Dave Broomhead’s 60th Birthday

Muldoon, Mark and Huke, Jeremy and Smallbone, Kieran

2011

MIMS EPrint: 2011.27

Manchester Institute for Mathematical Sciences
School of Mathematics
The University of Manchester

Reports available from: http://eprints.maths.manchester.ac.uk/
And by contacting: The MIMS Secretary
School of Mathematics
The University of Manchester
Manchester, M13 9PL, UK

ISSN 1749-9097
Dave Broomhead’s 60th Birthday

On 15–16 November 2010, friends and colleagues from all walks of Dave Broomhead’s wide research career gathered at a meeting in honour of his 60th birthday.

Dave is Professor of Applied Mathematics at the University of Manchester. Following a DPhil in theoretical chemistry, he held a NATO Postdoctoral Fellowship in the Department of Physics at the University of Kyoto. Dave then worked as a Senior Principal Scientific Officer at the Royal Signals and Radar Establishment (RSRE) at Malvern (latterly QinetiQ), before taking up a chair in Manchester.

Since the early 1980s, one of his main interests has been the development of methods for time series analysis and nonlinear signal processing using techniques from the theory of nonlinear dynamical systems. He has done interdisciplinary research through application of these ideas to a wide range of areas: mathematics, physics, signal processing and electrical engineering whilst in Malvern, and new collaborations in life science and systems biology since moving to Manchester.

Dave is currently director of the Centre for Interdisciplinary Computational and Dynamical Analysis (CICADA) who hosted this meeting. Dave is also a Fellow of the Institute and Editor of this publication.

Elastic instabilities lead to novel material properties

Tom Mullin (Manchester) met Dave at Oxford in a cupboard. As with all the speakers, he benefitted greatly from discussions with him. He spoke about how elastomeric cellular solids with holes arranged on a square lattice respond non-uniformly to uniaxial compression. These phenomena, discovered at the millimetre scale, can be applied to the nanometre scale to create tunable, scaleable auxetic crystals.

Where do instabilities go?

George Rowlands (Warwick) was Dave’s post-doctoral supervisor. He spoke about fusion reactors and the transition of plasma from an unstable state to two possible final states. By using Lagrangian methods some clues have been obtained about the transfer process, to ensure the plasma organises itself to go to the ‘good’ state.

Data, neurons and what happens next

Richard Clement was a colleague of Dave’s in Malvern. He presented his findings from a collaboration on applying dynamical systems analysis to the oculomotor system, with the help of spinning tops and optical illusions. The talk culminated with an argument that the visual objects which brains are capable of attending to depends on the type of maths of which they are capable.

Mathematics and biology – an overview

Douglas Kell (Manchester, BBSRC) and Dave enjoyed an extremely fruitful collaboration together, leading to many research papers and funding grants. Doug summarised a few strands of activity that show not only what mathematics can bring to biology but also what biology can bring to mathematics.

Speech analysis and synthesis based on dynamic modes

Steve McLaughlin (Edinburgh) showed that speech can be understood as a superposition of modes associated with physiological aspects of the vocal system such as vocal chords and lips. By using a framework based on dynamic mode predictors and filters, adapted using gradient-based techniques, a high-resolution representation of the speech signal can be obtained.

Another view from the Malverns – the third dimension

John McWhirter CMath FIMA (Cardiff) is another colleague of Dave’s from the signal processing group in Malvern, now working in Cardiff. He presented his recent work on the general Kogbetliantz algorithm for polynomial SVD and its applications in underwater acoustics or multichannel allpass filters for power-line communications.

Time stealing: An adventure in Tropical land

Marianne Johnson (Manchester) is a member of CICADA, who presented an entertaining analogy between ‘Tropical geometry land’ and ‘Alice’s Adventures in Wonderland’ from the book of Lewis Carroll. In particular, by applying tropical geometry, one can model and optimise the use of asynchronous processes in the design of digital hardware. Or, as the Duchess said, ‘If everybody minded their own business, the world would go around a deal faster than it does.’

Fractal Skeletons: The universality in death by starvation

Celso Grebogi (Aberdeen) was inspired by reading Dave’s work in the 1980s, though he didn’t meet him until the 1990s. He showed that, if the dynamics of active particles in flows – such as growing populations of plankton in the oceans – is chaotic, then necessarily the concentration of these particles have the observed fractal filamentary structures. These skeletons yield an unusual singularly enhanced productivity that could explain the paradoxical coexistence of such a large number of plankton species.
A mathematician’s view of circadian rhythms
David Rand (Warwick) is a long-time collaborator of Dave’s. He summarised his view of what are the most important questions about circadian rhythms at the single cell level, motivated by recent experimental results and mathematical ideas.

