ncaf Natural Computing Applications Forum

Networks

Disparate data collected for a common cause

Liverpool John Moores University, near Chester, 22–23 May 2007

The underlying need is the requirement to combine the patient's clinical signs with his or her molecular biomarkers.

The affordability of large-scale sensor systems, whether in engineering or bioinformatics, enables the compilation of complex data sets which do not always conform to statistical norms. One example of a multi-modal data combination is functional imaging, which fuses metabolic information from low-resolution magnetic resonance (MR) spectra with high-resolution anatomical MR images. The underlying need is the requirement to combine the patient's clinical signs with his or her molecular biomarkers. Fusing data sets of widely different natures is highly non-trivial and much more complicated than simply creating one large input vector containing the data from both (or all) sources. This is true whether one is interested in classification or clustering.

It is now commonplace to collect a larger number of covariates in a single observation than the overall sample size. Tissue micro-arrays are one example of this. This precludes the use of many traditional statistical approaches and stretches to breaking point the power of conventional neural network approaches. These data are typically hierarchical in nature, which introduces a further level of complexity into the analysis.

Finally, there is the issue of evaluation. When data and analytical models are as complex as those above, how do we interpret the final product? How do we assure inferences made by these models beyond limited out-of-sample assessments? Are these assessments sufficient, or can we do better by, for instance, translating non-linear high-dimensional models into simpler rules in the language of the user? Can we visualise the data so as to understand its structure and hence explore interesting features before identifying predictive variables? How can we do model selection with large covariate vectors, where some of the efficient methods that have proved robust for lower dimensional data, such as the Bayesian framework with approximation of the evidence, now become numerically unstable?

These issues will be debated at the next NCAF meeting to be held in Burton Manor, near Chester. The Manor is a historical house set in countryside near the picturesque hamlet of Burton, a stone's throw from the Ness Botanical Gardens and overlooking the Clwyd range set just the other side of the river Dee. This venue has a relaxed and homely atmosphere with catering to match. I look forward to seeing you there.

Professor Paulo Lisboa
Liverpool John Moores University

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Points of interest

- The AGM was held at the last meeting. Jo Thomas is the new Secretary, and Graham now has the joint role of Chairman and Treasurer. This is because NCAF has bought some accounting software, and it is logical that these roles be combined. NCAF is always looking for new members to join the committee to help with planning meetings and publicity.
- Students should still be planning to enter the 2007 Student Paper Competition to be held at the September meeting in Loughborough. Book tokens to the value of £150 will be awarded to the winner.

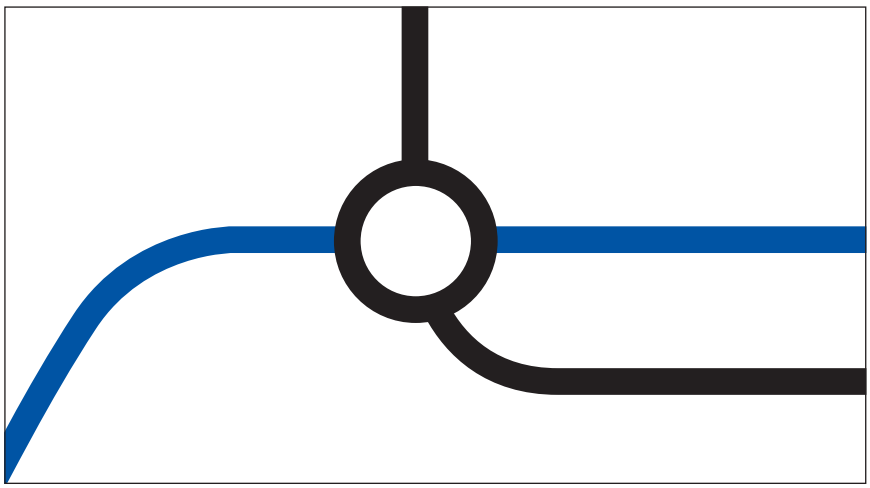
Editor

Visualisation in London

A consortium of chip suppliers, phone manufacturers, and network service providers needs to work as one team.

