

The Australian National University

Research School of Information Sciences and Engineering

2003 Annual Report to Council

OVERVIEW

Along with the other Research Schools of the Institute of Advanced Studies, RSISE focuses its work on research, research training and interaction with the national and international communities. It regards seriously its responsibility to produce postgraduates able to meet the research needs of Australia.

The year saw particular activity focused on developing the working relationship between the School and NICTA (National ICT Australia). Professor Bob Williamson worked much of the year as interim Director of the Canberra Laboratory for NICTA (and in 2004 was confirmed in that position). Along with University staff and staff of NICTA, the School spent considerable time during 2003 developing arrangements for NICTA scholarship support for postgraduate research students who will work in the University. Several School staff were appointed Program Leaders in NICTA and, at the end of 2003, 16 had signed Research Resource Agreements (RRAs) through which the School contributes its resources to the research programs of NICTA. NICTA also appointed its own staff in 2003, 9 of whom had become adjunct staff of the School by year-end. There is a good reciprocal relationship developing between the School and NICTA in the exchange of staff and in the commonality and comparability of research programs.

Professor Brian Anderson, who was successful in leading the consortium that won the NICTA bid, was appointed acting CEO from March to May and was appointed Chief Scientist of NICTA from May onwards. He remains a member of staff of the School with his time as Chief Scientist allocated to NICTA under an RRA.

Professor John Richards was appointed Director of the School in October 2003 for a two-year period during which the RSISE/NICTA arrangements are expected to be stabilised.

The School saw a pleasing increase in its postgraduate research student numbers and was particularly successful in attracting ARC grants (a success rate of 63% in discovery and linkage grants); also, two students received prizes for papers presented at symposia.

Apart from furthering good working relationships with NICTA the School has two immediate goals; first, to attract approximately 15-20 research students per annum for the next two years (17 were attracted in 2003 to give a total of 50). Secondly, now that the future with respect to NICTA is much clearer than it was 12 months ago, plans need to be put in place to grow RSISE as an essential component of the University's Institute of Advanced Studies.

During 2003 a new PhD study program was introduced in the School, largely in response to the need for NICTA PhD students to receive coursework instruction as well as research training. Attention is now to be focused on the place of coursework in the School's non-NICTA PhD programs as part of a response to the Actions required under the University's Education Strategic Goal.

The structure of the School will be examined in 2004 to ensure that the formal groupings are at viable size and provide the most effective working environment for our staff and students (University Tactical Goal 2). We will also examine former plans for the Computer Sciences Laboratory to grow to 24 academic staff.

The School has a recurrent deficit which it needs to address to ensure its long-term growth. Fortunately it has reserves which will carry it through for the next 2 years but considerable strategic planning will be required to ensure, consistently with the University's Tactical Goal 3, that its research programs can grow effectively while overcoming the current difficult financial situation.

KEY STATEMENTS OF ACHIEVEMENT AGAINST LOCAL STRATEGIC GOALS

Computer Sciences Laboratory

- *To bring both the Automated Reasoning Group and the Machine Learning Group up to a level of 6-8 researchers.* The establishment of NICTA has largely achieved the desired strengthening of the automated reasoning and machine learning groups, as new NICTA (adjunct) staff are working closely with CSL staff.
- *To commence a new area of research.* This has been achieved with the appointment to a Research Fellowship of Dr. Yannick Pencolé, whose research interests are in diagnosis and planning. Furthermore, through a project funded by the Smart Internet Technology CRC, a research programmer, Mr. Joshua Cole, has joined CSL and strengthened the Laboratory's profile in agent research.

Department of Telecommunications Engineering

- *To take leadership in establishing an Australian research network in communications to promote better collaboration and excellence in research.* The department has been a strong contributor to the annual Australian Communications Theory Workshop (AusCTW) that attracts over 100 researchers around Australia through membership of the organizing committee, technical program committee, and through editing and production of a 200 page proceedings.
- *To consolidate and strengthen the research team working in wireless and mobile communications.* This has been achieved through development and leadership of the Wireless Signal Processing Program in NICTA where we are on track to quadruple the effective number of researchers.

