
Networks 28 – August 2000

New NCAF Chairman

The recent NCAF meeting in Manchester was very successful. Despite a late programme announcement, there was a very encouraging turnout, with many people using the on-line registration. There were some excellent presentations and lively discussions, and the social event was extremely well attended.

Prior to the meeting, Peter Cowley, the NCAF Chairman of several years, tendered his resignation in order to step down from the Committee. In true evolutionary style, this was to enable young blood to come through, in the form of Mark Cheeseman. Mark is an enthusiastic, well-organised, and very capable member of the Information Engineering team at Rolls-Royce, and as a co-opted member he will be a very valuable addition to the Committee.

However, Peter's resignation also left open the position of Chairman. This prompted an Extraordinary General Meeting of the Committee (held after the social event), at which it was unanimously agreed that the new Chairman would be Graham Hesketh who said, 'I feel honoured and privileged to be entrusted with this position, and I hope that I can go on to emulate the successes of my illustrious predecessors.'

At the meeting, Peter was warmly, and rightly, thanked for all his efforts, and presented with a very nice bottle of single malt whisky. He will continue to attend NCAF meetings, and we look forward to debates stimulated by a 'back-bencher' able to be even more forthright than he was as a diplomatic Chairman!

NCAF birthday conference in 'Spitfire city'

Southampton University, 26 - 27 September 2000

This September NCAF will be 10 years old. As a celebration of this occasion we will be holding a joint conference with the EPSRC on 26-27 September at the University of Southampton. As the first ever NCAF meeting was held in Southampton it appears to be a most appropriate venue for the birthday celebrations.

The main theme of the event is the future of natural computing. There will be presentations from industry, academia and representatives of funding bodies such as the EPSRC. A workshop will be held on directed research in natural computing and backed up by presentations on the future of directed research programmes. There will, of course, also be a number of papers covering more general natural computing techniques and applications. To mark the occasion there will also be presentations from original NCAF committee members.

Southampton is an historic city well placed for both maritime and aviation events

among other attractions. It is the home of famous cruise liners such as the QE2 and Oriana, and boasts to be the 'City of the Spitfire'. Participants in the NCAF conference will have the opportunity to see a Spitfire and many other famous aircraft for themselves as the Hall of Aviation is the venue for the conference dinner, or is that Birthday Party?

*Neil Lightowler
AXEON Ltd*

Data fusion examined

Review of Manchester meeting, 5 - 6 July 2000

Dr Andrew Starr, hosted a very successful meeting at the Engineering Department at Manchester University in July. The theme was data fusion, with a strong emphasis on Bayesian methods and probabilistic graphical models (PGMs).

Mark Cheeseman from Rolls-Royce plc started off the meeting with a talk on genetic algorithms for job-shop scheduling, where a real-number coding was used, with the integer part indicating the machine number and the decimal part the order of operations on a machine. The three objectives being optimised were time taken for the manufacture (makespan), work in progress and smoothness (standard deviation). Mark found that optimising these objectives one at a time gave better results, establishing a baseline for the application of natural computing to this important area of operational research.

Andrew Starr gave an introduction to data fusion in condition monitoring. Defining data fusion as combining data and knowledge from different sources, and distinguishing three basic levels of raw data fusion, feature fusion and decision fusion, Andrew presented a number of different data fusion models. These included the OODA model (Observation, Orientation, Decision, Action), and the JDL (Joint Directors of Laboratories) model, again multi-level with association, tracking and identification as a first level, and situation assessment, threat assessment and feedback as higher levels. The terminology derives mainly from the American military, where much of the early work in data fusion has been carried out. Other models derive from Robotics and non-destructive testing. Having established stages of identification, estimation and validation, Andrew considered data-based, knowledge-based and model-based techniques, as part of work towards the development of an 'intelligent, multi-sensored engine'.