Despite the first snow of winter coinciding with January's meeting at the Department of Trade and Industry (DTI) in London, there was still a good turn out for this excellent NCAF meeting. Lee Vousden from the DTI welcomed us and explained that the theme of Visualisation of Complex Systems was related to recent DTI technology programmes. Lee asked us to look at the 'Intelligent Systems' element of the ITC strategy, and to contact him if we wanted to influence future initiatives.

Stuart Revell of Freescale Semiconductors UK Ltd gave a presentation on the validation of complex systems for the next generation of heterogeneous IP networks. The telecommunications area is growing exponentially in terms of power and bandwidth, and the boundaries with TV and other broadcast media are forever decreasing. This can lead to problems with performance. How to give users high quality experience and high quality of service are the twin optimising functions. This is a multi-supplier environment and it is vital that all players co-operate to deliver an integrated solution. Thus a consortium of chip suppliers, phone manufacturers, and network service providers needs to work as one team. Finally, the industry needs to interface to analogue legacy systems. This challenging collaboration is handled by HIPNet or Heterogeneous IP Networks. The HIPNet project helps the UK maintain its technological lead by the validation and verification of complex ICT networks. One aspect of network validation can be performed by a number of modelling activities, which can then be verified by comparison with the results from the network test-beds.



An excellent example of the visualisation of a complex system known to all Londoners is the underground map, first drawn by Harry Beck in 1933.

Geoffrey Butlin of TranscenData Europe Ltd. described the problem is linking different modelling packages. The geometry of design and machining (CAD/CAM) is concerned mostly with cutting the outside surface of a component whereas many finite element techniques are concerned with the geometry of what is left (FEA/CFD). An easy conversion would lead to such a complex array of shapes that the computation would be prohibitively long. To move from geometry one to another is not trivial and is best achieved with a medial plane – this being the locus of points described by the centre of largest inscribed spheres. The radii of the spheres give a guide to any simplifying assumptions. Small radii imply corners or narrow spaces which could be excluded from fluid flow, but could be critical in induced electromagnetic fields.

Alan Grigg of SEIC and Roger Bluff of Qinetiq spoke on the Visualisation of Complex Systems Performance. This was a presentation describing an approach that they would like to follow in order to model complex distributed architectures of multi processor/computer architectures. The proposal is that it should be based in part on reservation-based analysis with Matlab or Simulink as a front end visualisation tool. The Universities of York and Loughborough are interested in the project, which has yet to be funded. It would be interesting to revisit this project once it is started.

Jet engine vibrations

David Clifton of Oxford University is the first person to have met his future wife at an NCAF meeting. He returned to give us an update of what is happening with Lionel Tarassenko's group at Oxford when he talked on novelty detection in jet engine vibrations. The health monitoring of the Rolls Royce Trent jet engines is an activity that has been studied by the Oxford group for some time. Apart from the cost and mission critical nature of a jet engine in use, the problem is technically complex since there are three independent concentric shafts that may spin at speeds unrelated to one another. Thus normal harmonic analysis is not applicable and the complex vibration spectra are divided into ten frequency bands. The novelty in ten dimensions can be handled by software, but the visualisation by a human observer is not trivial. One technique is to use Sammon mapping and condense the 10-dimensional space down to 2 dimensions for an X-Y representation.

Robert Leese of the Smith Institute and Director of a Knowledge Transfer Network gave an introduction to the Industrial Mathematics KTN. Since starting in late 2005, they have been in touch with nearly 300 companies and 50 funding sources, giving £1.7m of new investment each year. They specialise in understanding industrial problems and establishing links with appropriate mathematics departments throughout the UK. The talk was peppered with some examples of emergent behaviour of complex systems, how connectivity and networks evolve and why decoy marketing works.