Department of Systems Engineering

- *To establish a Vision Systems group under the leadership of Professor Richard Hartley, and promote linkages to other areas.* This has been boosted by a joint ARC grant with Professor Richard Hartley in Vision Systems and Dr Alexander Smola in Machine Learning, leading to the appointment of a Level B staff member, Dr Fredrik Kahl. The advent of a NICTA program covering this field and the consequent attraction of students and staff is allowing build up to critical mass for long-term viability.
- *To spin off companies.* The success of the Seeing Machines set up by Professor Alexander Zelinsky is an example of what can be achieved; however there are no current additional proposals.
- *To deliver outcomes from the research platform now established in Robotics and to rebuild the original area of strength in Systems Engineering with an emphasis on developing Optimization.* Three ARC grants and NICTA program support have been attracted. The Intelligent Vehicle Project, Submersibles Project, Robotic Arm Project and Control Lab Projects are being successfully continued. New techniques for Signal Processing and Control of Complex Systems with applications to Robotics and Vision Systems have been developed.

SIGNIFICANT ACHIEVEMENTS IN RESEARCH AND TEACHING

Research

Optimisation and development of efficient algorithms. Many engineering problems need computer algorithms, the best of which require new techniques for their construction. In the Department of Systems Engineering such new approaches have been developed recently using methods from differential geometry. Standard applications are in vision systems, robotics and control theory, but other areas will also be explored.

Autonomous Underwater Vehicles (Dr U. Zimmer). Significant experimental progress has been made on submersible robots. This included reworking the design of the KAMBARA submersible and

carrying out swarm style underwater experiments. Three PhD projects have been initiated based on this work, and international collaboration is expected in 2004. Partners in this work include the CRC for Intelligent Manufacturing Systems, Real-Time Innovations (USA), Wurtz Electronics (Germany) and Modell U-boot Spezialitäten (Germany).

Theory of Rigid-Body Dynamics. Dr Roy Featherstone has obtained new results pertaining to the system mass matrix of a rigid-body system and how its condition number varies with the number of rigid bodies. This highlights previously unknown obstacles to the control of systems with a large number of bodies.

Robust Control Theory. Professor Brian Anderson, Dr Alexander Lanzon and Wynita Griggs have generalised results involving the Vinnicombe metric from linear time-invariant systems to linear time-varying systems. Such results are important in practical robust control systems design for both nonlinear and time-varying systems.

True 3D Recognition. An approach to recognition of a 3-dimensional object is being developed which starts from a reconstruction of the object followed by analysis of its true 3D geometry. Professors Richard Hartley and Hans Burkhardt together with Dr Hongdong Li have proposed space mapping and harmonic representation as mathematical tools.

Machine Learning. Dr Alex Smola and colleagues obtained several results concerning kernels on discrete structures. This is a promising method for dealing with machine learning problems on structured domains that arise, for example, in network and bioinformatics applications.

MIMO Communications Systems. Theoretical advances have been made by Professor Kennedy and Dr Abhayapala and student Tony Pollock in a new area of spatial communication systems which has implications in clarifying the limitations in the emerging area of multiple input multiple output communication (MIMO) systems.

Ultra-Wideband Communications. A number of world class theoretical contributions in Ultra-Wide Band (UWB) communications have been made by Jian Zhang under the direction of Professor Kennedy and Dr Abhayapala. These have led to a paper prize at the 2003 International Workshop on Ultra Wideband Systems in Finland and the Student Travel Grant to the IEEE ICC2003 in Alaska awarded by IEEE Computer Society based on review scores.

Orthogonal frequency division multiplexing (OFDM). OFDM offers an attractive solution to future broadband wireless systems. Techniques to improve the transmission characteristics of OFDM signals have been developed by Dr Jayalath.

Symbolic Machine Learning. Professor John Lloyd published a book entitled *Logic for Learning* that provides a higher-order reconstruction of symbolic machine learning. The book exploits the significant advantages that higher-order logic brings to knowledge representation and predicate construction in machine learning.

Planning. Drs Sylvie Thiebaux and Blai Bonet (a visitor from UCLA) attacked the Power Supply Restoration benchmark problem in AI planning and, for the first time, were able to use a general planning tool to deal with significant sized instances of this problem thereby generating optimal solutions under uncertainty. The work was presented at the International Conference on Automated Planning and Scheduling, 2003.

Uncertainty in Artificial Intelligence. Dr John Slaney, following up work in 2002 with Dr Sylvie Thiebaux and students Charles Gretton and David Price, and collaborator Froduald Kabanza (University of Sherbrooke, Canada), devised and investigated a new temporal logic designed for reasoning about decision processes with non-Markovian rewards. A paper on application to non-Markovian decision processes was presented at the Conference on Uncertainty in AI, 2003.

