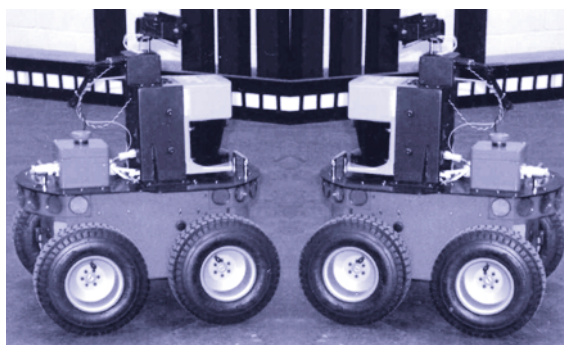


## Autonomous Navigation at Swansea

**NCAF Autumn Meeting, University of Wales, Swansea  
15–16 September 2004**



BAE System's Autonomous Navigation Project (SLAM)

Hollywood suggests that SKY-NET is probably the world's most powerful, super-intelligent computer that can learn, adapt and has the potential to beat the human race! Has the recent film 'Terminator 3' taken the film industry's imagination well beyond our current understanding of Intelligent

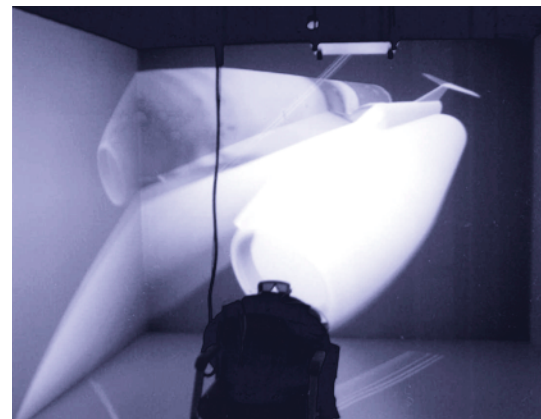
and Self Adaptive Computing? Let's find out at the next meeting in Swansea.

NCAF is coming to Wales for the first time and it is my great pleasure to welcome you to Swansea. Within the university, the School of Engineering provides a stimulating, dynamic academic environment with access to state-of-the-art facilities and resources. It has over 60 academic staff, over 35 support staff, approximately 250 research staff and students and over 800 undergraduates. The School has five recognised Welsh Development Agency (WDA) Centres of Excellence in Civil and Computational Engineering, Complex Fluids Processing, Materials Engineering, Power Electronics and Communications and Software Development. All the centres have a reputation for high quality research. In all previous UK Research Assessment Exercises, Civil Engineering has received the highest grades, and in 2001 was again awarded the prestigious Five Star rating. The research activities of Civil Engineering, which are focused on Computational Engineering, have been further strengthened by the formation of the Civil and Computational Engineering Centre that has benefited from an investment of over £3m in new premises and facilities.

The School has extensive collaborative links with industry. The £10.5m Digital Technium initiative in partnership with the WDA, will focus on the University's links with digital communications companies. In the field of Natural Computing, the School is also proposing a new interdisciplinary MSc/MPhil course on Intelligent and Adaptive Computation.

The theme for the first day of the September meeting is Self Learning Autonomous Systems and will include presentations from two University spin out ventures, case studies from BAE Systems

(Autonomous navigation), Corus (Self learning process control) and online gesture interpretation will be discussed in a presentation from Cranfield University. For autonomous systems, sensors and wireless communications are as important as natural computing algorithms. On the first day, we have also arranged a visit to the Digital Technium to see the £2.6m Agilent Communications Test and Measurement laboratory that houses some of the most sophisticated equipment in Europe. The visit will also include a demonstration of the recently developed Virtual Reality Laboratory, one of the very few such facilities in the UK.



Virtual Reality Cave – 3D image of the supersonic Thrust car which holds the world landspeed record. The aerodynamic simulation for Thrust was carried out at the University's School of Engineering.

The second day of the meeting will be more general, including presentations from Oxford and Southampton universities describing the ARGUS II DARP programme on intelligent agents for data fusion, a presentation on evolutionary computing from Swansea, and a presentation on robust reliability of neural networks using information-gap models from Sheffield.

For the social event, allow us to give you a taste of local hospitality with some food and wine accompanied by Welsh music and entertainment. We are very much looking forward to seeing you at Swansea in September.

