Research internship projects available in the College of Engineering and Physical Sciences, University of Birmingham

The College of Engineering and Physical Sciences at the University of Birmingham is one of the largest groupings in Europe, bringing together physical sciences and engineering into one coherent college. Home to nine academic schools, the College affords students, staff and alumni access to learning and career development opportunities which few educational institutions can match.

Much of our activity involves collaboration with multiple stakeholders – individuals, public bodies and private companies. The College focuses on fostering strong links with strategically important partners and stakeholders. From research collaborations and education networks to business engagement and alumni communications, the College has widened its reach and influence.

The College is home to many research groups that sit within and across academic Schools that also contribute to three overarching themes spanning the breadth of the College. They are:

- Science Frontiers: fundamental breakthroughs in our understanding of the way nature works.
- Advanced Manufacturing: driving industry forward; delivering the edge in the global competition through innovation.
- Resilience, Energy and Sustainability: tackling the challenges of future generations now.

On behalf of the College of Engineering and Physical Sciences, I am delighted to present a number of research internship opportunities which we are able to make available to outstanding students over the summer period of 2014. Each project is being made available by some our leading research groups in the School of Physics and Astronomy and in the School of Computer Science. For each available project, brief details have been provided, together with a list of key references and contact details for the supervisor.

I hope you find the list of project stimulating. If you would like to pursue any of the projects listed, in the first instance, please send a brief expression of interest outlining your reasons behind wanting to undertake a research internship in our College and your specific interest in the project selected, to the Director of the College of Engineering and Physical Sciences Graduate School, Dr Peter Hancox (P.J.Hancox@cs.bham.ac.uk) by 30th April.

I look forward to welcoming a cohort of research interns in the forthcoming summer months.

Professor John Bridgeman
Director of Research and Knowledge Transfer
College of Engineering and Physical Sciences
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Project: Software effort estimation using machine learning approaches

Supervisor: Prof Xin Yao (x.yao@cs.bham.ac.uk)

Estimating the cost of a software project is a task of strategic importance in project management. Both over and underestimations of cost can cause serious problems to a company. For instance, overestimations may result in a company losing contracts or wasting resources, whereas underestimations may result in poor quality, delayed or unfinished software. The major contributing factor for software cost is effort. An alternative to effort estimations by human is to use automated effort estimators. Models for estimating software effort can be used as decision support tools, allowing investigation of the impact of certain requirements and development team features on the cost/effort of a project to be developed. This project develops automated software effort estimation tools using machine learning approaches, e.g., multi-objective learning, online learning, semi-supervised learning, etc.

[1]   Minku, L.L. and Yao, X., `Software Effort Estimation as a Multi-objective Learning Problem, ACM Transactions on Software Engineering and Methodology, 22(4), Article No. 35, October 2013, 32 pages.

[2]   Minku, L.L. and Yao, X., Ensembles and Locality: Insight on Improving Software Effort Estimation, Information and Software Technology, 55(8):1512-1528, August 2013.

[3]   Minku, L.L. and Yao, X., How to Make Best Use of Cross-company Data in Software Effort Estimation? Proc. of the 36th International Conference on Software Engineering (ICSE'14), Hyderabad, India, 31/5-7/6/2014.

[4]   Song, L., Minku, L.L. and Yao, X., The impact of parameter tuning on software effort estimation using learning machines, Proceedings of the 9th International Conference on Predictive Models in Software Engineering (PROMISE'13), 9 October 2013, Baltimore, MD, USA.

[5]   Minku, L.L. and Yao, X., An analysis of multi-objective evolutionary algorithms for training ensemble models based on different performance measures in software effort estimation, Proceedings of the 9th International Conference on Predictive Models in Software Engineering (PROMISE'13), 9 October 2013, Baltimore, MD, USA.

Project: Analysis and Modelling of Multi-dimensional Geo-social Networks

Supervisor: Dr Mirco Musolesi (m.musolesi@cs.bham.ac.uk)

The goal of this project is to develop models and algorithms for studying multi-dimensional geo-social networks. We will consider social networks of entities that are linked through multiple types of links, in which geographic information plays a key role. The project will consist in the collection and analysis of social media datasets and the development of analytical tools for extracting significant properties from them. Time permitting, we will also characterize processes in these networks such as information diffusion and we will investigate critical properties such as network robustness. The project will be based on real-world networks and we will also consider possible practical applications of the models and tools developed during the project.