Teaching

RSISE offers courses at two levels: overview courses, available to all our students, and advanced courses, available to a significant subset of students. Four overview and four advanced courses were run in 2003. In October the RSISE Faculty Board approved a new PhD Study Program designed to use the enhanced resources and opportunities, including commercialisation training, available through our membership as foundation partners in NICTA.

In February the Machine Learning Summer School was held. Several courses were presented with the participation of external experts: Shun-Ichi Amari (Information Geometry), Gabor Lugosi (Concentration Inequalities) and Zoubin Ghahramani (Unsupervised Learning).

In December our annual Logic and Automated Reasoning Summer School was held. Several courses were presented with participation of international experts: Marcus Kracht (Modal Logic), Hector Levesque (Formal Methods), Tobias Nipkow (Formal Methods), Toby Walsh (Automated Reasoning).

In January we mounted a series of presentations with colleagues from the University of New South Wales for our joint summer scholar programs using video conferencing facilities. These presentations focused on the research programs of NICTA.

STUDENT NUMBERS

We attracted 17 new postgraduate research students during 2003, bringing our total cohort to 50. Six students successfully graduated in 2003; three PhD students discontinued their enrolment without completing.

NEW GRANTS

Awarded in 2003 for funding in 2004:

- Dr John Slaney, Dr Sylvie Thiebaut and Dr Toby Walsh were awarded an ARC Discovery Grant entitled “Where the Really Hard Problems Are: Beyond the Decision Case” with funding of \$225,000 over three years.
- Professor Alex Zelinsky and Dr David Austin were awarded an ARC Discovery Grant entitled “Autonomous Functions for Smart Cars” with funding of \$280,000 over three years.
- Professor John Moore and Dr Robert Orsi were awarded an ARC Discovery Grant entitled “Numerical Algorithms for Solving Convex Optimisation Problems Arising in Systems and Control Theory” with funding of \$243,966 over three years.
- Dr Shahar Mendelson and Professor Alain Pajor (France) were awarded a Linkage International Fellowship for level E appointment of Professor Pajor for a period of 12 months with funding of \$134,958 over the period.
- Professor Richard Hartley was awarded an ARC Linkage Grant entitled “Producing 3D Video Sequences from 2D Input Video” with total funding of \$84,099 over three years.

Grants taken up in 2003:

- Sixteen RSISE Researchers entered into Research Resource Agreements with NICTA that will involve participation in six of the newly established NICTA Research Programs. Approximately \$550,000 will flow through to the participating RSISE Researchers during 2004.
- NICTA has entered into an agreement with the ANU to fund NICTA postgraduate scholarships in areas of mutual interest to NICTA and the ANU. The funding for 2004 is \$898,000.
- Professor John Lloyd took up a project grant through the CRC for Smart Internet Technology for 2003 to 2005 worth \$700,000 for the “Machine Learning for the Smart Personal Assistant” project.
- Professor Brian Anderson and Dr Alexander Lanzon took up an ARC Discovery Project Grant entitled “Safe Adaptive Control”. The total value of the grant is \$253,000, over three years including an APD Fellowship for Dr Lanzon.
- Dr David Austin took up an ARC Linkage Grant entitled “Robotics for the Real World: A Museum Tourguide Robot”. The total grant awarded is \$195,000 over three years.

- Professor Richard Hartley took up an ARC Discovery Project Grant entitled “Pattern Recognition and Scene Analysis via Machine Learning”. This cross-departmental project combines expertise from the Computer Sciences Laboratory and the Department of Systems Engineering. The funding amounts to \$277,000 over three years.
- Dr Alexander Smola took up an ARC Discovery Project Grant entitled “Network Intrusion Detection via Machine Learning” with funding of \$167,000 over three years.
- Dr Thushara Abhayapala and Professor Rodney Kennedy took up an ARC Discovery Project Grant for “System Theoretical Aspects of Spatial Signal Processing” at the amount of \$162,000 over three years.
- Professor Bob Williamson, Dr Robert Mahoney, Dr Gunnar Räetsch, and Professor Manfred Warmuth took up an ARC Discovery Project Grant entitled “Analysing Iterative Machine Learning Algorithms with Information Geometry”. The grant totals \$159,000 over three years.
- Dr Shahar Mendelson, Prof Gideon Schechtman and Prof Alexander Litvak took up the ARC Discovery Project Grant “Geometric Parameters in Learning Theory” totalling \$100,000 over two years.
- Professor Rodney Kennedy is an investigator on the ARC Discovery Project “Adaptive Multi-User Detectors for Mobile Space-Time Communications Systems over Time Variable Fading Channels” administered at the University of NSW.