**Dr Rajesh Ransing  
School of Engineering  
University of Wales, Swansea**

*NCAF is coming to Wales for the first time...*

### INSIDE

- Finding faults in Sunderland
- Spotlight on CERCIA
- Puzzle Corner No. 27

### BACK PAGE

- Spotlight on RMSC, Cranfield University
- Diary Dates

---

# Finding faults in Sunderland

*The latest step is to automatically make predictions about the future – not quite Minority Report, but Giles Oatley has had some success in predicting which properties are likely to be burgled again after a break-in.*

This year's NCAF summer meeting was held at the sunny University of Sunderland, with the theme of 'Intelligent Fault Diagnosis'.

On the Tuesday night, a crowd gradually gathered in the bar of the Roker Hotel. After testing the beer-resistance of a laptop, we eventually made it to the Italian restaurant next door for a meal (or two in some cases). Back in the bar afterwards, Mark Cheeseman was presented with a decanter as thanks for his three years hard work as NCAF secretary.

The next day we strolled down to the exciting modern buildings of the St Peter's Campus, to begin another eagerly awaited NCAF meeting. There, members of the University of Sunderland contributed five presentations on the application of natural computing techniques to real-world problems.

Dale Adison opened the meeting by describing his work on fault-diagnosis for elevators. He gave a brief introduction to neural networks, radial basis functions and self-organising maps, and showed how these could be applied to fault diagnosis. Various methods of dimensionality-reduction were explained, including auto-associative neural networks and Wiegand weight regularisation. Dale then showed that self-organising maps and multi-layer perceptrons were useful in remotely diagnosing elevator faults, allowing the maintenance staff to bring appropriate spares and hence fix faults faster.

## Monitor degradation

The next speaker was Adam Adgar, describing a system to monitor the degradation of lubricating oil in machinery. Small visible and infra-red spectrometers have been developed, with the intention that they are mounted permanently inside expensive machinery to provide early warning of oil failure. Adam described how the most important spectral bands were selected, models of oil degradation were developed and a neural network was used to map the output of the sensors to a score for oil quality. This allows the operator of the machine to be alerted when the oil has degraded. Replacing degraded oil reduces wear, improves efficiency and prevents potential damage to expensive equipment.

Garen Arevian reminded us that using real-world data is not always easy. A small company had collected fuel consumption data from a range of vehicles, and wanted to show that their fuel additive improved efficiency. However, the data was of very poor quality, and with many erroneous values. Garen demonstrated the steps taken to 'cleanse' the data and described the Bayesian techniques used to incorporate uncertainty about the validity of each data point. After all this analysis it turned out that the additive had very little effect!

Phillip Tann spoke about his PhD work in conjunction with British Telecom. BT have many old paper maps showing their networks, with stencilled symbols representing the various components. Phillip has applied genetic algorithms to search the maps for recognisable symbols, automatically converting a scanned map into a network diagram suitable for the computer-based operations of the present day.

The final Sunderland representative was Giles Oatley, talking about his work on decision-support for various UK police forces. At a simple level this involves collecting, organising and visualising data from past crimes, to allow a human to detect trends. Data mining techniques were then applied to detect trends and identify associations between similar crimes. The latest step is to automatically make predictions about the future – not quite *Minority Report*, but Giles has had some success in predicting which properties are likely to be burgled again after a break-in.

Two papers relating to the Distributed Aircraft Maintenance Environment project (DAME) were presented. DAME is investigating the application of GRID computing to aero-engine maintenance, and involves the Universities of York, Sheffield, Oxford and Leeds, together with Rolls-Royce, Data Systems and Solutions, and Cybula Ltd. Xiaoxu Ren from Sheffield University introduced model-based fault detection, where the output of the system under test is compared with the output of a simulation. In the case of DAME, a model of an aircraft engine was made available to the consortium in the form of a web service. A case-based reasoning 'maintenance advisor' has also been provided as a web service.

Andy Pasley from York University spoke about analysing vibration data from aircraft engines. AURA is a fast searching tool, based on neural networks and implemented in specialist hardware (correlation matrix memories). A GRID-enabled version has been built for DAME. The QUICK tool is used to detect unusual events in the engine vibration data. These are then passed to AURA to see if similar events have occurred in the past. These past examples can then aid a maintenance decision. The GRID enables this to take place even if the historical data is distributed across many sites, without having to transfer all the data to one node.

## Northern invaders

All the speakers at this meeting had come from the north of England, with the exception of the following invaders from north of the border. Neil Lightowler and Chris Kirkham from Axion Ltd (Aberdeen) presented VindAX – their commercial hardware implementation of a self-organising map. The hardware is entirely general and could be applied to any classification or function-approximation problem. One market that Axion are targeting is the automobile industry, where it can be used for on-board diagnostics in vehicles. Neil and Chris showed how the map could solve the difficult task of detecting engine misfires.

