NCAF — Natural Computing Applications Forum

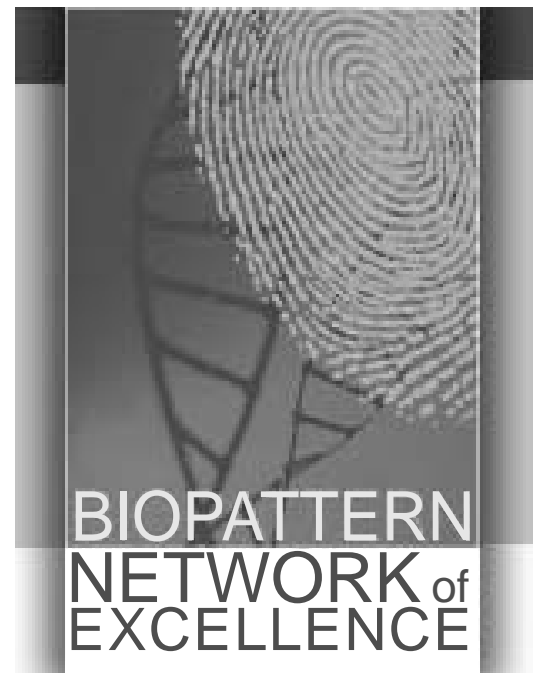# Biopatterns in Birmingham

Aston University
13–14 January 2005

The topics for discussion include 'standard' time series analysis and signal processing, gene expression and other bioinformatics data, and eHealth. There should be something to interest everyone.

The next NCAF meeting will be held at Aston University and will have as its first-day theme 'Biopatterns'. The day is being co-organised with the Biopattern Network of Excellence, a project whose goal is to integrate research across Europe to provide coherent and intelligent analysis of an individual's bioprofile and making the analysis of this bioprofile remotely accessible to clinicians and patients to help combat major diseases. Under this framework, the topics for discussion include 'standard' time series analysis and signal processing, gene expression and other bioinformatics data, and eHealth. There should be something to interest everyone.

The meeting will open with Paolo Lisboa (Liverpool John Moores University) giving us an overview of the role of biopatterns in medicine, including a survey of neural network medical applications. Nick Hughes (Oxford University) will be speaking on ECG analysis using probabilistic models (variants of the Hidden Markov Model) to determine timing information on each heartbeat. This is crucial in clinical drug trials, since prolongation of the QT-interval is now the most common cause of development delays, non-approvals and market withdrawals for new drugs. Davide d'Alimonte (University of Aston) will be speaking on how to classify data when labels are only available for one class. The application is to identify genes with a significant expression on microarrays, but the technique can also be used for novelty detection, and clearly has applications in many other domains, including condition monitoring.

Birmingham is famous for two things: having more canals than Venice (well, we do all right on the quantity, if not the quality) and the excellence of its Balti cooking. The social event will be a meal at one of Brum's best Baltis; the exact location is currently the focus of extensive consumer tests led by Vicky Bond, so a good night is guaranteed!

As usual, the second day consists of a more general selection of papers. Speakers include Peter Tino (Birmingham University), who will be speaking about latent class models for video classification, Jort van Mourik (University of Aston), who will be giving an overview of physics-inspired optimisation algorithms (making a nice change from all the biology-inspired algorithms), and Kathryn Thornton (Durham University), who has developed a wide variety of data mining applications. Not yet confirmed is Susan Stepney (York University), who is leading the Grand Challenge in Non-classical Computing, and wants to take 'natural computing' to new heights.

The NCAF AGM will also take place on the second day. This is your chance to query the committee on the direction of the organisation and have your say in how it should be run.

Prof Ian Nabney
University of Aston

BIOPATTERN
NETWORK of
EXCELLENCE

INSIDE

BACK PAGE

Self-learning software suits Swansea

So Graham Hesketh introduced us to the game of craps as a probabilistic selection procedure, and to warm us up for the "Puzzle Corner" solution the next day. Six of us played the 'shooter' in turn at craps, and as a result, four different puddings were selected by the winners, and duly shared out between the six of us.

The autumn meeting this year marked a new departure for NCAF, with its first visit to Wales for a meeting based at the University of Wales, Swansea. The meeting was kindly sponsored by Know-How Wales, Technium II, Digital Technium and the Civil and Computational Engineering Research department of the University.