Nick Granville of Smith & Nephew explained his midnight oil solution to solving the problem with too many variables, and not enough data. The data set comprised the size of wounds of 200 patients and how these evolved over time. 50 characteristics of each patient and up to 2,000 spectroscopic variables were recorded. After reserving records for testing, there were only 150 records left, and it was desired to select only five inputs per network to avoid overfitting. There are over 10^{15} ways to pick five from 2,700 which will take millions of years to solve. The trick was 'Moonlight Computing' and all available PC's at their offices were programmed to run the problem overnight. Each programme chose five variables at random and trained to convergence against a test set. After two nights the 100 worst performing variables were discarded from the data set, and the procedure repeated. A satisfactory solution was obtained within six months, using no specialist hardware, and at no time was an overfitting solution attempted.

'Fenella' persuaded a number of those present to act the solution to the riddle of why the Bayesientologists celebrated their gathering on Halloween. Peter Cowley, an ex-chairman was the only member to have come within 24 hours of a correct solution. This was followed by the buffet to the usual high DTI standard, after which Lee Vousden and Ray Browne staged a double act. Lee had set a general knowledge quiz. Every correct answer allowed the team to try out Ray's Wii bowling game, which determined the points scored for a correct answer.

The second day started with Rajesh Ransing of Swansea University presenting 'Doing What Comes Naturally', describing self-learning systems for industry. The essence of the project was to distil best practice from a set of self-learning tools that included

How mathematics can help industry

Mathematical modelling, simulation and analysis are indispensable tools for accelerating business innovation. They bring fresh approaches to problems in design, product and service development, operations and strategy. Their power is enhanced by the unparalleled versatility of mathematical thinking. This allows the Industrial Mathematics Knowledge Transfer Network (KTN) to address challenges across all business sectors and across all aspects of company activity. Our breadth of coverage unlocks a further competitive advantage for our industrial partners, through the ability to transfer and adapt techniques that underpin similar problems in other areas. We bring fresh thinking to difficult problems and delivering results that can be easily implemented.

The Industrial Mathematics KTN was launched in February 2006 and is managed by the Smith Institute for Industrial Mathematics and System Engineering. The network is a key element in the UK's cross-governmental Technology Programme, where it is leading the development of the associated Technology Strategy for Modelling and Simulation.

The Smith Institute's team of experienced Technology Translators provides companies with a first point of contact, where we match business requirements with mathematical know-how and turn mathematical results into exploitable actions. The KTN incorporates unparalleled connections into the mathematical science base. Our company partners have easy access to the ideas and experience of the UK's leading industrial mathematicians. We build the collaborative relationships that will underpin innovative performance in the long term by bringing leading university research groups into close contact with key business activities.

The following case study is an example of the work of the KTN. When the Kent Forensic Imaging Group and their industrial partner, VisionMetric Ltd of Canterbury and Hatfield, bid for a CASE studentship, they were confident that they would be successful. The team was part of an internationally renowned research group and had won several previous research grants.

The grant proposal was part of a major research effort being carried out within the Kent Forensic Imaging Group, which has seven members and a laboratory equipped with state-of-the-art imaging and computer facilities. The group's role is to develop a superior and novel facial composite system. Facial composites (often known as Photo-fits or E-FITs) are used to assist Police Forces in criminal investigations. The system being developed at Kent, known as EigenFIT, combines a statistical model of facial appearance with an interactive, evolutionary search algorithm for the witness to operate to achieve the desired likeness. The CASE studentship aims to put facial recognition on a sound mathematical footing and will encourage the exploration of compact, parametric representations of human facial appearance based on linear and non-linear approaches.

The studentship bid was reviewed and is now supported by the Industrial Mathematics KTN. Chris Solomon, Technical Director of VisionMetric Ltd, said that "the grant review was very thorough" and that the KTN "asked a lot of very searching questions, despite our pedigree". Chris was impressed that "the discussion with the KTN was very constructive, and improved the project". Following the award Chris added "we felt that the rigour of the process made the award a 'feather in our cap' when we were successful".

KTNs exist to play a vital role in making the necessary connections between the various parties to a knowledge transfer system. These parties do not just include the technology providers and the business organisations with the need, but also the DTI which has an important role to play within the Government. So the KTN needs to provide a forum for a coherent business voice to inform government of its technology needs and about issues, such as regulation, which either enhance or inhibit innovation within the UK.