Ants and slime mould solve the Towers of Hanoi
David Sumpter (Upsalla). In 2004, Dave – David’s then PhD supervisor – suggested that one could test whether ants could solve the famous Towers of Hanoi problem by mapping the problem onto a graph. Indeed, both ants and acellular slime mould can solve the problem. Moreover, by linearly reinforcing the edges of a graph, a mathematical model predicts that ‘simple’ organisms are guaranteed to find the shortest path through a graph.

David dedicated the following paper to Dave on the occasion of his 60th birthday: Reid, C. R., Sumpter, D. J. T. and Beekman, M. Optimization in a Natural System: Argentine Ants Solve the Towers of Hanoi, Journal of Experimental Biology.

Data reduction: A view from the Rockies
Michael Kirby (Colorado) presented some geometric approaches for analyzing data cubes. His application – the set of all of English chess grandmaster Michael Adams’ games – led to a dataset of around chess 300,000 boards. By drawing ideas from geometry to the encoding of such massive data-sets, Michael illustrated how interesting information can be extracted.

Mathcentre: Online drop-in support for mathematics resources

Mathcentre was developed in 2003 to ease the transition of students from school to university mathematics. It has grown into an on-line mathematics support centre for both students and staff providing access to over 1,000 individual resources and receiving on average over 21,800 requests per day. The level of mathematical topics covered ranges from what a student might expect in a post-GCSE programme to what they might meet as they progress through their first year of university studies.

The national support framework, conceived in 2002, consisted of the website www.mathcentre.ac.uk and a set of DVD-ROMs containing learning resources. Known as mathtutor, these also could be accessed from www.mathcentre.ac.uk. The intention was that students looking for drop-in support would access mathcentre whereas those wishing to follow a more structured course would make use of mathtutor. Partners for mathcentre were Loughborough, Coventry and Leeds Universities in association with the Higher Education Academy Mathematics, Statistics and Operations Research (MSOR) Subject Centre and the site, funded by the Higher Education Funding Council for England (HEFCE), went live in 2003. The same team together with the former Education Broadcasting Service Trust were responsible for mathtutor. Funding for this part of the project was received from the HEFCE Fund for the Development of Teaching & Learning and the Gatsby Technical Education Project in association with the Higher Education Academy.

Mathcentre has continued to expand with the addition of many new resources responding to the needs of active and enthusiastic users. Both mathcentre and mathtutor websites were upgraded in 2010 with funding from JISC [1] and have easy-to-access interfaces.

Students using mathcentre
Students may use mathcentre in a variety of ways. Whether they need a quick explanation on a particular topic, structured revision or wish to practice examples, resources covering a multitude of mathematical topics are available online or to be downloaded to their computer, iPods or mobile phones.

Key to an online support centre is the ability to locate the resource that is going to help you quickly and easily. mathcentre provides four way of doing this:

• by Course. “I am studying Engineering, what mathematics topics are covered?”
• by Topic. “I have a query on Integration, what resources are available?”
• by Resource type. “I would like to test my knowledge. What diagnostic tests and exercises are available on Differentiation?”
• Let me Choose. mathcentre offers a full search facility using keywords.

New developments
The JISC funded upgrade in early 2010 provided the opportunity to licence all mathcentre resources under Creative Commons [2] licences. Accessibility was improved by utilising san serif fonts throughout and allowing the font size and foreground/background colours on the site to be tailored to a user’s needs.

As new resources are developed, they are made available through mathcentre. Recent additions are Quick Reference leaflets and Video and iPod tutorials on complex numbers and matrices from sigma [3]. Through the IMA, with funding from the national HE STEM Programme, the sigma mathematics and statistics support network [4] has recently been launched. This is a free association of staff and institutions involved in providing mathematics support to students, generally those at the transition to university study. It aims to share resources and experience. The backbone of the resource base for the network is the mathcentre site.

During the upgrade, existing mathcentre resources were enhanced in two ways. A version of the Algebra Refresher Practice & Revision booklet is available with dynamic on-line links to other mathcentre resources such as video tutorials and quick reference leaflets. 12 Teach Yourself booklets covering calculus are now available with links to the STACK (System for Teaching and Assessment using a Computer Algebra Kernel developed by Dr Chris Sangwin of Birmingham University). Students may