 1 Jan 2013 – 31 December 2014.

**Benefits:** Build on unique strengths developed over the last few years which have produced major commercial and scientific impact and made NICTA and UNSW widely recognised and respected in the systems area.
Blue Iris

Description:

Project Title: Blue Iris: Human Behaviour Recognition Through Multimodal Robotic Vision

Research Group Association: Software Systems Research Group

University Group Association(s): University of New South Wales, School of Computer Science & UNSW Art & Design

Project Description:

The aim of this project is to explore the autonomous interpretation of human behaviour and affective states during human-robot interaction (HRI). By analysing and incorporating information from different perception based sensors, such as two-dimensional vision, depth and thermal (infra-red) information, this project will explore the contribution of different sensors during the identification human behaviours and/or affective states.

Specific project objectives are: to improve human-robot interaction in a social context with the aid of multimodal vision sensors; to improve current algorithms for human behaviour/affect identification using visual sensors; to explore the contribution of multiple non-intrusive sensors—such as 2D vision, depth, infrared and stereoscopic vision—during the identification of human behaviours and affective states and to develop algorithms that integrate information from multiple sensors in order to improve the autonomous interpretation of human behaviour and affective states during social interaction.

Trustworthy Systems, Verification

Description:
Project Title: Trustworthy Systems, Verification
Research Group Association: Software Systems (SSRG)
University Group Association(s): UNSW, CSE

Project Description: The Trustworthy Systems project is developing technologies to construct complex embedded systems that have assured guarantees of their behaviour. More specifically, the project builds on the formally verified seL4 micro-kernel and investigates how to use this kernel to build and formally verify whole systems. Areas of interest on the formal verification side include static analysis, interactive theorem proving, concurrency, refinement, security/information flow, and whole-system assurance. This CRP is closely related to the Trustworthy Systems CRP in the Operating Systems area.

Project Duration: 3 years, commencing 1 November 2012

Benefits (ref: clause 4.8): The completed L4.verified project this work builds on has provided significant international recognition to both, UNSW and NICTA in the area of formal verification of low-level software. The present project builds on the past success, and adds further capabilities to the team by including further staff from both NICTA and UNSW. This will enable attacking more problems which are outside the capabilities of probably anyone elsewhere, and has a high likelihood to lead to more high-profile breakthroughs, with the obvious benefits to the reputation of both institutions as well as the individual researchers involved.
Computational Complexity of Resource Allocation Problems

**Description:**

**Project Title:** Computational Complexity of Resource Allocation Problems  
**Research Group Association:** Optimisation Research Group  
**University Group Association(s):** UNSW, CSE

**Project Description:** Resource allocation is a fundamental optimisation problem. How do we best divide limited resources between multiple parties? The problem has many dimensions. What do we mean by best? Fairest, greatest social utility, least envy, . . . What are we dividing? Divisible goods like time on the processor or indivisible goods like a set of machines? What mechanism are we using to do the division? For example, is the mechanism centralized or decentralized? Does this mechanism encourage or prevent strategic behaviour? Can it be manipulated? The goal of this project is to use the tools of game theory and computational complexity, especially of parameterized complexity, to study such resource allocation problems in more detail.

**Project Duration:** 2 August 2013 to 31 December 2014. A previous CRP covers the period 1 August 2012 to 1 August 2013.

**Benefits:**
The project will take advantage of Dr Serge Gasper's recent arrival at UNSW on a DECRA postdoctoral award to involve him in core research in the Optimisation research group. Serge is a promising early career researcher (as witnessed by his DECRA award) with a growing international reputation in computational complexity. This CRP will help to build the reputations of both UNSW and NICTA in parameterized complexity. Travel funds are therefore requested to support extended visits to NICTA/UNSW by Professor Mike Fellows and Dr Fran Rosamond (CDU), two of the leading scholars in the area, with the expectation of involving them more formally in later years (perhaps via enlarging this CRP). The research outcomes will feed into the applications being developed within the ORG. For example, they may in time contribute to the allocation of aid in Disaster Management or to the allocation of resources in Smart Grids.
UNSW Research Student Administration

**Description:**

**Project Title:** University of NSW NICTA Research Student Administration  
**NICTA Group Association:** Student Administration  
**University Group Association(s):** School of Computer Science and Engineering, UNSW

**Project Description:**
The position will manage, develop and implement the NICTA Research Training Enhancement and Scholarship Program at the University of NSW and will be the first point of contact for NICTA Management, Research Group Leaders and higher degree research students enrolled at the University of NSW. This will include dealing with applicants’ and students’ queries, liaising and coordinating with NICTA, the School of CSE, other schools and faculties, the University’s Graduate Research School and students in relation to scholarship opportunities, applications and acceptances of offers, providing administrative support for induction sessions, progress reviews, and exit interviews, requests for extensions and so on. The incumbent will administer the NICTA scholarships budget, including reporting expenditure and budget forecasting for future funding. The incumbent will maintain the NICTA student database for UNSW NICTA-enhanced students and provide quarterly reports to NICTA as well as the UNSW In-Kind report annually. High level initiative will be required in the running of student events such as attendance at internship fairs and co-ordinating the annual NICTA Summer Scholars Showcase, including applications, travel, accommodation and speakers.