Keynote talk

For the keynote talk, we were very happy to welcome Professor Chris Bishop, from Microsoft, Cambridge, to give the talk that had been scheduled for the Cambridge meeting when Chris was on Jury service. Starting from the sum and product rules of probability, Chris built up to the very powerful and general framework of probabilistic graphical models, which uses a network diagram to represent conditional probabilities. The presence of links in the graph indicates dependencies between quantities, and the graphs can be used to specify prior knowledge. The

framework includes the Hidden Markov Model and the Kalman filter as special cases. Extra nodes in a graph can be added to represent prior distributions over parameters. Chris described the Junction Tree Algorithm for exact inference (Moralise, triangulate and construct tree of cliques), which is efficient in the sparse case, and went on to describe numeric methods for approximate inference, such as Markov Chain Monte Carlo (MCMC) with Gibbs sampling, and the variational methods. An application area is in representing manifolds of images, for recognizing similar pictures.

Paul Hannah, of Manchester University, applied a self-organising continuous map to the 'Queensland Rail Problem' (when long coal trains overturn while accelerating on a corner going over a hill), modelling the coupler force on two locomotives on the train. The method is applicable to control systems with multiple set points, and the self-organising map is used to find sub-problems, within which the modelling is done using a back-propagation network. There are some similarities to applications of mixtures of experts.

Gavin Kelly of the National Physical Laboratory, spoke of how natural computing and Bayesian methods are becoming more accepted and finding applications in the science of measurement, particularly when dealing with 'soft' measurements such as 'glossiness', 'obtrusiveness' etc., and when comparing between laboratories. He stressed how priors could be used in defining correct confidence intervals, particularly where there are physical constraints, e.g. where a number must be positive.

The first day was rounded off with preparation for the joint IEE/NCAF data fusion seminar, in the form of a data fusion tutorial written by Mark Bedworth (for the NATO Advanced Study Institute), delivered by Graham Hesketh of Rolls-Royce plc, and drawing heavily on material from David Hall at Penn State University.

After some sobering statistics about the amount of data collected in both modern warfare and particle physics (a new hadron particle collider will generate in one experiment 'more data than there currently is in the world'), Graham recapped types and architectures of data fusion and assessed present capabilities. These included: we can presently do automated target detection, identification and tracking, some situation refinement, and limited threat refinement using automated reasoning, but we cannot yet accurately track highly manoeuvring targets or those in complex environments, or gauge their intent. He then concentrated on 'decision fusion' (decision-in, decision-out stage according to Dasarathy's five-level model). Much of this is familiar from work on ensembles of neural nets: majority rule or weighted voting according to performance information, and decision transition matrices (confusion matrices). A technique known as 'behaviour knowledge space' learns accuracy from a large database of examples. Graham's tutorial ended with some 'dirty secrets' of data fusion (Don't get too depressed here - there are no 'magic' algorithms, there will never be enough training data, and the fused answer may be worse! Downstream processing cannot absolve the sins from upstream and there is no substitute for a good sensor!)

Day two

The second day began with Kathryn Burn-Thornton of Durham University describing how fusion of electrocardiogram (ECG) and patient history data for high-risk patients improves classification accuracy in the early detection of heart disease.

Health monitoring of machines was the subject of Dr Simukai Etete from the University of Oxford. The talk described real-time fusion of vibration and performance data for a Rolls-Royce Trent 500 aero engine using data from the test bed at Rolls-Royce plc. The performance parameters are able to provide information about blade fouling etc., which may not be apparent from vibration data.

Steve Roberts, of the pattern analysis research group, also at Oxford, then enlightened us on the joys of probabilistic data analysis, continuing the theme of probabilistic graphical models and Bayesian methods. He described graphical models as a neat method to do structured thinking about problems and described an application in a fascinating project named the Brain-Computer Interface, whereby changes in electroencephalogram (EEG) activity are directly interfaced to a moving cursor, so one can use a computer merely by thinking about it. Bayesian trained radial basis function networks predict the probability that the user is trying to move the cursor upwards, for example. Data fusion is shown to improve the accuracy from a chance-level 50 per cent up to a respectable 85 per cent. Steve also mentioned coupled hidden Markov models as a method for doing data fusion in state space for analysing multiple time series.