It is so much more than just asking an academic to talk to an industrialist. Please contact me for more information or register your interest at www.industrialmaths.net.

Claudia Centazzo, The Smith Institute
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both the design of experiments (DOE) and receiver operating characteristics (ROC). The software, X1 Recall, is intended to represent best possible practice even with an inexperienced user. More ambitious is to use the same technology in healthcare. Relevant and reliable patterns could be discerned and could used for diagnosis and medical training purposes.

Black body radiation

Andy Pryke of CERCIA talked on the visualisation of multi-objective algorithms. More and more analysis is being carried out in multiple dimensions and complex relationships need to be visualised to aid user understanding. Data reduction methods such as Pareto fronts and Sammon mapping allow a two dimensional surface to be created, but this loses much of the richness of the data. Various forms of self-organising maps are possible, but they can also be hard to interpret. The Birmingham vision is to present numerous pairwise data plots with an efficient use of colour. Using the analogy of black body radiation, such representation is called a heatmap. Several promising multi-variate data sets were presented with this technology, but it was clear that one must pay particular attention to what one is wishing to present and understand from the data.

Rui Zhang, also from Oxford University gave a talk describing complex service-oriented systems. Rebooting one computer in a cluster of 15,000 may be part of an efficient and robust recovery strategy, even if rebooting one computer out of one on our desk is seen as a sign of defeat. There can be a hierarchy of rebooting actions such as 'Microboot > Backend reboot > Container reboot > OS reboot > Manually investigate if a double occurrence'. Rui's work studies different approaches to rebooting.

Rade Ognajanovic of Innoval Technology Ltd gave the final presentation on the use of neural networks to predict fabric mechanical properties. Individual fibre properties can be mapped into complex woven fabric structural behaviour. There is too much of a jump between the basic material and the final structure. Rade introduced elements at an intermediate scale to make the link. Individual carbon fibre strands were scaled up to yarns and physical properties of the yarn structure were mapped by neural network models. The yarns were then mapped to fabrics of different weaves. This process allowed the modelling of a range of fabrics from theoretical principles before weaving. It is possible to design fabrics that are strong in tension, but pliable in shear. Such behaviour allows a strong construction, but a good drape of the fabrics over the object or person to be covered. It was a very nice application and a 'fitting' conclusion to a first rate meeting.

Peter Herdman and Sylvia C. M'Bemba Arjowiggins

PUZZLE CORNER

Number 35

At the Friday night poker school in the Beverley Hills YMCA, Lisa found herself in a head-to-head No Limit Texas Holdem tournament with local hero Wild Bill Sklansky. With starting stacks of $10,000 and initial blinds at $100 and $200, Lisa was very pleased to receive a pair of aces for her opening hand. First to speak, and trying to contain herself, she casually tossed in a raise of $600 and was even more pleased when Wild Bill re-raised another $600. Knowing that Pocket Rockets pre-flop are the best hand going, Lisa re-raised another $600 and was gratified to hear Bill call. With $,4000 already in the opening pot this was going to be a nice hand to start the heads-up tourney.

The flop came down A♦ K♣ 6♣, and Lisa immediately regretted letting out a whoop of,"Mama hit the mother lode!" Her pocket Aces (A♠ A♥) now effectively exposed she was just wondering how she could make any more decent money out of Bill on this hand when he countered with "Bullets are always nice when the flop delivers an ace, but you're still only about a 2-1 favourite here". Knowing that Bill was fiercely proud of his analytical skills and would always play a hand strictly by the odds, Lisa could now see a way to maximise her expected return. Showing Bill her aces, she questioned his ability to correctly assess his chances and was rewarded when he indignantly bared his hand to verify his claim.

Given that Bill was correct, what are the best possible cards he could have, and what is Lisa's expected gain on the hand?

The answer will be given at the next NCAF meeting (22–23 May 2007, Liverpool John Moores University).