**Project Duration:** 1 January 2015 to 30 June 2016

**Benefits** (ref: clause 4.8):
The role will support the national objectives for enhancing ICT in Australia by supporting the Education Strategy set down annually by the CEO and National University Liaison Officer. The three objectives underpinning the Education Strategy are to –

- To increase the quality and pool of students applying for NICTA scholarships  
- To improve student processes and the student experience  
- Outreach
Improving Authentication and Network Security with Privacy Preserving Voice Biometrics

**Description:**

**Project Title:** Improving Authentication and Network Security with Privacy Preserving Voice Biometrics  
**Research Group Association:** Networks Research Group  
**University Group Association(s):** School of Electrical Engineering, UNSW

**Project Description:**

In work in the previous CRP focussed on the use of coarse grain location information together one easily accessible biometric feature, namely speech to provide location based authentication. This work extends the scope of the previous CRP by investigating the privacy issues of using speech and location information for authentication.

With the increase in the number of students and the potential for privacy preserving network authentication, requires deeper collaboration with the Networks Research Group. To facilitate this, UNSW has agreed to jointly fund the appointment of post-doc, who will work closely with the NRG and Professor Ambikairajah’s group. This appointment will enable the leveraging of the speech/signal processing expertise of UNSW and the privacy preserving analytics of NICTA.

**Duration:** 17 November 2014 – 30 June 2016

**Benefits (ref: clause 4.8):**

This work will augment the proposed work with University of South Australia on location based authentication by using speech together with the wireless fingerprint of the location. This is a novel way of providing location based authentication. Prof. Ambikairajah, brings considerable experience in speech processing and signal processing in general. This combined with the system experience of Prof. Jha and the information theory expertise of Prof. Grant makes the project team truly complementary. Also, Prof. Ambikairajah will help with the recruitment of undergraduate and post graduate students for the project as well as NICTA overall.
Analysis of Mobile Phone Privacy Risks

**Description:**

**Project Title:** Analysis of Mobile Phone Privacy Risks  
**Research Group Association:** Networks  
**University Group Association(s):** Computer Science, UNSW

**Project Description:**

The research in security & privacy of smartphone applications has been both active and productive since the inception of app markets. A number of projects seeking to protect users’ privacy have developed privacy preserving and tools and privacy control applications (e.g. [1] [2] and [3]). These tools are designed to detect possible information leakage and notify users when potentially sensitive information is accessed by any installed application. Even though today, there is a lot of discussion in both research community and media about the increasing need for privacy preserving applications, control tools are not widely deployed. In this project, we aim to understand the main barriers towards the deployment of privacy control applications. The objective is to use crowd sourcing to capture users’ expectations.

The project will result in a novel methodology to capture users expectations using crowd sourcing. It will also identify key factors to the success/failure of the deployment of privacy-preserving applications. The findings of this project will provide new insights into privacy risks resulting from use of mobile apps.

http://appanalysis.org/tdroid10.pdf

[2] Peter Hornyack, Seungyeop Han, Jaeyeon Jung, Stuart Schechter, and David Wetherall, "These Aren't the Droids You're Looking For": Retrofitting Android to Protect Data from Imperious Applications, ACM CCS, October 2011  
http://appfence.org/ccs210-hornyack.pdf


**Project Duration:** August 2012 to July 2015

**Benefits:**

The increasing ubiquity of smart devices is creating tremendous opportunities to develop pervasive applications spanning both the public and commercial sectors: healthcare, energy management and social networking, for example. The project outcomes will lead to the development of robust and user-friendly privacy preserving solutions, which afford users of these services greater control over how their personal information is shared. The suite of algorithms and concepts developed herein will impact a wide-range of ubiquitous services that individuals will use on a day-to-day basis for years to come. This program will thus strengthen the
competitiveness of Australia’s ICT industry in this emerging multi-billion dollar global market. The entry cost for developing such solutions is fairly low. It is thus an ideal technology that local companies and startups can use to develop innovative privacy preserving services. The expected research results will be published in the premier research venues.
Autonomous Personal Indoor Localisation Using Smartphone Sensors

Description:

Project Title: Autonomous Personal Indoor Localisation Using Smartphone Sensors
Research Group Association: Networks
University Group Association(s): Computer Science and Engineering, UNSW

Project Description: Autonomous personal localization refers to the ability of the user to locate herself in a complex indoor environment with little or no interactions with external infrastructure. For next generation urban living, there is a growing need for such autonomous localization from both scalability and privacy points of view. For example, while a specific building or indoor complex could be instrumented with sophisticated sensors for pedestrian localization, it is (a) costly to provide personal localization on a global scale to every building of a city, and (b) difficult to guarantee the privacy of personal mobility data. This project aims at developing novel solutions for pedestrian localization that take advantage of the growing sophistication of smartphones to provide a scalable and an autonomous indoor pedestrian localization solution for any buildings in any city. In particular, it aims to make use of motion sensors (e.g., accelerometers, magnetometers, and gyroscopes) available in a modern smartphone to track user location within a building. The theoretical framework that allows such form of user tracking is called pedestrian dead reckoning or PDR [1], which allows one to keep track of the current position by estimating the displacement and heading from a known position using human step detection and step length estimation. However, with commercial-grade miniature sensors, PDR error is known to increase rapidly with distance travelled [2], which makes it difficult to use in large indoor complexes. We aim to control and reduce the PDR error using novel algorithms that detect user location on a map based on the activity of the user. We will develop novel solutions for human activity detection using smartphone sensors and use this to retrieve user location based on the activity location on a map. As part of this project, we will also investigate location-based content streaming solutions that are easy to personalize. The outcome will be pervasive autonomous pedestrian localization and its applications for next general urban living.