Colin Fyfe (University of Paisley) presented an excellent general paper on Hebbian Learning and Negative Feedback Neural Networks. He showed how these could be used to explore a data set, performing factor analysis or independent component analysis. One nice example showed that the network's description of a well-known optical illusion suffers from the same ambiguity that a human perceives. Part two of his talk introduced the concept of twinned neural networks. Here, several input streams are fed into a single network, which can be set up to learn various interesting features of the streams such as identifying common components. I think Colin may also have mentioned that he has a book on these subjects coming out this summer.

Elaine Martin (Newcastle University) spoke about combining process and spectral data for monitoring the progress of pharmaceutical and chemical batch processes. Infra-red spectral data give information about the chemical composition of the product. Elaine discussed a method of automatically selecting the wavelengths that contain the required information about the process state. However, this information is sometimes insufficient to detect that a process is diverging from the desired path, and so should be combined with measurements such as temperature and pressure to get a fuller picture.

Michalis Titsias (Edinburgh University) spoke about his method for unsupervised video segmentation. It assumes that each image in a set is a superposition of the same planar objects. These objects are allowed to translate, scale and rotate in the image plane, and need not appear in every image. The greedy algorithm learns one object at a time,

---

# Spotlight on ... CERCIA

The Centre of Excellence for Research in Computational Intelligence and Applications is a Research and Development centre established in 2003 in the School of Computer Science at The University of Birmingham. CERCIA focuses on technology transfer and applied research by working with both regional and international industrial partners including BT Exact, Honda Research Institute, HP Labs, Marconi, Qinetiq, Rolls Royce, SPSS (UK), STMicroelectronics and Thales Research and Technology.

CERCIA has its roots in the Natural Computation Research Group at The University of Birmingham. This highly regarded group is composed of more than 40 full-time researchers including 19 staff members (6 of whom are dedicated CERCIA researchers). Our research interests vary greatly but revolve around the central theme of systems inspired by nature. Current research includes work on neural networks, evolutionary computation, machine learning and agent-based systems. Some of our most exciting research is at the interface of different disciplines including work on evolving neural networks, artificial life, co-evolution and biotic selection, evolvable architectures of the human mind and applying physical and biological models of image understanding for medical applications (including early melanoma and retinopathy detection).

CERCIA is funded jointly by The University of Birmingham and Advantage West Midlands (AWM, the local regional development agency), and actively works with local industry to champion and support the uptake of computational intelligence (CI) techniques for business improvement. Our core competencies include applying CI for:

- Optimisation: including logistics and supply chain problems, vehicle routing (routing of salt trucks for de-icing of roads), cutting stock problems, etc.
- Data Mining: prediction of telecommunication traffic flow, medical diagnosis by classification of positive cases, object recognition, fraud detection, etc.
- Design: ranging from engineering applications – including the design of novel digital filters (UK and EU patent pending), and materials modelling for the design of new materials (alloy design) – to more artistic and creative applications such as graphics design.

avoiding the combinatorial explosion when the number of objects increases. Michalis showed some impressive results and described how his algorithm can dramatically speed up the tracking of several objects through a video sequence.

Of the serious work, that just leaves Andrew Batchelor (Newcastle University), who described all the hard work that he and his colleague have put into developing Netlab++ (the C++ version of Netlab, the suite of Matlab routines available from the Neural Computing Research Group at Aston University) and the underlying matrix code. Andrew said that the software is now in alpha testing, and runs about ten times more quickly than the Matlab routines. We look forward to testing it. What made this project all the more impressive was that the majority of the development had been done in Andrew's spare time at home.

Of course, everyone's favourite canine, Fenella the Rottweiler, was on hand at the end of day one to reveal the answer to Puzzle Corner. Glamorous assistants were duly recruited, and not one but several ingenious solutions were explained. The lack of correct answers meant that the bottle of wine on offer went unclaimed.

CERCIA regularly runs training programmes at both an introductory and advanced level on assorted topics in natural computation. To date, CERCIA has organised four comprehensive five-day courses on cluster-based computing, evolutionary computation and data mining. The courses have received an excellent response and have attracted participants (some international) from both academia and industry. Future training programmes include two-day courses on the practical applications of evolutionary computation and data mining and an advanced one-day course on probabilistic modelling in machine learning. CERCIA can, on request, also run customised training courses.

