School of Computer Science

RESEARCH NEWS

Welcome to the first research newsletter for the School of Computer Science at the University of Nottingham.

Research in the School is organised around groups. Currently these are:
- Automated Scheduling, Optimisation And Planning
- Intelligent Modelling and Analysis
- Function Programming Laboratory
- Agents Laboratory
- Computer Vision Laboratory
- Mixed Reality Laboratory
- Data Science

These groups can be found at the research web page for the School - http://www.nottingham.ac.uk/computerscience/research/researchintro.aspx

In this newsletter we have highlighted some of our recent grant successes, PhD completions in 2015 and short introductions on new staff.

One recent highlight is our performance in the Research Excellence Framework 2014. We were placed 9th in the whole country based on the score that combines number of staff and our scores with 88% of our research internationally excellent or world leading.

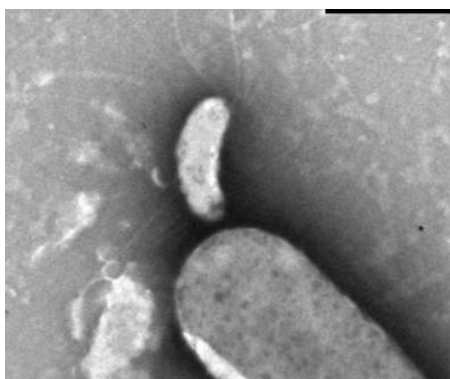Finally, I would like to thank Nadine Holmes for putting this together.

Bob John
Director of Research

AWARDS THIS ACADEMIC YEAR

Bdellovibrio – Bacterial Security Guards against Dangerous Pathogens – Defence Advanced Research Projects Agency (DARPA)
JAMIE TWYCROSS (PI – PROFESSOR LIZ SOCKETT, SCHOOL OF LIFE SCIENCES, COLLABORATION WITH DR MATHEW DIGGLE, NUH EMPATH)

The Pathogen Predators program will test whether infections, caused by drug-resistant bacterial pathogens and bacterial threat agents, might be effectively treated with live predatory bacteria. This approach would represent a significant departure from conventional antibacterial therapies that rely on small molecule antibiotics. While antibiotics have been remarkably effective in the past, their widespread use has helped to select for the emergence of antibiotic-resistant bacterial infections that are difficult or impossible to treat. The novel path explored in this program relies on the existence of predatory bacteria that prey upon and consume other Gram- negative bacteria. Our goals are to evaluate three strains of predatory bacteria as anti-pathogen agents. Through a combination of experimental lab work and computational modelling, we will evaluate these strains on five antibiotic resistant bacteria, and five NIAID CatA/B bio hazardous bacteria.

Automated Intelligent Decision Support Using Hyper-Heuristics – Royal Society (Newton International Exchanges)
ENDER OZCAN

This grant will support a two-year long collaborative research project through exchange of visits with Prof Nelishia Pillay and a PhD student from the School of Mathematics, Statistics and Computer Science at University of KwaZulu-Natal. Intelligent decision support systems are playing an increasingly important role in providing solutions to various computational problems in society, industry, academia and government. However, the design, development and maintenance of heuristic methods underpinning those intelligent decision support systems are extremely challenging, time-consuming and so costly, often requiring human expert intervention. This collaboration aims to study adaptive, effective, generic, reusable and low-cost hyper-heuristics automating the heuristic design process for intelligent decision support, focusing on vehicle routing, packing and timetabling domains.

Homotopy Type Theory - EPSRC
THORSTEN ALTENKIRCH

The cost of software failure is truly staggering a 2008 study by the US government estimated that faulty software costs the US economy £100 billion annually

Programming languages and interactive proof systems have been developed based on a formal system called Martin-Löf Type Theory. In these systems, we can write programs, express properties of programs using types, and write programs to express proofs that our programs are correct. However, in large projects, the issue of scalability arises: how can we use these systems to build large libraries of verified software in an effective way? This is related to the problem of reusability and modularity: a component in a software system should be replaceable by another which behaves the same way even though it may be constructed differently. That is, we need an "extensional equality" which is computationally well behaved. Finding such an equality is a fundamental and difficult problem which has remained unresolved for over 40 years.