Project Duration: June 2012 – June 2015

Benefits: The project will develop new ICT capabilities with significant national benefits. The methods and algorithms developed for indoor localization can be used by both private and public sectors to facilitate location-based services, emergency navigation, and optimization of energy consumption. Indoor localization and tracking
is a matter of international significance as it concerns all major cities in the world. The proposed research is novel and will help Australian researchers to gain international visibility and attract top post-graduate students and researchers in this topical field of research.
Location-based Authentication in Wireless Networks

Description:
Project Title: Location-based Authentication in Wireless Networks
Research Group Association: Networks
University Group Association(s): CSE, UNSW

Project Description: In a rapidly growing Information Technology (IT) world, it is a necessity of users to communicate securely without the fear of interception or spoofing. Today's conventional authentication mechanisms are based on three factors: knowledge, possession and biometrics. Authentication of an identity must extend beyond conventional security layers: username-password, tokens like SIM cards, and, biometrics like fingerprints, iris scanning etc., to include location specific signatures that attest to the veracity of a user. These factors are prone to theft, hardware failure and are expensive. Consequently, there is a need for a stronger and reliable solution. One such solution is Location Based Authentication (LBA) that considers the location information of a user. The location information has a spatio-temporal linkage that is hard to steal. However, accuracy of the GPS, signal strength inside the building, makes it harder to deploy. Therefore, there is a need to address the alternatives. This project will develop tools and techniques for location based authentication for future wireless networks.

Project Duration: 1.07.2012 to 1.07.15

Benefits: This project has the ability to develop significant ICT outcomes in the national benefit. This need of secure and effective transmission of sensitive data is more stringent in sectors like military, aviation, wireless, healthcare, banking etc., and thus it is critical to determine the authenticity of a genuine user. A whole range of applications will benefit from a robust authentication mechanism. The capabilities developed in this project related to authentication techniques will be world-leading and published/presented in the premier research venues, increasing our visibility and standing in the research community, and providing advanced training to our postgraduate students.
Mapping the Brain: The Arcanum of Deep Brain Stimulation

**Description:**

**Project Title:** Mapping the Brain: The Arcanum of Deep Brain Stimulation  
**Research Group Association:** Implant Systems  
**University Group Association(s):** University of New South Wales, Faculty of Engineering, School of Electrical Engineering and Telecommunication

**Project Description:** The aim of this project is to gain insight on the mechanisms of deep brain stimulation (DBS). Although DBS is a successful treatment not only for Parkinson’s disease but a whole range of neurological pathologies, its mechanisms are still poorly understood. The first part of this project will consist in analysing recorded evoked compound action potentials (ECAPs) in order to prove feasibility of measurements and gain insight on the direct effect of stimulation on the brain target. Secondly, an experiment will be designed to map the brain’s response to DBS. This step will allow us weigh the two prevailing but colliding theories of a local vs. a system effect of DBS. Finally, a draft system providing feedback to conventional DBS will be designed.

**Project Duration:** 01.09.2012 – 31.08.2015

**Benefits** (ref: clause 4.8): Deep brain stimulation is an important therapeutic method that delivers positive results in patients who do not respond to medication or encounter lepodova-related motor problems. It is implanted in around 100,000 patients worldwide with new applications gaining approval each year. However, the system is very crude and works on an ON/OFF scheme. Understanding its mechanism will lead to the development of feedback-enabled systems that will increase both the efficacy and safety of these devices dramatically. A feedback-enabled DBS system will also enable further investigative research and help unravel the brain’s mechanisms.

The development of a feedback-enabled DBS system will be a significant improvement to the current system and such an advancement will certainly lead to commercialization opportunities. This work will also lead to opportunities to further enhance our ability to treat other brain-related conditions, improving the health and well-being of future Australians. Australia has a history of contributing to world-class biomedical research and this work will put us on the forefront of biomedical ICT research once again.

The program aims to explore the neural recording technology developed by NICTA Implant Systems in the application on Deep Brain Stimulation. It has the potential to not only help define the mechanisms of action but substantially improve the therapy. Achieving these goals will deliver significant ICT outcomes by providing significant clinical benefit for sufferers of diseases such as Parkinson’s and is potentially commercialisable.
Data-centric Groundwater Modelling

Description:
- Project Title: Data-Centric Groundwater Modelling (Variation)
- Research Group Association: Control and Signal Processing
- University Group Association(s): UNSW Civil and Environmental Engineering

Project Description: This cooperative research project feeds into a larger Data-Centric Groundwater Modelling project, which is a collaboration between NICTA and the NSW Office of Water and has been setup to address the significant uncertainty that exists in assessing the impacts of coal seam gas and large scale coal mining developments on groundwater resources. This larger project aims to bring together a combination of experts in hydrology and groundwater modelling with experts in statistical signal processing, machine learning and data fusion to develop principled data-centric and evidence-based groundwater models to support decision making processes that are capable of capturing the level of uncertainty that exists.

Within the context of the larger project, this CRP will:
- Explore the use of multiple point statistical (MPS) methods to characterise flow in heterogeneous aquifers and multi aquifer systems
- Develop inverse methods that integrate MPS methods to assimilate pressure head and other data
- Explore inverse methods based around sequential Bayesian updating (e.g. filtering) techniques in conjunction with MPS, and also with analytical Gaussian processes and variogram-based methods
- Investigate methods that substitute statistical dependencies, defined via stochastic partial differential equations, by learning more general spatio-temporal statistical models from flow simulations that use real physics and/or real data
- Provide an interface to other experts in the National Centre for Groundwater Research and Training and the wider academic community of statistical hydrogeology.

Project Duration: 2 years, 1st Jan 2013 to 31st Dec 2014.