As usual, the meeting began the evening before when hardened NCAF members assembled in the nearest pub for a meal. Inevitably the discussion turned to probability for the first serious decision of the evening – what to have for pudding. Not everyone was certain that they wanted pudding. So NCAF Chairman Graham Hesketh introduced us to the game of craps as a probabilistic selection procedure, and to warm us up for the Puzzle Corner solution the next day. Six of us played the 'shooter' in turn at craps, and as a result, four different puddings were selected by the winners, and duly shared out between the six of us.

The first day's venue was the Technium II building on the main seafront at Swansea. Denis Sodiri of Cranfield University gave the first lecture. He described a solution to the problem of automatic recognition of gestures made by trainee Flight Deck Officers. The problem is a challenging one because the pattern of the gestures is subject to spatial and temporal variability, which means that conventional approaches encounter problems. The application was able to achieve high levels of recognition over a common set of gestures, using a technique that is a hybrid of Hidden Markov Models and Dynamic Time Warping.

Following this was a presentation from our host, Rajesh Ransing, on defect analysis using the 'X1 Recall' system. This is a piece of self-learning diagnostic software for process control and scrap reduction in the steel industry. A punning description of the key concept behind this software might be Cause and Defect. The key to X1 Recall is the knowledge representation, which is described as 'Defect – Metacause – Rootcause'. In this representation, the 'Metacause' is a description of the physical process that is happening to give rise to a particular manufacturing defect. The 'Rootcause' would be the underlying process parameters that would need adjusting to prevent the defect-inducing physical process from occurring. The key breakthrough the software achieves is to enable the effect of multiple causes on associated effects to be stored as a multi-dimensional surface.

After a coffee break, Chris Solomon, of Kent University gave an excellent presentation of an evolutionary technique for producing photofit pictures. He first showed that existing means of producing photofit pictures did not work well because subjects are required to build up an image piecemeal from sets of eyes, noses, etc. However, humans recognise faces from the overall shape, rather than recalling individual bits. To illustrate this, he put up a professionally produced photofit picture, and challenged the audience to identify it. For the first time ever, the wind was slightly taken out of his sails by Mark Cheeseman of Rolls-Royce who recognised it as a very bad Tony Blair apparently from the Bambi ears! The new system produces whole faces from a parameterised representation made from the Principal Components reduction of shape and texture data of a real facial image database. The subject is first presented with a panel of nine faces randomly generated by sampling the 50 dimensional parameter space. Then the best representation is evolved in a process where the subject chooses one of the nine as most like their recalled image. This is retained, and eight further faces are generated from it by mutation (small random displacements of the feature vector). Subjects are generally able to evolve good representations in around 10 to 25 generations.

Immediately after lunch was a short presentation from Mike Day of the Welsh Development Agency on the 'Technium' concept. A Technium is part of an initiative to encourage high tech businesses to set up in Wales, by providing infrastructure and partnerships with academic and business advisors. The network of Technium buildings provides a start-up environment to incubate fledgling businesses.

After this, the first technical paper of the afternoon was from James Swinnerton of BAE Systems on the Simultaneous Localisation and Mapping (SLAM) algorithm for Autonomous Navigation. This algorithm allows an autonomous vehicle starting from no prior knowledge to build up an internal map of its environment, using a combination of dead reckoning and landmark identification. A form of Extended Kalman Filter is used to update the mapping. The extension to multiple autonomous vehicle problems was also discussed.

Continuing the same theme, the next paper, presented by Jafar Elmirghani of the University of Wales, Swansea, was on the subject of wireless communication in autonomous systems, under the constraints of limited bandwidth for a wireless ad-hoc network with no centralised backbone. The paper discussed various information-spread models, using mathematical concepts from epidemiology and chaotic maps. In simulation, it was possible to predict the probabilities of dropping packets of data, given a finite buffer size.

Following the time-honoured tradition, Fenella the Rottweiler presented the final lecture of the first day – the solution to Puzzle Corner. The traditional pantomime, in this case, was more of a static tableau, as the two protagonists, Lisa, and Modesty Blaise faced each other, each holding a craps die that they had biased in a certain way to gain advantage in the game. The optimum way of biasing one craps die would achieve a 66.7% probability of the shooter winning. Astute readers may recall that this was precisely the pudding ratio we achieved the previous night (4 puddings from 6 shooters). Were Fenella's craps dice biased? Clearly the sample size was too small to tell, and this reviewer proposes that the Probabilistic Pudding Procurement Procedure (P4) be adopted at future NCAF meetings to test this hypothesis properly.