CERCIA has active collaborations with several departments at The University of Birmingham including Physics, Mechanical Engineering, Metallurgy & Materials, Chemistry, Biosciences, School of Medicine, Geography and Earth Sciences and even Theology. These collaborations have led to exciting new applications of CI to these disciplines. For example, we are applying genetic programming to model radial brightness distributions in elliptical galaxies; applying multi-objective evolutionary optimisation for materials modelling (optimising superplastic-damage constitutive equations and determining unified creep damage constitutive equations); training evolutionary rule generation systems to predict alloy properties from composition ratios and using data compression for text analysis to investigate the authorship in the letters of St. Paul.

Some of our projects that have led to proof-of-concept prototypes include:

- A CI based utility monitoring system to monitor and detect outliers in consumption
- A new method to predict epileptic seizures by analysing EEG data (combining wavelet transforms and similarity)
- A new technique for visualisation of large, complex data-sets for knowledge generation and discovering regularities

More information about CERCIA is available from our website: [www.cercia.ac.uk](http://www.cercia.ac.uk). If you have any queries please get in touch with me.

**Vibhu Walia**  
Centre Manager, CERCIA

The conference dinner was held at the Beamish Museum. But, in best NCAF tradition, this was no ordinary dinner. How many other conferences can offer a tram ride, a trip to the dentist and exclusive use of an entire pub? And that was before the meal even started. The Beamish is a 'living-history' outdoor museum, with an entire village of 1913 for us to explore, complete with various inhabitants to talk to. A banquet was then consumed before we retired to our pub for some serious networking, and some more very good beer. I think that it may have been here that the suggestion of writing this entire article in heroic verse may have originated...

Apologies to those expecting verse,  
They only gave me seven days; and worse,  
I've had a very busy 'week from hell',  
With lots of other things to do as well.  
I could have made the whole of this page rhyme,  
If only I was given extra time,  
But this is all that you are going to get:  
It's Friday and I've hardly started yet.

**Tom Young**  
BAE Systems

## PUZZLE CORNER

### Number 27

Lisa was invited to play an informal game of Craps in a back room at the Casino Royale. In Craps a 'Shooter' has to roll two six-sided dice. If the total is 7 or 11 (naturals) the Shooter wins immediately. If the total is 2 (Snake-Eyes), 3 (Craps) or 12 (Boxcars) the Shooter loses immediately. If the total is any other number (4,5,6,8,9, or 10) that becomes the Shooters 'point' and they must continue rolling until they either win by 'making the point', or lose by rolling 7.

In a strictly fair game the Shooter has a slightly less than even chance of winning. Since Lisa was a newcomer to the game, her opponent, Modesty Blaise, offered to be Shooter. However, Modesty cheats and has biased one of the dice to give herself the maximum advantage, averaging 2 wins out of every 3 games. Lisa was forewarned, however, and, unbeknownst to Modesty, has biased the other die to minimise the Shooter's advantage. Nevertheless, the game still favoured the Shooter, but the margin was now much smaller.

Playing the innocent, Lisa declined to play unless the Shooter paid one and a half times the stake if they lost. Modesty accepted, still confident of bleeding another chump dry in the long run.

*How had Modesty biased the first die, how had Lisa biased the second die, and what was Lisa's expected profit per game?*

The answers will be given at the next NCAF meeting (15–16 September 2004, University of Wales, Swansea).

**Fenella the Rottweiler**

## COMMITTEE NOTES

### Chairman

Graham Hesketh  
Rolls-Royce plc

### Secretary

Armin Stranjak  
Rolls-Royce plc

### Treasurer

Dr Ian Nabney  
Aston University

### Editor of Neural Computing & Applications Journal

Professor John MacIntyre  
University of Sunderland

### Managing Editor of Networks

Dr Nick Granville  
Smith & Nephew plc

### Publicity Officer

Mandy Bradley  
Technical Forecasts Ltd

'Bert Bullen  
BAE Systems

Richard Ellis  
Stratum Management Ltd

Dr Richard Everson  
University of Exeter

Dr Elaine Martin  
University of Newcastle

Dr Lead Rezek  
Oxford University

Please contact NCAF through Graham Hesketh, Chairman – NCAF  
PO Box 5944  
Derby DE24 8ZD U.K.  
Tel: +44 (0) 1332 246989  
Fax: +44 (0) 1332 247129  
e-mail: [enquiries@ncaf.org.uk](mailto:enquiries@ncaf.org.uk)  
<http://www.ncaf.org.uk>

*Edited and Produced by:*  
Chris Hawthorne  
Forum Communications  
Eastgate House  
Eastgate Street  
Winchester SO23 8DZ  
Tel: 01962 877833  
e-mail:  
[chrishawthorne@forum-pr.co.uk](mailto:chrishawthorne@forum-pr.co.uk)