Benefits: Groundwater resources are critical to Australia and must be managed appropriately to satisfy many competing users. It accounts for over 30% of the total water use, including for industrial, agricultural and domestic applications including drinking water for many cities, towns and individual farms. This CRP will develop world class ICT research capabilities and outcomes by combining leading expertise in machine learning and data fusion with statistical geology and hydrology. This will be performed with the goal of providing new modelling and decision making tools that may be subsequently commercialised.
Cross-layer security in wireless networks

Description:
Project Title: Cross-layer security in wireless networks
Research Group Association: Networks Research Group
University Group Association(s): University of New South Wales, Faculty of Engineering, School of Computer Science and Engineering

Project Description: The project will investigate the use of physical layer information from a wireless signal to improve security aspects of communication systems. For example, it is well known that the RSSI is a bad indicator for predicting the data rates in wireless LANs. In search of a reliable parameter to correctly predict the data rates, the past research has looked at the sub-carrier level and it was found that the SNR for each sub-carrier is also fluctuating. For that reason RSSI measurements are unreliable; they are the average SNR of all sub-carriers and thus biased towards the strongest sub-carrier. This implies that for perfectly flat links without frequency selective fading, RSSI should be a good indicator; but, in practice, this does not seem to be the case.

Therefore, effective SNR has been used as an alternative indicator with better reliability.

It has been shown that effective SNR is very stable across all subcarriers, and hence provides reliability to the overall observation. However, effective SNR is dependent on the modulation scheme, and so there will be a different effective SNR for each modulation scheme of WiFi.

In this research we will examine if parameters such as effective SNR can be used as the metric for location fingerprinting which would provide reliability not achieved by RSSI-based location fingerprinting techniques. As a proof-of-concept, one can wardrive and collect effective SNR (for all possible modulation schemes of WiFi) at a particular location. Using this training data, one can check if the reliable location information is provided during the online location estimation phase. We will also investigate if limited data collected in a wardrive can be interpolated using standard techniques, such as Kriging, used in geological modeling/remote sensing problems.

Project Duration: 1 July 2013 to 30 April 2015.

Benefits: This project has the ability to develop significant ICT outcomes for the national benefit. The need for secure and effective transmission of sensitive data is more stringent in sectors like military, aviation, wireless, healthcare and banking, and thus it is critical to determine the authenticity of a genuine user. A broad range of applications will benefit from a robust authentication mechanism. The capabilities developed in this project related to authentication techniques will be world-leading and published/presented in the premier research venues, increasing our visibility and standing in the research community, and providing advanced training to our post-graduate students.
Understanding the Accuracy of Traffic Estimation, Monitoring and Incident Detection through Wireless Vehicular Communications

Description:

Project Title: Understanding the Accuracy of Traffic Estimation, Monitoring and Incident Detection through Wireless Vehicular Communications

Business Team Association: Intelligent Transport and Logistics (ITL)

University Group Association: UNSW, Computer Science and Engineering, Civil Engineering

Project Description: The use of wireless communications in the context of intelligent traffic information systems has attracted increasing attention from transportation agencies, who are interested in understanding, for example, how the deployment of ITS infrastructure which communicates with cars over direct short-range communications (DSRC) can improve traffic control and incident detection. Most of the existing research in the vehicular communications space either tackles general questions of wireless performance in the outdoor road environment, such as physical-layer modelling of wireless channel characteristics, or focuses on protocol design around the requirements of safety applications or passenger infotainment. Thus, the existing research is centred mostly around the perspective of the equipment manufacturer, with a detailed focus on the wireless performance side and uses only simplified models to account for the application requirements and characteristics. Similar attention within the research community has not been given to the perspective of the traffic authority, which is not interested in the details of the wireless protocols but, rather, in better design of the traffic management application.

The aim of the project is to bridge this gap and create a better understanding of the utility of wireless vehicular communication to the accuracy of traffic monitoring.

In the proposed time frame, the focus of the project is expected to be predominantly on the metric of traffic estimation accuracy. This will create the basic understanding that will subsequently be necessary for any follow-up work on using wireless beacons for traffic control by the road agency (e.g. control of traffic lights, contraflows, or tolling), and ultimately to infrastructure-less setting where algorithms inside the vehicles themselves, rather than RSUs, estimate the traffic in their vicinity and assist drivers to make their own travel decisions by fusing overheard information from other vehicles. Accordingly, the simulation code will be designed and developed with an eye to allowing future extensions for feeding information gathered from the wireless beacons back to the traffic simulator, so as to allow the simulation and evaluation of wireless ITS-based traffic control policies and driver behaviour, and the impact of beaconing on actual traffic flows.

Project Duration: 1 January 2014 to 31 December 2014

Benefits: An important benefit of the project will be the development of tools to allow traffic models to incorporate information collected from wireless transmissions, and fuse them with the more traditional approaches from traffic flow theory. Code developed for the simulation framework will be useful for future research efforts, and can be released as NICTA open-source software for the use of other research
groups in this space (provided ongoing support and maintenance can be made available beyond the project term).