Fenella the Rottweiler

COMMITTEE NOTES

MEMBERS' NEWS AND VIEWS

Deadline for contributions for the next edition – 1 July 2007.
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NEXT EDITION
Review of Liverpool meeting
Preview of Loughborough meeting

The self-diagnosing computer that learns from its mistakes

Engineers at Swansea University have developed software that enables computers to learn from their mistakes. The software, called X1 Recall, uses artificial intelligence (AI) to help manufacturing companies eliminate waste and improve quality control in their production processes.

The system is the result of a research project undertaken by Dr Rajesh Ransing, of the School of Engineering. The first phase of the research was funded by the Engineering and Physical Sciences Research Council (EPSRC), and the latter stages of the project have been supported by a £200,000 Knowledge Exploitation Fund (KEF) grant from the Welsh Assembly Government with equal participation from a number of Welsh companies.

Reducing the amount of scrap produced is one of the biggest challenges facing the manufacturing industry. Scrap consumes materials, energy and time, and the cost of re-working products can be a major drain on a company. The ultimate result of this research should see the commercial development of self-learning software that enables industry to produce defect-free components right the first time, providing a quality control process that is, by its very design, continually improving.

X1 Recall has the potential to be used in any manufacturing situation where the production process relies on close management of a range of factors and variables, such as temperature or chemical composition. The software collates and analyses cause and response data from the manufacturing process, looking at how changes to different factors affect the quality of the end product. Where malfunctions, machinery breakdowns or faulty products result, the computer can examine the potential causes and recommend appropriate adjustments to the settings and variables. The recommendations are based on empirical evidence collected over time.

The technology behind the system has been tested and proven in collaborative partnership with companies including Rolls Royce, the Cast Metals Federation (CMF), and several smaller businesses. A prototype is now being developed for use in industrial settings via a University spin out company, MetaCause Solutions Ltd.

The UK's manufacturing industry faces stiff competition from other countries, particularly those with lower cost bases such as China and India. The opportunity to generate substantial cost savings by reducing waste and improving quality cannot be over-emphasised. As part of the deal with the KEF, member companies of the CMF who wish to use the software when it becomes commercially available will have access to the technology for five years at a small fee, in return for their participation in the commercial development process. This will give UK companies an edge over their international competitors.

The NHS may also benefit from X1 Recall, facilitating more consistent diagnoses and treatments for patients, particularly in terms of recommending medical and pharmaceutical interventions. Hospitals rely on pharmaceutical companies to advise on the appropriate dosage of their products in treating different conditions, but doctors very often develop their own gut feeling on treatments, perhaps increasing or decreasing dosages according to their experience of the drug. However, if doctors move on to different roles, hospitals lose their experience and knowledge. X1 Recall will have the ability to analyse patient records across the NHS, learn from the combined experience of all doctors, and recommend appropriate courses of treatment based upon the collated evidence.

This represents a rare success story for a natural computing application that is about to enter the business world. The Editor would be pleased to include other successes in future editions of *Networks*.

Nick Granville
Editor (based upon a news release from the University of Swansea)

DIARY DATES 2007

21–27 July – ISSPR and IWAPR 2007: International Summer School on Pattern Recognition and International Workshop on Advances in Pattern Recognition. Plymouth, UK.
http://www.paaonline.net/isspr/ and
http://www.paaonline.net/iwapr/

12–17 August – IJCNN 2007: 2007 International Joint Conference on Neural Networks. Orlando, Florida.
http://ijcnn2007.org

29–31 August – EANN 2007: 10th International Conference on Engineering Applications of Neural Networks. Thessaloniki, Greece.
http://skyblue.csd.auth.gr/eann2007/

9-13 September – ICANN '07: International Conference on Artificial Neural Networks. Porto, Portugal. http://www.icann2007.org/

19–20 September – NCAF meeting (theme to be confirmed) at the Systems Engineering Innovation Centre, Loughborough University. For information, email enquiries@ncaf.org.uk or telephone +44 (0)1332 246989.

25–28 September – CEC 2007: IEEE Congress on Evolutionary Computation. Singapore.
http://www.cec2007.org/

10–12 December – AI-2007: 27th SGAI International Conference on Artificial Intelligence. Cambridge, England.
http://www.bcs-sgai.org/ai2007/