Science and Technology Christmas Conference

Tuesday 16 December 2008 - Management School Building

The Faculty of Science and Technology's annual Christmas Conference is a chance for faculty members to hear talks from colleagues in other departments, as well as presentations from invited speakers.

0900	Tea, coffee and pastries		
0920	Welcome from Associate Dean for Research Colin Lambert		
0930	Session One: Talks from Physics, Engineering and Mathematics & Statistics		
1045	Tea and coffee		
1115	Session Two: Talks from Psychology, Communication Systems and Computing		
1230	Lunch - Posters will be on display during lunch and onwards		
1400	Why should scientists bother getting involved in public affairs?	Peter Cotgreave	Director of Public Affairs, The Royal Society
1500	Mince pies and mulled wine - Poster prizes awarded		
1530	Session Three: Talks from Lancaster Environment Centre		
1620	Closing presentation from Dean of Science and Technology Mary Smyth		

Session One

Where Galaxies Really Come From

Kostas Dimopoulos **09:30-09:55**

Modern cosmology concludes that structure in the Universe, such as galaxies and galactic clusters, is due to a tiny perturbation in the density of the gaseous content of the Early Universe. This perturbation is thought to be of quantum mechanical origin and it is generated during a period of ultra-rapid expansion of space, called cosmic inflation.

This talk, by the Physics Department's **Kostas Dimopoulos**, will give a descriptive summary of how this perturbation is created and then discuss what kind of fundamental fields can be involved in its formation and whether they correspond to particles that are observable in colliders, such as the Large Hadron Collider in CERN.

A new scenario involving vector boson fields, with its distinct observational signatures in the Cosmic Microwave Background radiation, will be briefly outlined.

Engineering Challenges of Particle Accelerators

Richard Carter **09:55-10:20**

Engineers seek to respond to human needs and aspirations. They do this by drawing on the vast accumulated knowledge of the profession and by engaging in research to meet new challenges. An example of this process is found in the design of particle accelerators for advanced scientific research.

Particle accelerators are essential research tools in many fields of science and technology. The use of machines such as the Large Hadron Collider at CERN to probe the fundamental secrets of the universe is well-known. Other, less familiar, machines are used to make progress in life sciences, surface and materials science and nano-technology. All accelerators employ high power radio waves to accelerate tiny bunches of charged particles to speeds approaching that of light. The particle bunches may be used directly in scientific experiments or to generate other particles or intense light for that purpose. The development of these machines provides great challenges for the engineers who design and build them.

This talk, by **Richard Carter** of the Engineering Department and Cockcroft Institute, will describe some of the engineering challenges involved in developing accelerators and illustrate them from research being carried out in the High Power Microwave Research Group in the Engineering Department.

Using statistical methods to analyse environmental extremes

Emma Eastoe **10:20-10:45**

Statistical methods for the analysis of extreme values are useful when trying to estimate or predict characteristics of the tails of a statistical distribution.

For example, they may be used to estimate the N-year return level, i.e. the level exceeded on average once every N-years, where N is much larger than the number of years n of data that have been observed, or to find a distribution for the series of annual maxima.

Applications can be found in areas as diverse as structural engineering, hydrology, finance, insurance and communications. Interesting issues arise when the underlying (physical) process from which the data are produced varies with time and/or covariates, since care is then required in both the definition of and the model for extreme events.

In this talk, by **Emma Eastoe** of the Department of Mathematics and Statistics, the focus is on a hydrological application in which an improved model for the number of flood events in a year at a particular site is sought. A flood event is defined using the peaks over threshold method, so that events occur when the river flow exceeds some high threshold.

By definition the number of events in each year is low. The simplest model is a Poisson process, with constant rate parameter, for the number of events in a year.

Such a model can be improved by accounting for between-year variation in the number of events, using a random effects model, and by accounting for within-year variation in the rate of occurrence using a covariate model.

By assuming a distribution for the size of the event peaks, quite different distributions for the annual maximum flow are obtained for each of the models for the number of events discussed.