Fields medallist Vladimir Voevodsky has come up with a completely different take on the problem by thinking of equalities as paths such as those which occur in one of the most abstract branches of mathematics, namely homotopy theory, leading to Homotopy Type Theory (HoTT). In HoTT, two objects are completely interchangeable if they behave the same way. The goal of our project is to develop the first of a new breed of HoTT-based programming languages and verification systems, and develop case studies which demonstrate the power of HoTT.

Certified Programming with Dependent Types – US Air Force
THORSTEN ALTENKIRCH

Certified software is software with some guarantee about its behaviour. Certificates are traditionally issued by humans based on testing and code inspection. These approaches are error prone, unreliable and expensive. In this project we are going to investigate the use of programming languages based on Martin-Löf Type Theory to address this problem. Programs written in these languages can exploit types to specify the behaviours of programs and we can construct certificates by writing programs exploiting the Curry-Howard principle of propositions as types. In this project we want to go further and investigate the following topics:

- **Using Homotopy Type Theory (HoTT) to facilitate large scale formalisation**
If we want to verify realistic software and hardware systems we have to build up large libraries of formally verified software and underlying mathematical theories. To do this we need an underlying language that supports mathematical abstractions effectively. Our hypothesis is that HoTT is ideally suited for this since it supports a very extensional view of mathematical structure.

- **Specify and certify quantum systems in Type Theory**
Quantum algorithms and systems based on quantum behaviour will have a major impact on internet safety and security. The algorithms involved are often very subtle and the informal correctness arguments unreliable. Based on our previous work related to the QIO monad we want to investigate how a type theoretic approach can help to address those issues. These topics have many interesting interactions (eg. the interaction of Homotopy Type Theory and quantum computing, and with reflection) which we want to explore and which may provide additional synergy to the work.

Bridging the Gaps: Systems-Level Approaches to Antimicrobial Resistance – EPSRC

JAMIE TWYCROSS (PI – PROFESSOR JOHN KING, SCHOOL OF MATHEMATICAL SCIENCES)

The problem of antimicrobial resistance (AMR) is an increasing challenge, not only in the context of healthcare but also in, for example, food safety and agriculture. The prevalence of resistant bugs such as MRSA has received widespread media coverage and the problems relating to resistance are now more widely recognised than ever before, as is the importance of developing new approaches, particularly given the increase in issues associated with multidrug resistant species. Our project draws on wide-ranging applicable expertise in engineering and the physical sciences that, in collaboration with biological-science researchers, clinicians and industry, offers hitherto unexploited opportunities to contribute significantly to addressing these very significant challenges. We are delivering a programme of activities that promotes new interdisciplinary collaborations across traditional boundaries between engineering, the physical sciences and the biological sciences.

COSLE – Collaborative Optimisation in a Shared-Logistics Environment – Innovate UK

DARIO LANDA SILVA

The aim of the proposed research work is to develop online/composite optimisation algorithms for freight transport logistic problems and to develop image processing algorithms for automatically capturing weight and volume. These algorithms are essential to develop the optimisation engine and mobile augmented reality components of GeoH, a system for Collaborative Optimisation in Shared Logistics Environment (COSLE). The purpose of the GeoH system is to enable fleet operators in the freight transportation industry to achieve more efficient operations by reducing the proportion of kilometres that vehicles are driven without a load or with a partial load. This research will contribute to tackling a major problem in the freight transport sector, the huge proportion of kilometres driven by vehicles without a load, which has considerable economic and environmental costs. For this, it is essential to develop a system that allows fleet operators, senders and consignees to tackle freight transport logistic operations in a collaborative manner. The research brings together location data (about where goods, vehicles, senders and consignees are at any time), environmental data (weather, traffic, events, etc.), vehicle telematics, optimisation, image processing and mobile technology (including augmented reality).Industrial Partner – Microlise Ltd.