Required skills: good programming skills (possibly in Python and R) and good mathematical and statistical skills.

The project will require the use of various Python libraries for scientific computation.

[1]   De Domenico,M., Lima, A., Mougel, P. and Musolesi, M., The Anatomy of a Scientific Rumor, Nature Scientific Reports. 3:2980. Nature Publishing Group. October 2013.

[2]   De Domenico,M., Lima, A. and Musolesi, M., Interdependence and Predictability of Human Mobility and Social Interactions, In Pervasive and Mobile Computing, 9, 6, December 2013.

[3]   Nicosia, V., Tang, J., Mascolo, C., Musolesi, M., Russo, G. and Latora, V., Extended version of the paper originally submitted for the Nokia Mobile Data Challenge, Graph Metrics for Temporal Networks, Book Chapter in Petter Home and Jari Saramaki (Editors), Temporal Networks. 2013.

[4]   Tang, J., Mascolo, C., Musolesi, M., and Latora, V., Exploiting Temporal Complex Network Metrics in Mobile Malware Containment, In Proceedings of the 12th IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WOWMOM'11). Lucca, Italy, June 2011.

[5]   Tang, J., Scellato, S., Musolesi, M., Mascolo, C. and Latora, V., Small-world Behavior in Time-varying Graphs, Physical Review E., 81, 5, 055101(R), May 2010.

Project: Seamless Computing

Supervisor: Dr Dan Ghica (d.r.ghica@cs.bham.ac.uk)

In the "Seamless Computing" project we are compiling conventional programming languages onto unconventional platforms such as distributed architectures or reconfigurable devices. Our work will allow programmers without special expertise to use these state-of-the-art computing devices efficiently and effectively. We have developed a solid theoretical foundation and several proof-of-concept compilers. To contribute to this project a potential intern must have some grounding in functional programming (such as OCaml or Haskell).

The more accessible projects (from a programming point of view) involve using our compiler(s) to implement standard off-the-shelf algorithms, such as linear algebra, Monte Carlo simulations, data encoding/decoding or network packet inspection, and comparing their performance with that of conventional compilers.

Contributing to the compiler itself requires expert knowledge of Haskell or OCaml and some knowledge of compilation technology. Projects may include implementing some compiler optimisations (such as constant propagation) or improving the front-end syntax of our programming language, Verity. Finally, a knowledge of hardware design will allow the development of mixed Verity-HDL projects for an FPGA.

References

[1]   Web site: www.veritygos.org

[2]   Blog: http://researchblogs.cs.bham.ac.uk/thelablunch/

Articles:

[3]   Seamless distributed computing from the Geometry of Interaction TGC 2012, 7th International Symposium on Trustworthy Global Computing Newcastle upon Tyne, UK, 7-8 September 2012 With O. Fredriksson. http://www.cs.bham.ac.uk/~drg/papers/tgc12.pdf

[4]   Geometry of Synthesis IV: Compiling affine recursion into static hardware, ICFP 2011. The 16th ACM SIGPLAN International Conference on Functional Programming, Tokyo, Japan, September 19-21, 2011. With S. Singh and A. Smith. http://www.cs.bham.ac.uk/~drg/papers/icfp11.pdf

Project: Causal models of human judgement

Supervisor: Dr Andrew Howes (howesa@bham.ac.uk)

The project will work on the development of a causal model of human judgement & decision-making (JDM) that explains why people make decisions, identifying key environmental or human constraints. The project aims to demonstrate that if the constraints imposed by the environment and the limitations of the human cognitive system are taken into account, human judgment and decision making (JDM) are optimal. This is a major shift from the current dominant perspective in Psychology and Behavioural Economics which suggests JDM is irrational, biased or sub-optimal. The model will allow the testing of behavioural change scenarios and prediction of real-life decision making. Practically, it would inform a principled approach to policy change and strategies for behavioural change interventions in a range of contexts, for example to remove the cognitive barriers against sustainable consumption and healthy life styles or to promote better personal finance/financial investment decisions.