Dedicated short range communications will enhance the safety, efficiency and sustainability of road transport networks. Australia needs to develop research capabilities in this space to address the unique Australian road transport environment especially particular in the road freight domain. This project will help to establish Australia as a leader in combined wireless and road traffic simulation down to the physical layer.
Associate Director of Education

Description:

Project Title: Associate Director of Education, University of New South Wales
Research Group Association: University Engagement
University Group Association(s): Faculty of Engineering, University of New South Wales

Project Description:
The role of Associate Director of Education oversees scholarship and student-related activities relevant to NICTA supported PhD students at the University of New South Wales. The following summarises the main responsibilities:
1) Act as Chair of the Scholarships Selection Committee, which meets a minimum of twice a year to determine scholarship offers (draft Terms of Reference attached)
2) Review and determine scholarship extension requests
3) Oversee the NICTA UNSW scholarship budget pipeline (assisted by the NICTA UNSW research student administrator)
4) Review and approve summer scholarship project allocations
5) Attend the Summer Scholars Showcase (December) and summer scholars presentations (February)
6) Actively review and improve processes used to select students to ensure the highest quality students are being recruited for NICTA scholarships
7) Provide guidance and input to the facilitation of new recruitment strategies to increase the quality and pool of students applying for NICTA scholarships.

Project Duration: 1 September 2014 to 30 June 2016

Benefits (ref: clause 4.8):
The role will support the national objectives for enhancing ICT in Australia by supporting the Education Strategy set down annually by the CEO and National University Liaison Officer. The three objectives underpinning the Education Strategy are to –
• To increase the quality and pool of students applying for NICTA scholarships
• To improve student processes and the student experience
• Outreach
University of Queensland
Context-Awareness in Dynamic, Mobile Environments

Description:
Project Title: Context-Awareness in Dynamic, Mobile Environments
Research Group Association: Networks Research Group
University Group Association(s): School of Information Technology and Electrical Engineering, The University of Queensland

Project Description: The project has two subtopics: activity recognition in mobile environments and context-aware collaborative streaming of high quality video. The aim of the first subtopic is to design, develop and evaluate a mobile activity recognition technology that is able to infer individual and collective activities of mobile users in smart spaces while giving users control over their sensor data, activity inference/recognition process and the decision to share this with other users/environments. The project will focus on (i) managing the learning of new, evolving and personalised activities from sensory information on-board the user’s mobile device, (ii) using contextual reasoning to identify a broader situation of the user’s activity and to infer higher level situations while incorporating data from sensors on the mobile phone/users, sensors in the environment and any other rich contextual data that is available/accessible from external sources, and (iii) giving users control over learning of personalised activity models, recognition of activities and inference of context, as well as the decision to share this information to receive better service/information delivery.

The aim of the second subtopic is to improve user experience in smoothing the video playout and in maintaining the video quality in cellular networks. The number of mobile users that require on demand video content for a variety of applications is growing rapidly. However, bandwidth insufficiency is an obstacle in providing high quality smooth video playout in cellular networks. This research explores the idea of collaborative streaming by facilitating the available idle wireless devices in the vicinity. New collaborative streaming algorithms (including bandwidth estimation) in cellular networks will be proposed and thoroughly evaluated to prove that it provides better performance than the existing solutions.

Project Duration: 1 July 2014 – 30 June 2016

Benefits: This project will provide significant and innovative contributions in (i) the area of mobile activity recognition that can be applied in a variety of applications including independent leaving of the elderly and work safety, and (ii) the area of collaborative video streaming which has a potential for commercialisation. This research involves developing a variety of algorithms that can be used in commercial applications including bandwidth estimation in wireless networks and an energy efficient algorithm for selecting collaborating devices.

The project will increase the availability within Australia of world-class ICT research skills by providing postgraduate research training to two postgraduate students and a number of Master/Honours Computer Science students and undergraduate engineering students undertaking Engineering Theses.
University of South Australia
Mobile Computing/Augmented Reality Hardware

**Description:**

**Project Title:** Mobile Computing/Augmented Reality Hardware.

**Research Group Association:** Computer Vision

**University Group Association(s):** University of South Australia (UniSA), School of Information Technology and Mathematical Sciences

**Project Description:** To build mobile computing/augmented reality hardware. This project will develop a wearable processor and augmented reality kit that is tailored to simulations of prosthetic vision. This is suitable for orientation and mobility trials particularly to be used to develop and evaluate new algorithms for orientation and mobility, particularly in the lead up to clinical trials of low vision assistive devices. This will better facilitate NICTAs ability to develop algorithms that are suitable for this purpose, and to evaluate their clinical efficacy. Demonstration of clinical efficacy is key to commercialisation of these research outcomes.

**Project Duration:** 1 April 2013 – 31 March 2014.

**Benefits** (ref: clause 4.8):

This work will enable NICTA to have more effective setups for simulated prosthetic vision experiments and contribute to the work NICTA is undertaking with Bionic Vision Australia a national consortium of researchers working together to develop a bionic eye.
University of Sydney
USyd NICTA Research Student Administration

Description:

Project Title: University of Sydney NICTA Research Student Administration
NICTA Group Association: Student Administration
University Group Association(s): School of Information Technologies, USyd

Project Description:
The position will manage, develop and implement the NICTA Research Training Enhancement and Scholarship Program at the University of Sydney and will be the first point of contact for NICTA Management, Research Group Leaders and higher degree research students enrolled at the University of Sydney. This will include dealing with applicants’ and students’ queries, liaising and coordinating with NICTA, the School of IT, other schools and faculties, the University’s Research Office and students in relation to scholarship opportunities, applications and acceptances of offers, providing administrative support for induction sessions, progress reviews, and exit interviews, requests for extensions and so on. The incumbent will administer the NICTA scholarships budget, including reporting expenditure and budget forecasting for future funding. The incumbent will maintain the NICTA student database and the School of IT database for NICTA-enhanced students. High level involvement and initiative will be required in the running of student events including the annual NICTA Summer Scholars Showcase. General administrative support will also be provided to NICTA’s National University Liaison Officer on a needs basis, not exceeding one day per week.