After lunch Chris Harris from Southampton University's 'Image, Speech & Intelligent Systems' Department discussed 'Data-centric multi-data fusion in collision avoidance', emphasizing the need to translate between rules, knowledge and linguistics for reliable systems in cars, aircraft and ships.

David Nicholson from BAe Systems presented us with 'Covariance intersection in theory and practice', considering data fusion problems with applications such as map-building and navigation for robots.

Terry Windeatt of Surrey University's 'Centre for Vision, Speech & Signal processing' discussed 'Labelling techniques for combining multiple classifiers'. And on the non-arrival of one speaker Graham Hesketh stepped into the breach, delivering a paper with the unlikely title 'Kalman filters for fun'!

Simon Cummings (British Airways plc)

Mandy Bradley (Royal Sun & Alliance Insurance)

Rick Adderley (West Midlands Police)

ANNIMAB-1 – Conference Review

Artificial Neural Networks in Medicine and Biology

Göteborg, Sweden, 13-16 May 2000

This sunny four day event took place in the Quality Inn Hotel, an imaginatively renovated maritime warehouse, on the banks of the Göta river a couple of ferry stops

from the centre of Göteborg. The conference was admirably organised by Helge Malmgren and the ANNIMAB-Society based at Göteborg University. The society collects links to people and organisations world-wide working with biological or medical applications of ANNs and related techniques

(<http://www.phil.gu.se/animab.html>).

The conference benefited from being relatively small with about 100 delegates from Europe, USA, Canada, Hong Kong, Taiwan, Japan, Ethiopia and Saudi Arabia. Single track oral sessions provided an interesting variety of topics on medical image analysis, signal processing in medicine, clinical diagnosis, medical decision support, bio-molecular applications and biological modelling, learning methods and hybrid algorithms. One attraction was the excellent mix of keynote talks by an impressive array of invited speakers.

The conference started at lunchtime on Saturday possibly because economy fares to Sweden require a Saturday night stopover and the afternoon was dedicated to invited talks. Richard Dybowski, Kings College London, gave an overview of neural computation in medicine. From the Medline database he has found that the most commonly used network in medicine is the multi-layer perceptron (MLP) with sigmoidal activation functions, followed by radial basis function networks. Pierre Baldi, University of California, presented an overview of biological applications of ANNs and Teuvo Kohonen, Helsinki University of Technology, summarised 150 medical applications that use his self-organising map (SOM). He spoke about his websom map which enables users to search seven million patented abstracts (<http://websom.hut.fi/websom/>) - impressive!

Other keynote talks started the morning and the afternoon oral sessions on the following days. Georg Dorffner, Austrian Research Institute for AI, spoke about modelling uncertainty in biomedical applications; Pierre Baldi told us about predicting protein β -sheet partners using neural networks and Gail Carpenter, Boston University, presented ART networks for medical data analysis. Paul Lisboa, Liverpool University, summed up with outstanding issues for clinical decision support using neural networks. Despite numerous pilot studies he knows of only two decision support systems which have reached the clinical trials stage Papnet and Questar. After June 2001 all equipment 'placed on the market' will need a CE marking. New products will have to demonstrate best practice, include novelty detection, and carry out a detailed risk analysis and comparison with a standard benchmark methodology.

One reason put forward at the conference that neural network decision support systems are not used more by doctors, despite their demonstrated higher accuracy and consistency, is the lack of interpretability. However, progress is being made in this area. In an oral presentation the author of this article showed how direct explanations are given to orthopaedic surgeons at a hospital in Swindon for an MLP network currently being installed that classifies low back pain patients - recently the topic of a BBC Science News 24 programme.

The highlight of the conference was the dinner at Marstrand, an island with beautiful old wooden summer residences reached by a vintage steamer hired especially for the occasion. It was magical to watch the evening sun set over the Sound as the steamer

glided away from us into the distance. So ended a memorable and highly successful conference. The proceedings of the conference are published in a paperback book by Springer, ISBN 1-85233-289-1, ISSN 1431-6854, eds. H. Malmgren, M. Borga, and L. Niklasson.