Session Two

Learning motor actions by observing others: The roles of the mirror neuron system and prefrontal cortex

Stefan Vogt **11:15-11:40**

Mirror neurons become activated both during performing actions and whilst observing another individual performing a similar action. Two main functions of these neurons are understanding the actions of others, and, predominantly in humans, imitation. Mirror neurons are thus a crucial building block for social interaction and communication. Are these neurons also involved when novel actions are learned via observing others?

This talk, by Psychology's **Stefan Vogt**, will outline a series of brain imaging studies employing functional magnetic resonance imaging (fMRI), which have explored the role of the mirror neuron system in learning novel actions by observation.

Participants were scanned whilst they imitated unfamiliar hand actions (guitar chords). It was found that:

- The mirror neuron system is indeed involved in imitation learning
- It is involved more strongly for novel actions than for familiar actions
- The dorsolateral prefrontal cortex (DLPFC) was activated during imitation of novel actions.

The DLPFC is a high-level control system which was likely engaging in restructuring the represented motor elements into a complete finger configuration.

A further study demonstrated that chords can also be learned by pure observation. Participants who benefitted most from this observational practice showed stronger activations in DLPFC as well as in posterior parietal cortex, which most likely engaged in transforming the observed actions into motor and tactile signals. This opens up an interesting avenue for optimising observational learning procedures in sport and rehabilitation of motor function.

Ongoing research contrasting the imitation of hand postures with imitating sequences of finger movements and rhythms. Whereas the sequences largely engaged the same cortical regions as the hand postures (mirror neuron system), the rhythms mainly activated the human expressive speech region ('Broca's area').

Thus, the primary cortical representation system can vary according to the type of action observed. In addition, DLPFC tended to be less activated for the rhythms than for the sequences and hand postures: one possible explanation is that rhythms are encoded in a specialised system which does require less supervisory control than spatially oriented actions such as postures and sequences.

Evolving Intelligent Systems - Concept, Applications and Opportunities for Security Systems of the Future

Plamen Angelov **11:40-12:05**

Research into innovative computational intelligence methods to deal with data streams in real time will be presented by **Plamen Angelov** of Communication Systems.

By using fuzzy rule based systems to capture knowledge from the data streams by on-line learning of both their parameters and structure a series of powerful computational engines were pioneered at Lancaster - evolving clustering (eClustering), classifiers (eClass family), predictors (eTS family), controllers (eControl). They can be seen as fuzzy blends of locally valid Gaussian filters and also as self-developing neuro-fuzzy systems. They possess a high level of adpativity to unknown environments and have been applied to a range of practical problems:

a) intelligent sensors in oil refining (CEPSA Total) and chemical industry (Dow Chemical);

b) on-line machine health monitoring and prognostics (Ford);

c) autonomous systems for passive sense and avoid algorithm (BAE Systems);

d) landmark recognition and self-localisation of robots;

e) cyber security (hacker attacks and intruders detection, user behaviour modelling);

f) surveillance: object detection and tracking.

This approach possesses significant potential to be used in the security systems of the future for the following reasons:

a) evolving intelligent systems are convenient and rigorous tool for integration of expert knowledge and learning from data and experience;

b) they can integrate the behavioural and psychological aspects of a security system and technological (engineering, mathematical, statistical);

c) they can deal with uncertainties and linguistic variables such as Anxiety, Fear, Hesitation which are hard to be quantified otherwise;

d) they tolerate imprecision. Interest to this original methodology for designing innovative in-flight security systems has been expressed by companies such as ULTRA and Thales.

Such research can be a building block in the new Centre on Behavioural Security Technologies (CBEST) that combines the efforts across the Faculty (led by the Psychology Department, Prof. T. Ormerod it also involves Communication Systems, Computing, and Engineering Departments) and is currently in its infancy.

Firefly: Highlighting future trends in computer systems

Joe Finney **12:05-12:30**

Project Firefly is an ongoing research and development project within the Computing department at Lancaster that is investigating ways of building coherent, self-organizing display surfaces. In other words, bringing the pixels off a computer screen and into the real world. A public deployment and field trial of Firefly is already underway in Dalton Square, Lancaster, and was recently featured on BBC1 North West.