From Human Data to Personal Experience – EPSRC

DEREK MCAULEY

Technology that motivates us to save energy; informing best practice in out-of-hours secondary care; enhancing 'thrill' experiences across the entertainment sector; and survey tools and intelligent data software to inform decision-making in the field of sustainable development and environmental policy; these are just some of the innovations led by the Horizon Digital Economy Research Centre at The University of Nottingham.

In recognition of the impact it has already had on our daily lives the centre has received an additional £4m to support its work to 2020. The funding via the Engineering and Physical Sciences Research Council (EPSRC) is part of a £23m investment to support six new multidisciplinary research centres in driving forward the UK's Digital Economy research, knowledge and skills.

Nottingham Molecular Pathology Node (NMPN) - Medical Research Council (MRC)

JON GARIBALDI

There have been substantial recent investments in Stratified Medicine and Analytical Science by the MRC and EPSRC. A recent MRC Pathology Review has highlighted the need for a robust pathway and capability for the development and adoption of new diagnostic tests. Nottingham Molecular Pathology Node will provide the necessary path and capability to fill the needs identified by the MRC review.

The project aims to create an infrastructure to drive molecular diagnostic biomarker research down the development pathway utilising molecular pathology / biobanking strengths and integrating computational /bioinformatics expertise.

Nottingham Research Fellowship – University of Nottingham
HOLGER SCHNÄDELBACH

The Built Environment as the Interface to Personal Data: Developing the strategies, mechanisms and applications, which allow people to interact with personal data through the built environment.

This research project investigates that role of the built environment in our interaction with personal data. There is particular emphasis on the feedback loops that are created when architectural adaptation is linked to personal data and on the role of the built environment in the path of personal data becoming big data to be stored, mined and re-used. The project will be driven by prototyping framed by fieldwork and theoretical enquiry in collaboration with internal and external partners.

PRIZES, AWARDS AND RECOGNITION

Professor Graham Hutton – ACM Distinguished Scientist 2015

Graham Hutton has been recognised as a "distinguished scientist" by the ACM, the world's leading association for computing professionals.

Professor Hutton, co-leader of the functional programming lab, was one of 49 from more than 100,000 ACM members to receive this award in November 2015, and one of only two from the UK.

The ACM distinguished scientist programme recognizes those members with at least 15 years of professional experience who have made significant accomplishments or achieved a significant impact on the computing field. The 2015 distinguished scientists are drawn from leading academic institutions, as well as corporate and national research laboratories from around the world.

Generating Impact Transport Industry through Big Data Analytics

ASAP group members along with ADAC analysts were invited to hand out the prizes in the Driver of the Year Awards Ceremony, held at the biggest Transport Conference in the UK, organised by Microlise. The awards were launched in 2015 to honour the most talented HGV drivers in 2014 across the UK. The competition was designed to encourage improvements in industry regarding both safe and economic driving. ASAP and ADAC supported the competition by providing the data analysis and the design of the methodology employed to shortlist the best drivers in the UK.

Initial data for the awards was gathered from over 90,000 drivers engaging with Microlise's telematics solutions. Between them, these drivers covered in excess of 600 million miles and made 5.5 million separate journeys. The University of Nottingham's ASAP and ADAC analysed the data, generating an initial shortlist of fifteen drivers in each of the three categories – short, medium and long distance drivers. The data was analysed anonymously to identify the best criteria to establish the top performing drivers. ASAP and ADAC were able to bring a range of data analytics knowledge and expertise together to come up with objective and scientific strategies to help Microlise identify the winner of the award.

This was the first successful outcome of the VEDAT (Value Enhancement for Data from Assets & Transactions) project, funded by the Innovate UK Technology Strategy Board.

Natasa Milic-Frayling joined the School of Computer Science in October 2015 as Professor and Chair of Data Science. She has a long track record in computer science research and innovation, focusing on new paradigms for digital content management and analysis, online communication and social interactions. She fosters collaborative approach to exploring opportunities and addressing challenges of digital systems by engaging in inter-disciplinary and user focussed research.

Natasa received her undergraduate degree in Applied Mathematics from University of Zagreb, Croatia and Doctorate in Applied Mathematics from Carnegie Mellon University, Pittsburgh.