This was followed by a trip back to the campus and a tour round the virtual reality cave and communications lab in the Digital Technium at the University campus.

The social event was a traditional Welsh evening held at the university. An excellent meal was served, during which we were entertained by a harpist, singers and recitations of poetry, most memorably a series of extracts from 'Under Milk Wood'. We learnt that the name of Dylan Thomas's fictional town 'Llareggub', is in fact 'Bugger all' spelt backwards.

Artificial intelligence incorporated into computer simulation software

Conventional methodology of design of high performance components for use in aerospace, automotive and a variety of manufacturing industries is based on 'make and break' philosophy. In other words, after conceptual design a number of prototype components have to be made and then tested by breaking them to assess their performance. If the product performance is unsatisfactory, the design has to be revised and the component re-tested. This expensive and time-consuming process is repeated until a satisfactory solution is found.

The product development may take many months to years from the drawing board to production, adding to enormous costs, which finally the consumer has to pay. In recent years, it has been shown that computer modelling offers a viable method for bringing products to market in far less time whilst lowering costs.

For reliable computer modelling, however, an accurate description of the mechanical behaviour of the materials used in the product is required. Many modern manufactured materials, as well as most natural materials, have complex material behaviours. In addition, they are anisotropic, i.e. their properties are direction dependent. This means expensive and time consuming testing of the materials under various axes of material anisotropy and load paths has to be carried out which then, often, proves to be the bottleneck. In many cases, it may not be possible to prepare samples for testing, as they may be too fragile, hard or expensive.

Funded by a regional innovation grant from the Welsh Development Agency (WDA), Computers & Geotechnics Ltd, a niche company based in Wales has recently developed unique self-learning finite element (FE) analysis software. In this software, an artificial neural network (ANN) is embedded to represent the behaviour of the material(s) involved in the product. The ANN is recursively trained either from the raw experimental data of materials tests, if available, or from the monitored data from component testing. No specific theory of idealised material behaviour is invoked but the 'intelligent' FE code uses its self-learning capabilities so its material model becomes progressively more accurate. The FE code can then make better predictions of the behaviour of the overall assembly that is being modelled.

Computers & Geotechnics has developed this software product in the form of a Plug-in Pull-out Module (PIPOM). It can be incorporated in any FE engine for use by product developers and researchers in engineering and manufacturing companies. The software can be pulled out for re-training as and when additional data on material or structural behaviour become available. The beauty is that this unique software can be used for any material – composites, alloys, ceramics, biological materials etc. without the need for extensive programmes of material testing and parameter identification. Time-dependent behaviour and temperature-dependent responses can be modelled naturally without making additional assumptions and hypotheses.

The company has received enquiries from far off countries like Canada and Korea and is involved in developing bespoke software for many applications. An incidental bye-product of this research has been a methodology and protocol for learning from observations and transfer of experience from individuals to a computer.

Dr Gyan Pande
Computers & Geotechnics Ltd.
Web site: http://www.comgeo.com

The first lecture the next morning, now back at the campus, was from Ian Cox, formerly of Corus, on issues with self-learning in Basic Oxygen Steel making. The objective of the study was to find the best corrective action to the process so that the final temperature and carbon content at the end of the process were both within their target windows, based on measurements from a test sample taken towards the end. Historical data were used to train a neural network, which produced results that outperformed conventional operators.

The next lecture was a tour-de-force presentation of the use of evolutionary computing techniques for the optimal design of engineering structures, by Johann Sienz of the University of Wales. The speaker first presented some impressive examples of structures from nature that were optimal (in a stress analysis sense); notably that of a tiger's claw. Using the same principle (that an evolutionary process can produce optimal structures), a large and diverse variety of solutions were presented, including load-bearing structures, air-dryer design, design of the drop nose for the Airbus A380, and for light relief, the optimal shape of a cherry.

There now followed two papers on decentralised and distributed multi-agent systems. The first, given by Steven Reece of the University of Oxford, concentrated on probabilistic methods of inference for data fusion, in order to estimate the covariance between signals received from separate sources in a network of autonomous vehicles.