Using Firefly as a case study, this talk by **Joe Finney**, Computing Department, will provide a conceptual overview of how the technology operates, the advantages it brings, and through this will highlight some future trends, challenges and opportunities in computing.

Computers have now become commodity items. Most people now treat the presence of a computer in the home or at work with about the same enthusiasm as a washing machine, and they cost about the same amount too. In fact, home computers can now often be found on sale in supermarkets somewhere between the cheese crackers and last year's Easter eggs...

Some people believe the commoditisation of computing spells the end of the recent boom in the development and utilisation of innovative computer systems and applications. In reality, this couldn't be further from the truth. Computing is being applied to an increasingly diverse range of new and exciting scenarios, and this is resulting in the development of new and novel technologies, many of which we use every day without giving them a second thought. By using Firefly as a worked example, this talk will highlight how we are slipping into a whole new era of computer systems.

Why should scientists bother getting involved in public affairs?

Dr Peter Cotgreave **14:00-15:00**

The invited speaker for our 2008 conference is Dr Peter Cotgreave, Director of Public Affairs, The Royal Society.

Why should scientists bother getting involved in public affairs? What influence can they have collectively or individually? How can we overcome the cultural differences between science and policy-making and the timescales on which they operate? How can scientists change the terms of debates that they have an interest in? How important is indirect influence, such as working through the media, relative to direct influence on policy-makers and politicians? What opportunities exist to get involved?

Good recent case studies that illustrate some of the answers to these questions are (i) the stem cell legislation that is going through Parliament at the moment and (ii) the funding furore over STFC that blew up earlier this year.

Session Three

Soil-water systems and the future of civilization

Phil Haygarth 15:30-15:55

Soil and water systems provide a critical interface for the earth's biogeochemical cycles and platforms for supporting human activities.

This presentation by **Phil Haygarth** of the Centre for Sustainable Water Management, Lancaster Environment Centre will explore how soils provide a 'junction box' for a range of ecosystem services. Special focus is given to the provision of clean and plentiful water for society, particularly in context with management of agricultural land. Historically, the relationship between agricultural soil and water has been on a substance by substance basis, with interest in nitrate, phosphorus, sediment/colloids, pathogens and organic substances. Diffuse substance transport can be conceptually broken into sources, their subsequent mobilisation, transport and finally impact on receiving water body. Issues of flood and water management are also influenced by land management. A new paradigm is emerging akin to 'systems biology of the landscape' that is growing from our ability to measure and sense soil-water systems at multiple scales and in high resolution. We must embrace the complexity this reveals by adopting the best mathematical techniques, working towards multiple spatial and temporal models for prediction.

New advances in observation can help refine our empirical understanding across all scales and can, in turn, help feedback on hypotheses tested, setting new challenges for reductionist approaches. Thus we must grasp soil and water system science, addressing issues across multiple scales and disciplines (from 'plant to planet'). Whilst soils are relatively resilient and underpinning, water is a more temporally dynamic and thus a more sensitive barometer of pressures and responses. We must work towards a new vision for sustainable water management in context with today's needs that embody multiple-media and multiple quality indices, in context with changes in climate and societal pressures for land use and secure water and food supplies.

This provides some exciting challenges for the Centre for Sustainable Water Management and will help contribute towards our future strategy in Lancaster Environment Centre and the University.

Is there too much 'water' in water research? Bringing the social dimension into sustainable water management

Will Medd **15:55-16:20**

There is arguably too much focus on 'water' in research on sustainable water management - sustainable water management (SWM) is not just a question of getting the science and technology right.

SWM is inherently social, cultural, economic, political. There has been growing recognition in SWM that social science research, in its broadest senses, has to be more than an interdisciplinary 'add-on' to more natural science questions. Social science has fundamental contributions to make to SWM, from developing our understanding of the routines and habits of everyday water consumption to how we can better understand the potential for building resilience to future flood impact.

Using the examples of research projects on the social dimensions of both flood and drought this presentation by Lancaster Environment Centres **Will Medd** will give a flavour of the potential of the social science contribution to an interdisciplinary research agenda on SWM.