MAJOR PRIZES, HONOURS AND AWARDS

- Professors Brian Anderson, John Moore and John Richards were awarded the Centenary Medal.
- Professor Alex Zelinsky was a winner in The Bulletin's (October 28, 2003) Smart 100 Competition for the IT and Communications Category. He also received Innovation Software Award from Australian Information Industries Association and was declared Technology Pioneer at the World Economic Forum Meeting in January 2004.
- Jian Zhang received the best paper award at International Workshop on Ultra Wideband Systems (2003) IWUWBS, June 2003, Oulu, Finland.
- Petra Phillips won the COLT 2003 Student Paper Award for “Random Subclass Bounds” co-authored with Shahar Mendelson.

BUDGET PERFORMANCE

The School's recurrent operating grant for 2003 was \$4,699,000. Owing to pre-existing commitments the total expenditure for the year exceeded this grant by \$209,000. However, the School does have an accumulated surplus which, at the end of year, resulted in a carry forward of \$1,401,000; this is fully committed to existing appointments and other known commitments over the next three-year period. Forward projections show a potential shortfall of funds by 2006. The School is developing strategies with regard to; likely revenues from its association with NICTA, meeting the unfunded component of the new Enterprise Agreement, and the potential variation in the IGS, RIBG & RTS components of the budget. The program of increasing PhD numbers has seen new scholarships being awarded during 2003, resulting in an internal increase in the allocation to this budget area. The establishment of the NICTA Scholarship Agreement will further enhance the ability of the School to increase the number of postgraduate students.

MENTORING AND GENDER EQUITY PERFORMANCE

The School has one woman of a total of 25 academic staff (down from three previously) and nine women of a total of 49 students. Our 2003 Summer Scholar cohort of 22 included seven women. Rosemary Shepherd, Executive Assistant in the Department of Systems Engineering applied for a place in the ANU Career Development Scheme and gained entry for 2004. Dr Anat Lerner from the Open University of Israel was the first Visiting Fellow under National Institute of Engineering and Information Sciences (NIEIS) Women in Engineering and Information Sciences Fellowship during July-August 2003. The second NIEIS Fellowship has been awarded to Professor Lesley Ward, a mathematician at Harvey Mudd College, USA. She will be at ANU for 3 months from February 2004 based in MSI but will be working as well with staff of the School.

FUTURE DIRECTIONS

The establishment of NICTA has allowed CSL effectively to strengthen its research efforts in automated reasoning and machine learning. It can be expected that interaction between CSL and NICTA will provide considerable benefits over the next few years. Furthermore, CSL now has more freedom to explore new research directions such as complexity theory, optimisation, and artificial intelligence.

By gearing off NICTA, the Department of Telecommunications Engineering will assemble the strongest team internationally dealing with the new field of Spatial and Continuous, Multidimensional Communication Systems.

The Department of Systems Engineering will continue its efforts to

- (i) establish a Vision Systems group under the leadership of Professor Richard Hartley, and promote linkages to other areas,
- (ii) spin-off companies,
- (iii) deliver outcomes from research in Robotics, and
- (iv) rebuild the original area of strength in Systems Engineering.

Since these goals match closely NICTA targets in the relevant Programs the department expects a substantial boost to its already-strong research in these areas.

INVOLVEMENT IN THE NATIONAL INSTITUTES

The School supports the National Institute of Engineering and Information Sciences (NIEIS), both administratively and collegially. During 2003 staff and students attended several NIEIS lectures, and a half-day themed symposium. In September 2003 Professor Rodney Kennedy, Head of Telecommunications Engineering at RSISE, delivered a thoughtful and provocative National Institute Public Lecture at the National Museum of Australia on the future of wireless communications. NIEIS also hosted the inaugural 'ANU Engineering Industry Alliance' industry forum in collaboration with BusinessACT, which focused on the potential for the ACT to foster and develop business entrepreneurship in ICT.

In collaboration with RSISE (and NICTA) NIEIS prepared a proposal to boost the School's outreach activities via a Student Recruitment Task Force. The Task Force would provide professional development opportunities to PhD students and assist in the long-term recruitment of undergraduate students.

RSISE staff also participated in two Summer Schools that were held at RSISE, and supported by NIEIS: the Machine Learning Summer School and the Logic and Automated Reasoning Summer School.