Project Duration: 1 January 2012 to 31 December 2014

Benefits (ref: clause 4.8):
The role will support the national objectives for enhancing ICT in Australia by supporting the Education Strategy set down annually by the CEO and National University Liaison Officer. The three objectives underpinning the Education Strategy are to –

- To increase the quality and pool of students applying for NICTA scholarships
- To improve student processes and the student experience
- Outreach
Consumer-run Operation of Cloud Computing Platforms

**Description:**

**Project Title:** Consumer-run Operation of Cloud Computing Platforms  
**Research Group Association:** SSRG  
**University Group Association(s):** University of Sydney, School of Information Technologies, Faculty of Engineering and Information Technologies.

**Project Description:** Investigate how an enterprise can effectively operate software on cloud computing platforms. A key concern is monitoring and control to determine (and improve) the quality of service provided. Attributes that need to be measured and controlled include availability, computational power, consistency of data and elasticity. The hard challenge is to work through the monitoring and control APIs provided by cloud vendors, which are quite restricted compared to what system administrators usually have access to in platforms they own or control. Another key concern in operations from outside the authority of the platform is how to deploy software or configuration changes; here a challenge lies in the need to prevent service interruptions, to track compatibility between versions of different software, libraries and configurations; and to allow effective undo, redo and auditing of changes.

**Project Duration:** 1 January 2012 – 31 December 2014

**Benefits:** Cloud platforms offer potential cost savings to both small and established enterprises, however they are much less predictable/ understandable than when using resources in traditional data centres. An understanding of how to measure and control quality attributes, and more effective deployment of software updates or configuration changes, would be very useful to these enterprises. IP developed in this project could be commercialised either through provision of consultancy services, or by encapsulation in tools. As well, there are substantial intellectual challenges (and thus scientific advances when these are solved), in overcoming the restrictions imposed by the lack of authority of the consumer within the platform on which they are operating. Thus high-quality publications and valuable research training should also be outcomes from this project.
Research Leader

**Description:**
Project Title: Research Leader
Research Group Association: Software Systems Research Group
University Group Association(s): School of Information Technologies, University of Sydney.

**Project Description:** Mentoring and Culture Building. Professor Fekete will work closely with NICTA's mid-career and early-career researchers, to support them in strategically planning their research agenda, targeting appropriate publication venues and presenting work to suit, assisting them to develop their supervision skills. He will also work with the research students to enhance their capacity to evaluate research and understand it in the context of different research communities, to communicate the value and contribution of their work. He will mentor both staff and students towards understanding their career goals, and positioning themselves for success.

**Project Duration:** 1 July 2013 – 30 June 2014.

**Benefits:** Improve the research capabilities of research students and early career researchers.
Associate Director of Education

Description:
Project Title: Associate Director of Education, University of Sydney
Research Group Association: University Engagement
University Group Association(s): Faculty of Engineering, University of Sydney

Project Description:
The role of Associate Director of Education overseas scholarship and student-related activities relevant to NICTA supported PhD students at the University of Sydney. The following summarises the main responsibilities:

8) Act as Chair of the Scholarships Selection Committee, which meets a minimum of twice a year to determine scholarship offers (draft Terms of Reference attached)
9) Review and determine scholarship extension requests
10) Oversee the NICTA USyd scholarship budget pipeline (assisted by the NICTA USYD research administrator)
11) Review and approve summer scholarship project allocations
12) Attend the Summer Scholars Showcase (December) and summer scholars presentations (February)
13) Actively review and improve processes used to select students to ensure the highest quality students are being recruited for NICTA scholarships
14) Provide guidance and input to the facilitation of new recruitment strategies to increase the quality and pool of students applying for NICTA scholarships
15) Co-ordinate the research relationship between NICTA and the University of Sydney

Project Duration: 1 January 2013 to 31 July 2015

Benefits (ref: clause 4.8):
The role will support the national objectives for enhancing ICT in Australia by supporting the Education Strategy set down annually by the CEO and National University Liaison Officer. The three objectives underpinning the Education Strategy are to –

• To increase the quality and pool of students applying for NICTA scholarships
• To improve student processes and the student experience
• Outreach
**Approximation algorithms for voting scenarios and cost allocation of vehicle routing games**

**Description:**

**Project Title:** Approximation algorithms for voting scenarios and cost allocation of vehicle routing games.

**Research Group Association:** NICTA’s Optimisation Research Group, Algorithmic Decision Theory

**University Group Association(s):** University of Sydney, Faculty of Engineering and Information Technologies, School of Information Technologies.

**Project Description:** Elections and voting are an important part of a modern society. In the standard model of voting, each voter’s preferences are represented by a partial or total order over the candidates, and some voting protocol is used to determine the election winner(s).

This project will focus on developing approximation algorithms for voting scenarios where it is possible to affect the outcome of the election, for example, having a coalition of voters manipulating their votes, by campaigning for or against a certain candidate, or even using bribery. This project will aim to design approximation algorithms for problems arising in these settings. Typical examples are: approximating the size of a required coalition to manipulate an election, or approximating the minimum cost to make a preferred candidate a winner.

The second part of the project will focus on variants of vehicle routing games (VRG), specifically cost allocation schemes for VRGs. An example is the Shapley value which aims to distribute the gains from cooperation in a fair manner. This project will study the problem for specific scenarios/applications as well as for the general case.

**Project Duration:** 1 Mar 2013 – 31 Dec 2013 (on a trial basis for six months, with the option to continue for the remainder of the year).