The second of the two papers on this topic was given by Alex Rogers of the University of Southampton. Here, the concepts of game theory were applied to the problem of message passing in multi-agent networks. Message passing strategies, often using multiple-hop paths can be induced, by assigning a notional reward for actions taken by the sensors. This was demonstrated in an example application with a network of autonomous sensors embedded in a Norwegian glacier.

Finally, after lunch, Keith Worden presented some work by Gareth Pierce of the University of Sheffield, on Robust Reliability of Neural Networks using Information-Gap models. The key idea was to use interval arithmetic, to see how much variability was allowed on the input data (due to measurement noise) before the network started to fail. Computation was done by fusing together Netlab code and the new Matlab Intlab toolbox for interval arithmetic. The application was classification of faults from accelerometer data from a GNAT wing.

All in all, it was a highly successful and enjoyable meeting, and it was agreed that NCAF ought to return to Wales in the not too distant future.

Iain Strachan
AspenTech Ltd.

NEXT EDITION
Preview of the York meeting
Review of the Aston meeting

What can NCAF and DTI do for each other?

This is the challenging title that Nick Granville, Editor of NCAF *Networks*, has set for this article; and it has given me real cause for reflection, at a time of major change in the delivery of DTI's Science, Innovation and Technology strategies.

Take a look at the website http://www.dti.gov.uk/technologyprogramme/ and you will find the latest information about DTI's view of its role as the focal point for encouraging UK industry (and academia, Government, Regional Development Agencies and others), to put innovation at the heart of long-term economic plans and creating the best possible conditions for businesses to innovate and succeed. You will find that there is a newly-appointed Technology Strategy Board (TSB) in place, led by Graham Spittle, chair of IBM's Hursley Laboratory, that is taking decisions to complement the long-term strategy of DTI's Innovation Report and the Government's 10-year Science and Innovation Investment Framework.

DTI has now launched (on 29 November 2004), the next competition for funding in one of the two leading 'products' in its technology programme – Collaborative Research and Development. By the time you read this, detailed information about the launch should be available on the website. DTI will be seeking applications for the other product, Knowledge Transfer Networks (KTNs) in the New Year, when the TSB have had time to review the role of such networks.

So what has all this to do with NCAF, you may ask?

Well, I am sure that the nine technological clusters and interrelated applications in this competition, will provide interest and possible funding routes for many of the academics, industrials and business people (outlined in NCAF's Mission Statement), who consider themselves to be members of the NCAF community. For example, in the 'Imaging' cluster, there should be scope for close industry-academic collaboration, involving natural computing practitioners, in both the Healthcare and Crime Prevention themes. And on 'Pervasive Computing' there will be scope for work in AI and agent technologies and improvements in predictive modelling across several themes, with the latter also apparent in the 'Design, Simulation and Modelling' cluster.

But what about the networking?

From my personal viewpoint as an NCAF member, the NCAF aim to disseminate information on all aspects of natural computing, aligns well with the original DTI aim for the KTNs – of enabling the sharing of a host of useful information, including 'what's new' in technology or policy that may benefit or affect participants – as well as enabling members to find suitable, collaborative partners, or put forward their opinions and debate specific issues in their field of interest.

If you followed the FT's Mastering Innovation series, you will have seen Professor John Bessant's (Cranfield University) masterful article of 24 September 2004, on networks. He notes that "The challenge is no longer how to manage business, but how to manage it within the wider context of networks"; and that "Managing innovation is about bringing together different people and the knowledge they carry, and this involves building and running effective internal and external networks". He talks too, of additional "emergent properties" of networking, through which "participating in innovation networks can help even mature businesses bump into new ideas and creative combinations"; and of providing support for "shared learning within a network", with innovation being a "social process" that "involves people getting together and sharing ideas".

I personally believe that NCAF presents DTI with a great model of the sort of modern network that the UK needs to help to overcome its failure to convert its scientific research advantage into products and services (as Professor Bessant describes it). NCAF appears to exist (independently of government funding), because its members want to meet and share information in a friendly environment, and it has the enormous benefit of both industrial and academic champions who are prepared to put themselves out personally, to sustain it.

What do you think?

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DIARY DATES 2005

MEMBERS' NEWS AND VIEWS

Deadline for contributions for the next edition – 1 February 2005. Please send to Managing Editor – Nick Granville, e-mail: Nick.Granville@smith-nephew.com