### NEXT EDITION

Review of the Swansea meeting  
Preview of the Aston meeting

# Spotlight on ... RMCS, Cranfield University

The Royal Military College of Science is part of Cranfield University, and is based at Shrivenham, near Swindon. It is where officers of the British Armed Forces can meet academia, and learn about modern technology, management, and other military and defence issues. The Engineering Systems Department is concerned with the design and analysis of various engineered systems, and therefore has a wide range of data analysis problems. Within this department, the Applied Mathematics and Operational Research Group (AMORG) is responsible for the teaching of and research into mathematical techniques, numerical methods and scientific software.

AMORG offers a range of postgraduate courses in Defence Simulation and Modelling, Scientific Computation and Military Operational Research leading to an MSc. These programmes consist of eight, one-week long taught modules followed by two weeks of directed study. Some of the modules are also offered as stand-alone short courses. Those registered for an MSc undertake a project exploring a topic of their choice in some depth. The postgraduate degrees are also offered in part-time mode. The project is normally carried over a four-month period.

One of the modules provides an introduction to neural networks. This is aimed at practicing scientists and engineers who wish to extend their problem-solving skills. No prior knowledge of neural networks is assumed, but participants should normally have a degree in scientific or engineering discipline. A basic understanding of matrix algebra and calculus is a definite advantage. The module covers the essentials of neural networks, supervised and unsupervised learning, multilayer networks, associative models, and statistical techniques. Most of the practical work is

based on Matlab on Unix workstations. The module also includes a brief overview of matrix algebra, calculus and Matlab at the beginning of the week. Some of the review material is provided to the participants in advance. During the practical sessions, the participants are provided with a selection of data sets and simple networks to consolidate the theory. The short course normally includes a visiting speaker from industry to explore a meaty application in sufficient depth.

Full-time MSc programmes tend to attract more mature students with a wealth of experience in defence sector. The MSc project offers them a good opportunity to explore some of the techniques learnt during the module. One recent student exploited his expertise on satellites and space weather to develop simple neural network models to identify anomalies that occur on satellites. Another topic that has been studied in a series of projects is that of the interpretation of gestures that arise during flight deck officer training, ending with a successful demonstration of the use of Hebbian learning models to recognize the gestures performed by the trainee. Finally, neural networks have been used to develop a set of rules that can be used to predict damage in aircraft structures.

The group is also interested in exploring applications that are industrially relevant. It is possible to develop some of these problems into a suitable MSc project to conduct a preliminary investigation in some depth. For further details, either about the course or to enquire whether your own problems can be developed into an MSc project, contact [amor@rmcs.cranfield.ac.uk](mailto:amor@rmcs.cranfield.ac.uk)

**Venkat Sastry**  
RMCS, Cranfield University

## DIARY DATES 2004/2005

**23–25 August** – COMADEM 2004: The 17th International Congress & Exhibition on Condition Monitoring And Diagnostic Engineering Management, Robinson College, Cambridge, UK.  
<http://www.comadem.com/2004.htm>  
<<http://www.ise.canberra.edu.au/conferences/cimca04/>>

**29 August – 1 September** – BICS, 2004: Brain Inspired Cognitive Systems, University of Stirling, Scotland. <http://www.icsc-naiso.org/conferences/bics2004/> program.html <<http://www.ise.canberra.edu.au/conferences/cimca04/>>

**7–10 September** – Sheffield Machine Learning Workshop: University of Sheffield.  
<http://www.dcs.shef.ac.uk/ml/workshop/>

**15–16 September** – NCAF Meeting (Self-Learning Autonomous Systems) at the University of Swansea. For information, email [enquiries@ncaf.org.uk](mailto:enquiries@ncaf.org.uk) or telephone +44 (0)1332 246989.

**13–15 December** – AI-2004: The 24th SGAI International Conference on Innovative Techniques and Applications of Artificial Intelligence, Queens College, Cambridge, UK.  
<http://www.bcs-sgai.org/ai2004/>

**January 2005** – NCAF Meeting (Theme TBA) at Aston University. For information, email [enquiries@ncaf.org.uk](mailto:enquiries@ncaf.org.uk) or telephone +44 (0)1332 246989.

## MEMBERS' NEWS AND VIEWS

Deadline for contributions for the next edition – 5 November 2004. Please send to Managing Editor – Nick Granville, e-mail: [Nick.Granville@smith-nephew.com](mailto:Nick.Granville@smith-nephew.com)