Prior to joining University of Nottingham in October 2015, Natasa worked as a Principal Researcher at Microsoft Research (MSR) in Cambridge, UK. During her tenure at Microsoft Research, starting in June 1998, she was setting directions for the Integrated Systems team and covered a range of research areas, from core IR topics, such as relevance feedback and systems evaluation, to robust reputation scoring in social media, design of peer-to-peer recommendation systems, and Personal Information Management support across multiple devices and platforms. Her research was published in +80 papers, presented at top tier conferences and produced +20 working prototypes, including contributions to NodeXL and Project Colletta that have been used by thousands of users. She has been granted 13 patents for technical innovation in her work.

Thomas Gärtner joined the School of Computer Science in July 2015 as Professor of Data Science. Before that he was leading a research group jointly hosted by the University of Bonn and the Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS. Amongst other grants, he also received an award from the Emmy Noether-Programme of the German science foundation (DFG) which funded a large part of his group over five years.

During his MSc studies at the University of Bristol and his PhD studies at the University of Bonn, Thomas focused on kernel functions for structured data in order to bridge the gap between theoretically sound learning algorithms and their real world applications. Since then he has been investigating various questions regarding the efficiency and effectiveness of machine learning and data mining algorithms as well as their application to domains including chemoinformatics, computational cooking, and computer games.

Currently he is co-organizing the leading European conference on machine learning and data mining. He has been an editor of the Machine Learning journal for several years and served as a senior program committee member for several international flagship conferences on machine learning and data mining. His book, Kernels for Structured Data, was published in 2008.

PHD STUDENTS GRADUATED IN 2015

Aslam Ahmed	Variance & Scaling in Agent Based Modelling & System Dynamics
Ragad Al-Lwhihan	Investigating methods of Capturing and sharing experience in a field trip to support students activity
Shahriar Asta	Machine Learning for Improving Heuristic Optimisation
Florent Balestieri	Coinductive types in functional programming
Naisan Benatar	An investigation into the effects of uncertainty upon fuzzy logic systems
Arturo Castillo	Optimization Models and Algorithms for Workforce Scheduling and Routing
Ian Dent	Deriving Knowledge of Household Behaviour from Domestic Electricity Usage Metering
Heshan Du	Matching disparate Geogspatial Datasets & Validating Matches using Spatial Logic
Ha Duong	Heuristics approaches for three dimensional strip packing and multiple carrier transportation plans
Anas Elhag	Selection Hyper-heuristics for grouping problems
Salvador Garcia Bernal	The design & Implementation of High Dynamic Range Video Systems
James Gilbert	A Probabilistic Model for the Evaluation of Module Extraction Algorithms in Complex Biological Networks
Nils Jaeger	Enacted Embodiment in Adaptive Architecture: Physiological Interactions Between Inhabitants and Biofeed-back Architecture
Muhammad Haris Khan	Visual tracking over multiple temporal scales
Nicolai Kraus	Truncation levels in homotopy type theory
Nuo Li	Quotient types in type theory
Xiaofan Liu	Reasoning about business rules and access control rules
Khin Thein Lwin	Metaheuristics & Computational Methods in Portfolio Optimisation
Urszula Neuman	Modelling and Analysis of real world airport gate allocation problem
Tuan Nguyen	Adaptive visual tracking via multiple appearance models & multiple linear searches
Louis Parsonson	Modelling Angiogenesis in three dimensions
Alexander Pinkney	Improving typography & minimising computation for documents with s calable layouts
Orod Razeghi	An investigation of a human in the loop approach to object recognition
Christian Sattler	On the complexities of polymorphic stream equation systems, isomorphism of finitary inductive types and higher homotopies in univalent universes
Saiful Izwan Suliman	Optimisation of Frequency Assignments Utilising Constructive Heuristics & Artificial Immune Systems
Mercedes Torres	Automatic image annotation applied to habitat classification
James Walker	Hyper-Heuristic & Other Techniques for Robust General Solvers of Vehicle Routing Problems
Qian Zhang	Novel Techniques for Partial -duplicate Landmark Image Discovery