*Marilyn Vaughn
Cranfield University*

PUZZLE CORNER

Number 14

Samantha, an old friend of Lisa, had been doing some research in their local library.

'What have you been reading?' asked Lisa. 'All sorts', replied Samantha, 'but particularly Elizabeth I, Field Marshall Montgomery, Richard of York, and Popular 20th Century All-Girl Irish Bands.'

The nine very large volumes of the encyclopaedia were now back on the shelf, but Lisa noticed that they weren't in their correct sequence. However, the order was particularly interesting. She noticed that the N-digit number formed from the first N books was evenly divisible by N, for all the values of N from 1 to 9.

'Yes', said Samantha, 'I thought it was quite amusing: it's a unique ordering. But I suppose I'd better put them back in the right order.'

'That will take some effort', said Lisa. 'I'll tell you what; if you call a move, taking a volume from the shelf, sliding some other volumes to make a gap, and replacing the volume, then I can tell you the minimum number of moves necessary. Even better, if removing and replacing a volume uses 10 times as much energy as sliding one volume one position, I can also give you the solution which expends the minimum energy.'

'I've got a better idea', said Samantha. She wiggled her nose, and all the books floated off the shelf, reordered themselves and floated back, without anyone lifting so much as a finger.

'I should have seen that coming!' said Lisa.

What was the original sequence, and how many moves did it take to correctly reorder them? What was Lisa's minimum energy solution, and why should she have known it would be bettered by Samantha? The answer will be given at the next NCAF meeting (26-27 September 2000, Southampton University).

Fenella the Rottweiler

Book review

C++ TOOLKIT FOR ENGINEERS AND SCIENTISTS (Author: James T. Smith. Publisher: Springer Verlag, ISBN 0-387-98797-5 www.springer-ny.com.)

This book covers some of the fundamental aspects of numerical analysis. On this foundation it constructs routines to solve linear and non-linear systems of equations. The book uses object oriented design methods and the language C++ to handle vectors, polynomials and matrices. The book also discusses the design and development of math libraries to implement a number of numerical methods.

An accompanying CD contains some of the source code described in the text and several test or demonstration programs. To compile these programs users should use Borland C++ 5.02 or newer. The author recommends that users select a large memory model and an Easywin target file to build the library. The source code for the libraries makes use of the Borland compiler features, templates and exception handling.

A part of the file readme.txt lists the various software modules within the library. A typical fragment code from a program (GaussTest.cpp) is also given after the list of modules. This library is comparable in its features and size to the free library NEWMAT and it is smaller than the equivalent commercial ROGUEWAVE library.

The general purpose mathematical libraries described in the book may be applied to help solve engineering problems. However, the book does not include any engineering applications or solutions to practical problems as stated on the back cover.

This is a useful book and designers who wish to develop artificial neural networks by using matrix methods will find most of the functions they require available in this general-purpose C++ maths library.

John Tindle
University of Sunderland

Members News and Views

What new techniques do you want to know more about? Please tell us if there are any new techniques that you know about or would like to know about so that these can also be included in Networks.

DIARY DATES 2000

September 11-14 British Machine Vision Conference. Bristol
<http://www.cs.bris.ac.uk/Events/BMVC2000>

September 26-27 NCAF, University of Southampton

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November 5-8 Artificial Neural Networks in Engineering. St Louis, Missouri, USA
<http://www.umn.edu/~annie/annie2000.htm>

December 11-13 IEEE Workshop on Neural Networks for Signal Processing.
Sydney
<http://www.eivind.imm.dtu.dk/nfsp2000>

January, 2001 NCAF, Aston University

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NEXT EDITION

Preview of the Aston meeting

Review of the Southampton meeting

The History of NCAF – a review by David Bounds

Deadline for contributions for the next edition 23 October 2000