**Benefits:** Social choice theory research has only recently focussed on the computational aspects. In this project we have a unique opportunity to blend the various expertise that we are fortunate to have available in Sydney. The NICTA group with extensive experience in AI and voting theory, Serge Gaspers (UNSW and NICTA) with expertise in multivariate complexity and Joachim Gudmundsson (USyd) with an expertise in approximation algorithms. Together this will form an innovative group that have the potential to make a huge impact to the research area, as well as to the larger community.

In addition, the range of problems to be tackled in the project will provide a high-level training ground for PhD/masters/honours students at NICTA and the University of Sydney. These students will acquire highly sought-after skills for Australian universities and ICT companies keen to understand the development of theoretical results and how they can be transformed into practical tools.
Machine learning for air pollution monitoring

**Description:**

**Project Title:** Machine learning for air pollution monitoring  
**Business Team Association:** The project is associated with the Security and Environment Business Team.  
**University Group Association(s):** University of Sydney, School of Information Technologies.

**Project Description:** This project will develop and apply modern statistical machine learning and data fusion methods to forecast air pollution from ground monitoring stations.

**Project Duration:** 1 March 2013 to 31 December 2014

**Benefits (ref: clause 4.8):**

The focus of the work is to develop spatial–temporal statistical models for predicting air pollution and anomalies in air quality monitoring equipment. The foundation underpinning this development consists of statistical inference procedures for spatially and temporally dependent data to estimate pollution levels of PM10, PM2.5 and other pollutants and determine where exceedances are occurring or equipment is failing. The techniques developed in the project will have a broad range of applications in problems related to space–time reasoning that can significantly impact other environmental problems.

Beyond the direct impact in environmental sciences, this research tackles fundamental problems of data analytics when dealing with streaming data and has the potential to dramatically enhance our understanding and capabilities in this emerging ICT field. The project will develop cutting edge algorithms with significant commercialisation potential in key national research priorities.
Data Mining Techniques for Network Security and Optimisation

Description:

Project Title: Data Mining Techniques for Network Security and Optimisation
Research Group Association: Networks Research Group
University Group Association(s): University of Sydney, Faculty of Engineering, School of Information Technologies

Project Description:

Two projects:
1. Development of Statistical Signature Anomaly Detection Systems which provides the same benefits as Intrusion detection systems which Intrusion Detection Systems which match packets against a database of malicious signatures, and Network Anomaly Detection Systems which use statistical deviations to identify anomalies; and
2. Development of a framework, based on probabilistic modeling, to automatically categorise and detect miscategorised in mobile app stores.

Project Duration: 01 January 2014 – 30 June 2016

Benefits (ref: clause 4.8):
Brings together expertise from two different fields, networking and data mining to address one of the major challenges of networked applications – detecting malicious behaviour.
Crack Detection In Steel Reinforced Concrete Beams based on Vibration Analysis and Guided Waves

**Description:**

**Project Title:** Crack Detection In Steel Reinforced Concrete Beams based on Vibration Analysis and Guided Waves

**Research Group Association:**

Infrastructure Transport and Logistics Business Team  
Machine Learning Research Group

**University Group Association(s):**

1. The University of Sydney, School of Aerospace, Mechanical and Mechatronic Engineering, Faculty of Engineering and Information Technologies  
2. The University of Technology Sydney, School of Civil and Environmental Engineering, Faculty of Engineering and Information Technology

**Project Description:** The project aims to investigate the effectiveness of the Structural Health Monitoring (SHM) system, developed at NICTA, for crack identification/propagation in steel reinforced concrete based on vibration analysis. The system will be a vital tool to help bridge managers and engineers improve the safety and maintainability of critical structures.

The project will focus on developing data processing methods to extract features from collected data to identify flaws. The supervised and unsupervised learning approaches will be adopted to identify crack location and propagation. In addition, an algorithm based on frequency response function (FRF) analysis, principal component analysis (PCA) and artificial neural networks (ANNs) will be adopted for crack identification and propagation.

Furthermore, the crack propagation will be monitored using ultrasonic waves excited with piezoelectric (PZT) elements, functioning as actuators and sensors, mounted on the top and bottom surfaces of the beams. The wave signal captured using the PZT sensors, before and after the crack is introduced, will be used to identify and characterise the cracking in the concrete beams.

**Project Duration:** 1 July 2013 until 30 June 2014

**Benefits:** This research project will add value to the current SHM system developed at NICTA and will ensure its reliability in crack identification and propagation. Information and communication technology (ICT) will provide many novel and efficient solutions for existing SHM systems through improving data acquisition and transmission methods, as well as data analysis algorithms for assessment of new and aging infrastructures in Australia.

The SHM system combines a variety of sensing technologies with embedded measurement controllers to capture, log, and analyse real-time data. Through ICT, the most iconic structure in Australia, the Sydney Harbour Bridge, will be equipped with an SHM system and live monitoring will be provided. The system will help to ensure that the structure is in appropriate condition and that required inspection/repairs are done on time.
University of Tasmania
SenseT Freight and Logistics Lab

Description:
Project Title: Sense-T Freight and Logistics Lab (“The F&L Lab”)
NICTA Research Group Association: NICTA Executive
University Group Association(s): University of Tasmania

Project Description: The aim of the Project is to jointly establish a UTAS and NICTA Sense-T Freight and Logistics Lab (The F&L Lab’) at UTAS, Hobart campus. Once established the F&L Lab will undertake freight and logistics optimisation research designed to help improve freight and logistics outcomes for governments, business and community in Tasmania. The parties intend that the specific Research Projects undertaken at the F&L Lab will be scoped and described and agreed in separate CRP Schedules, pursuant to the NUCA. Those research projects will combine world-leading research with practical applications.