Required skills: good programming skills (possibly in Python and R) and good mathematical and statistical skills.

[1]   Hahn, U. & Warren, P.A. (2009) Perceptions of randomness: Why three heads are better than four. Psychological Review. 116, 454-461.

[2]   Howes, A., Lewis, R.L. & Vera, A. (2009). Rational adaptation under task and processing constraints: Implications for testing theories of cognition and action. Psychological Review, 116, 4, 717-751.

[3]   Howes, A., Lewis, R. L. & Singh, S. (2014). Utility maximization and bounds on information processing. Topics in Cognitive Science, in press.

[4]   Lewis, R. L., Singh, S., & Howes, A. (2014). A Bounded Optimality Approach to Psychological Theory: Linking Mechanism and Behavior Through Utility Maximization. Topics in Cognitive Science, in press.

Project Title: Planning for robot grasping under uncertainty

Advisors: Prof Jeremy Wyatt (J.L.Wyatt@cs.bham.ac.uk)

Manipulation benefits from gathering information (about size, shape, mass, friction) during execution. Planning of manipulation can therefore taking advantage of this by planning to actively gather information. Recently we have developed techniques to do this for tactile information during the reach to grasp. This work is based on a method that warp the distances in the space of reach to grasp paths [1]. Essentially the greater the information to be gained the shorter the distance. We have also worked on how information can be gathered using active vision, directing the robot's gaze to the most useful part of the scene [2]. In this work we want to explore randomised search methods that learn the value of information to find generalisable reach to grasp trajectories. The simplest way to imagine these is to imagine an RRT style planner that is driven by gain in value, and which works on a combination of the configuration space plus a low dimensional representation of the state uncertainty.

[1]   Zito, C., Kopicki, M.S., Stolkin, R., Borst, C., Schmidt, F., Roa, M.A. and Wyatt, J.L., Sequential Trajectory Re-planning with Tactile Information Gain for Dexterous Grasping under Object-pose Uncertainty. In Proceedings of IROS 2013.

[2]   Nunez, J, and Wyatt, J.L., Models of Gaze Control During Visually Guided Manipulation. ACM Transactions on Applied Perception, October 2012.

Project: Understanding object arrangements over time

Supervisor: Prof Jeremy Wyatt, Dr Michael Mistry, Dr Nick Hawes, Dr Lars Kunze
(J.L.Wyatt@cs.bham.ac.uk, M.N.Mistry@cs.bham.ac.uk, n.a.hawes@cs.bham.ac.uk,
L.Kunze@cs.bham.ac.uk)

The aim of this project is to develop a theory about arrangements of objects over time. In the beginning of the project the student will identify a set of objects of interest and means to monitor them over time. The monitoring can be realized through methods of active perception or simply manual bookkeeping in form of a survey. Based on the resulting object logs over time the student will employ methods of machine learning (e.g. unsupervised clustering methods) to identify (repeating) patterns of the presence of objects, their co-occurrence and relations with other objects. For example, a survey could monitor the objects used at breakfast. It would be interesting see how patterns change wrt weekdays and weekends or number of people participating in the meal.

Requirements:

- Background knowledge in machine learning and probabilistic graphical models would be a plus.

Project: Learning context-depend regions from human activities.

Supervisor: Prof Jeremy Wyatt, Dr Michael Mistry, Dr Nick Hawes, Dr Lars Kunze

(J.L.Wyatt@cs.bham.ac.uk, M.N.Mistry@cs.bham.ac.uk, n.a.hawes@cs.bham.ac.uk, L.Kunze@cs.bham.ac.uk)

The aim of the project is to record tracks of people over time and associate these tracks with meaningful events/regions in the environment. The student will integrate a state-of-the-art people detection and tracking software into the control framework of a patrolling robot. While the robot is patrolling the environment, the poses and tracks of various persons are recorded. Using clustering methods the student identifies regions of interest (in time) and relates these regions to predefined objects and areas in the environment (defined through a semantic map, e.g. sitting area, vending machine, microwave, toilettes etc).

Requirements:

- