DEPARTMENT OF COMPUTER & INFORMATION SCIENCES

University of Strathclyde Science

Computer and Information Sciences Research

Introduction

The Department of Computer and Information Sciences hosts world-class research in areas such as Software Engineering, Data Intensive Systems, Mathematically Structured Programming, Mobile and Tangible Computing, Combinatorics, Computer Security, Information Science, Similarity Search and Artificial Intelligence.

Our research is funded by a broad range of funding bodies including the Engineering and Physical Sciences Research Council, Arts and Humanities Research Council, Economic and Social Research Council, European Union, and industry collaborations. We work with a wide range of industrial and public sector partners including the NHS Scotland, Microsoft, Scottish Ballet, Rolls Royce Marine and the European Space Agency.

As part of the Scottish Informatics and Computer Science Alliance, the Scottish Graduate School of Social Science and the Arts and Humanities Block Grant Partnership we are engaged in collaborations with other Scottish centres of excellence in Computer and Information Sciences research, especially in the areas of Multimodal interaction, Complex Systems Engineering and Information Science.

We offer a range of opportunities for collaboration including collaborative and CASE studentships, Knowledge Transfer Partnerships, consultancy, bespoke continuing professional development programmes and professional doctorates.

We hope you enjoy learning more about the research in Computer and Information Sciences.

Contents

The Mobiquitous Lab

Modern computing extends far beyond the traditional desktop and its graphical user interfaces. The Mobiquitous Lab investigates user behaviour in the context of mobiles, ubiquitous computing and with emerging interaction techniques such as multimodal interaction on multi-touch tables and interaction with tangible objects.

These technologies provide new opportunities for how computing can improve our lives and how it can integrate into everyday contexts. We engage in research investigating these new options, for example by studying how visitors to a museum interact with an interactive table and how haptic feedback can support typing eyes-free on a mobile device.

New technologies and interface concepts also pose new challenges for interface design, e.g. mobile devices require designing for small screens, and multi-touch tables can be viewed from all sides. Our research contributes to understanding and catering for these issues.

Our research spans a variety of user-centred design methods, including quantitative user studies in controlled experiments, field studies of technology deployment in the use context, and participant observation. We have experience in conducting system evaluations as well as in contributing to requirements analysis through working closely with end users over the course of a system development project.

The Mobiquitous Lab is led by Dr. Mark Dunlop
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Mathematically Structured Programming

The worldwide software market is estimated at £250 billion every year. This figure will grow significantly in real terms over time as software becomes ever more ubiquitous. Good programming languages are crucial since they allow the cost-effective production of high-quality software, while bad programming languages stand in the way of this. Programming languages research is a broad discipline, providing solutions to problems in numerous important areas such as concurrency and distribution, program verification, multi-core architectures, domain specific languages, security, web programming and mobile apps.

The vision of the Mathematically Structured Programming group is to use mathematics to understand the nature of computation, and to turn that understanding into the next generation of programming languages. We see the mathematical foundations of computation and programming as inextricably linked: indeed we study one so as to develop the other. This reflects the symbiotic relationship between mathematics, programming, and the design of programming languages, and we believe that any attempt to sever this connection will diminish each component. In order to achieve our research goals, we mainly use ideas from category theory, type theory, and functional programming. Specific areas which excite us are the semantics of programming languages, parametricity, and dependently typed programming

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iLab

iLab is an interdisciplinary information science research group investigating socio-techno phenomena and information behaviour. In pursuit of a literate and informed society, much of our work is societal in nature, investigating human information need and use, and informing future interactive public information system service design. Holistic in perspective, our work is theoretically underpinned by shared interests in interactive information retrieval, information seeking behaviour, and information architecture:

Interactive Information Retrieval is concerned with the development of user-centred information systems to support access to large repositories of information objects. We are particularly interested in developing systems that support human strategies for finding information. This brings in a wide range of research including theoretical research on the design and modelling of information access systems, empirical research on interfaces and user interaction, and research on the methodology of evaluating information access systems.

Information Seeking Behaviour is concerned with how (and why) people engage and interact with information, and associated information seeking processes. We are particularly interested in the information seeking behaviour of marginalised groups, and of young people; how they engage with information, the challenges and issues experienced, and the design implications for future interactive information systems and services.

Information Architecture is concerned with the effective and efficient structural design of interactive information systems, encompassing content classification and categorization, and usability design. We are particularly interested in common cataloguing standards for the organisation and dissemination of information, the structural design of shared online information environments, and associated usability considerations.

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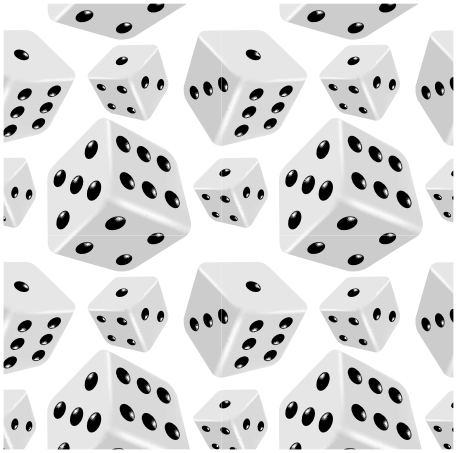
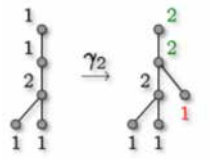
Combinatorics



The research interests of the Strathclyde Combinatorics Group are in enumerative, bijective and algebraic combinatorics. Recently, the focus has been on permutation patterns, a relatively young, but very active, research area, with several hundred papers published in the last ten years. The driving force behind much of our work is to find connections between families of different combinatorial structures and to other fields of computer science, mathematics and physics.

Although permutations and patterns play a prominent role in our research, we have lately also been working with lattice paths, plane trees, planar maps and Ferrers diagrams with various types of fillings. The goal here is to find connections between different kinds of combinatorial objects, in the form of bijections that send a set of statistics on one side to a set of statistics on the other. Such statistics-preserving bijections not only reveal structural similarities between different combinatorial objects; they often also reveal previously unknown properties of the structures being studied.

We are also in the process of strengthening our work in algebraic combinatorics, with an emphasis on algebraic and topological properties of combinatorially defined simplicial complexes.



Another interest of ours is combinatorics on words. This is a research area with roots going back a century, which has flourished during the last two decades. The motivation comes not only from different modern, as well as classical, fields of mathematics, but also from computer science, physics, and biology. In fact, many fundamental results of the theory have been discovered, or rediscovered, when using words as tools for other sciences.

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Computer Security

The increasing penetration of computer-based systems throughout industry, commerce and leisure, gives rise to many issues concerning security. These issues range from techniques for protecting system and network integrity, strategies for securing the information used, generated and stored by such services, and the development of robust network services.

The research interests of the Computer Security group cover a wide spectrum of such issues, from intrusion detection techniques, malware characteristics, textual steganography, trusted systems and the role of human factors in enterprise security in general and usable authentication in particular.

The group is particularly interested in social- and nature- inspired approaches to security, and situational awareness in self-protecting systems. In this context, it has been investigating approaches to web intrusion detection inspired by the human immune system, and mechanisms based on the human notion of trust for managing security risks in pervasive computing systems.

In addition, this group addresses research problems and solutions in the related domains of digital forensics and cybercrime. In this sphere, the tasks relate primarily to the detection, isolation and proof of digital evidence. Such aspects often have bearing upon criminal proceedings and the group maintains close links with digital forensic investigators, the legal profession and law enforcement agencies.

Often, the quantity of available data presents an obstacle to ready detection and characterisation and presents challenges for data exploration techniques. Current research includes data visualisation and auralisation as well as the neutralisation of sexually explicit language.

Computer Security research is led by Dr Changyu Dong, Dr Sotirios Terzis and Dr George Weir
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Applied Intelligence

The Strathclyde Applied Intelligence Research Group is broadly concerned with two areas: creating intelligent behaviours in computer-based agents, especially agents that need to plan their future activities; and searching for very high quality solutions for difficult combinatorial optimisation problems, such as multi-processor scheduling and bin packing. These two areas are clearly related since they both involve search over a vast number of alternatives, and the same techniques can often be used for both problems.

The techniques that the group are using to solve these problems often have their inspiration in biological systems: genetic algorithms, genetic programming, neural networks and swarm intelligence. These forms of natural computation are massively parallel and can be seen as solving the problems of survival, learning and problem solving in the natural environment.

Solving difficult problems involves deliberating on how to transform an initial state of the world into a desired state which has not yet come into being. This is a key area of AI, as any agent which needs to make decisions in the real world needs to be able to choose actions to achieve a satisfactory end result. The research we are doing in this area includes application of AI planning in games, making AI planning algorithms faster using evolutionary learning, and the solution of combinatorial optimisation problems using meta-heuristics and local search.

Computer Games are a great testing ground for theories of intelligent behaviour, so we frequently use these in our research. Games are of great fascination to human players because of the very large number of interesting decisions which must be made during the course of the game. If we could make agents to play games well, we think we would be part of the way to knowing how intelligence works.

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Similarity and Metric Search

Searching is one of the oldest topics in computer science. Search for information is among the most important applications of today's computing systems – second probably only to e-mail. Recent figures suggest that up to 95% of the world's computing resource use is performing search in one form or another.

Computational searching is a huge success, as evidenced by well-known commercial enterprises from, among others, Google, Yahoo and Microsoft. However, almost all commercial search is based on a straightforward vector space model, and a mathematically simple comparison of texts according to their term frequency.

Our research is into largely unsolved problems, concentrated on metric space models and distance-based searching, where no coordinate system is available; all that can be determined is the similarity of any two objects to each other. Images and other multimedia objects, for example, have various notions of similarity that do not translate into a conveniently indexed space; all that can be determined is how similar two images are to each other. An unsolved question: given a very large collection of, for example, images (billions, not millions!) can we efficiently find all those that are very similar to a new image?

Even Google don't know!

Similarity and Metric Search Systems research is led by Professor Richard Connor
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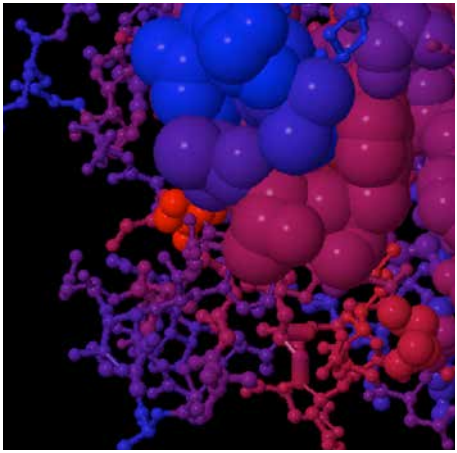
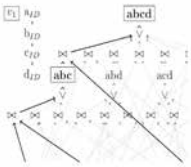
Data Intensive Systems



The growing size and diversity of data sets that underlie many governmental, commercial and academic enterprises leads to challenges for effective data management. The increasingly distributed nature of such data collections provides many opportunities for flexible use. In addition, finding new ways to integrate data presents the potential for using valuable repositories in new and exciting ways. In all aspects of life, enterprises are becoming more dependent on their use of data and require it to generate solution faster than ever before.

These challenges and opportunities are addressed by the Data Intensive Systems research group. We are interested particularly in the prospects for using novel techniques to process large biological data sets and to integrate these with other collections so as to provide new insights into discovering allosteric drugs, which offer precise control over the causes of disease.



Representing and indexing such data presents challenges particularly in the use of semistructured data representations, which underlie Internet-based data resources. In this area we are working on maintaining data that is distributed across small mobile devices. We are also investigating the efficient maintenance of large linked data collections that embody the Semantic Web framework for sharing definitions and future-proofing data.

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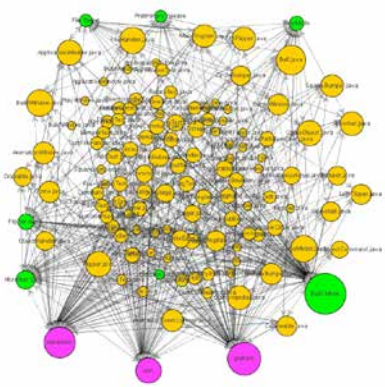
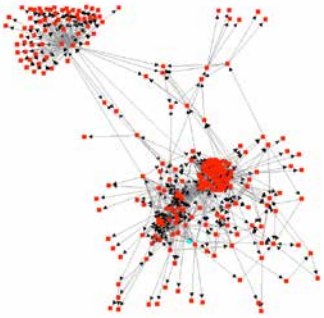
Software engineering



Research in the area of Software Engineering is targeted at the problems associated with engineering complex and novel software intensive systems, is strongly influenced by real problems, and aims to produce solutions that are ultimately of benefit to the practising software engineer.

Understanding the ways in which features in a system interact is one of the fundamental problems faced by software developers. By capturing software engineers' activity, we are able to create a real-time social network which models the relationships between developers, modules, and requirements. Work in this area is now looking to answer questions such as: What are the key features, abstractions and interactions in any design and how can these be identified? Can good design be identified and visualised? What empirical evidence exists to support good design?

Several areas of our research draw on biological metaphors for inspiration. Our work on automatically generating program test data was one of the earliest to make use of Genetic Algorithms to tackle this problem. This work has in turn evolved to consider the broader problems of autonomic systems and self-healing systems – those software systems which are able to monitor their state and repair themselves using search-based strategies to explore program mutations - in particular.



Our work has a particularly strong practical and empirical philosophy. We evaluate our solutions using real data and build systems to demonstrate and test our ideas, and as a consequence we have many years of experience in experimentally assessing tools and techniques.

Software Engineering research is led my Dr. Marc Roper and Dr. Murray Wood
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Ways to collaborate with CIS

Research and knowledge exchange collaborations

Academic staff in CIS collaborate with a wide range of industrial and third-sector partners. There are many mechanisms to support collaboration, including Knowledge Transfer Partnerships, consultancy, continuing professional development and collaborative studentships. If you have an idea for collaboration with a specific research group, please contact the group representative.

If you would like to discuss a potential collaboration but are unsure of who would be the best contact please, email our Director of Research Professor Neil Ghani neil.ghani@strath.ac.uk or our Director of Knowledge Exchange, Dr Mark Dunlop mark.dunlop@strath.ac.uk.

PhD Enquiries

The Department welcomes all applications for MPhil and PhD study in any of the areas described in this booklet. If you don't immediately see how your interests fit in, contact us anyway and let us see whether we do related research that might be of interest to you. We also run a professional doctorate scheme for practicing professionals who wish to study for a doctorate within their workplace.

See: http://www.strath.ac.uk/cis/research/phdresearchopportunities/ for more details.

Technology and Innovation Centre

The Technology and Innovation Centre at Strathclyde is a hub for world-leading research, transforming the way academics, business, industry and the public sector collaborate.

We are working together to find solutions to challenges that matter in areas of economic importance – including power and energy, health and manufacturing – and helping companies compete globally.

With a clear focus on industrial and business needs, the Technology & Innovation Centre brings together academics from the University of Strathclyde and across the Scottish university sector to work in collaboration with industry partners. These multidisciplinary teams combine expertise and strengths in engineering, science, business, humanities and social science.

http://www.strath.ac.uk/tic/

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