Project Duration (Term of Project): The F&L Lab Project shall have a Term of 2 years from Commencement Date. In the event that NICTA receives an adequate funding commitment (i.e. no less than the current annual funding commitment in 2014) from the Commonwealth Government for the period beyond 30 June 2016, then, both parties shall continue the Project (including making their further annual cash contributions) under the terms of this CRP for another one (1) immediate consecutive year.

Benefits (ref: clause 4.8): Sense-T is a major research collaboration led by UTAS that is creating the world’s first economy-wide sensor network. It combines research excellence with practical outcomes, demonstrating how real-time data can be harnessed to help users be more competitive, efficient and sustainable. Sense-T is federating existing sensor networks that monitor environmental conditions across Tasmania, such as those owned by government departments, energy and water utilities and businesses. The parties agree that Tasmania is the ideal test-bed for real-time freight and logistics optimisation research given its scale, economies of scope and the Sense-T research environment. Accordingly UTAS shall be responsible for the appropriation of the physical facility to accommodate the F&L Lab. Once established, the F&L Lab will undertake freight and logistics optimisation research designed to help improve freight and logistics outcomes for governments, business and community in Tasmania. It will combine world-leading research with practical applications.

The F&L Lab will use the Sense-T platform for all its research projects.
University of Technology Sydney
Investigation of Effective Damage Detection Algorithms for Structural Health Monitoring of Large Iconic Bridges Using Vibration Measurements

**Description:**

**Project Title:** Investigation of Effective Damage Detection Algorithms for Structural Health Monitoring of Large Iconic Bridges Using Vibration Measurements

**Business Team Association:** Infrastructure, Transport and Logistics

**University Group Association(s):** The University of Technology Sydney, School of Civil and Environmental Engineering, Faculty of Engineering and Information Technology

**Project Description:** The current research on the Sydney Harbour Bridge mainly focuses on monitoring local regions on the Jack arches. Moreover, monitoring is done for only a particular type of failure mechanism. The identification of local failure is crucial to the bridge manager to maintain such an iconic structure. Local monitoring of damage on large structures does not provide information about the global behaviour of the structure. Therefore, it is critical to start considering a network of sensors (currently installed on the bridge) and study their behaviour in order to identify global structural deterioration on the bridge.

This project will extend current research for engineering applications by exploring the vibration-based damage detection method. Finite element models for the whole structure will be produced to develop a better understanding of the dynamic behaviour of the structure and its response to damage. The results produced from the finite element model and data collected from the Sydney Harbour Bridge will be used to predict the sub-global and global behaviour of the bridge due to damage.

**Project Duration:** January 2014 to January 2016

**Benefits:** This research project will add value to the current structural health monitoring (SHM) system developed at NICTA as one of main deliverables of the project will include the development of new methods that can predict the global behaviour of the monitored structure, using only few sensors. Information and communication technology (ICT) will provide many novel and efficient solutions for existing SHM systems through improving data acquisition and transmission methods, as well as data analysis algorithms.

The SHM system combines a variety of sensing technologies with embedded measurement controllers to capture, log and analyse real-time data. Through ICT, the most iconic structure in Australia, the Sydney Harbour Bridge, will be equipped with an SHM system and live monitoring will be provided. The system will ensure that the condition of the structure is well maintained and that required inspection and repairs are done on time.

To date NICTA and UTS have collaborated on localised damage detection – one facet of Structural Health Monitoring (SHM) research. This research extends the collaboration to date by addressing the problem of determining the condition of structures on a larger scale than previously thus returning greater benefit to operators of civil infrastructure. If successful the results of the research can be used by operators to increase productivity significantly. It will further establish UTS and NICTA as leaders in the field of Structural Health Monitoring.
University of Wollongong
Sample-wise Learning and its Application

**Description:**

**Project Title:** Sample-wise Learning and its Application  
**Research Group Association:** Machine Learning Research Group  
**University Group Association(s):** School of Computer Science and Software Engineering, Faculty of Engineering and Information Sciences, University of Wollongong  
**Supervisors:** Dr Lei Wang (UoW), Dr Yang Wang (NICTA)

**Project Description:**

The recent literature has seen significant progress on the methods of localized linear or kernel learning, latent model learning and multiple instance learning, as well as their wide applications. Research on these methods has generally been conducted independently and different specific algorithms have been developed for each of them. This proposal argues that they essentially share a key concept which we call "Sample-wise learning". This proposal aims to conduct a systematic research on the framework of sample-wise learning and further generalizes this concept to other learning methods to improve their efficiency and performance. In specific, the following research questions will be focused:

1. How to design a learning model set with appropriate compactness and learning complexity?
2. How to jointly learn the association between sample and models and train these models?
3. How to utilize the similarity among samples and the similarity among models to avoid the sample-wise learning fall apart?
4. How to achieve computationally efficient training and test, especially in light of the advent of big data in visual recognition?
5. The applications to large-scale visual recognition and infrastructure failure prediction.

**Project Duration:** 1 March 2014 to 31 August 2017

**Benefits:** This project explores the synergy of researchers from NICTA and UOW in the area of ICT. This applied research project aims to apply research outcomes to large-scale visual recognition and infrastructure failure prediction. It is expected that the algorithms and methods developed by this project will have commercialisation potential and will benefit Australia’s ICT sector. Through the joint efforts of NICTA and UOW staff, this project expects to make significant research achievements and increase Australia’s ICT research capability.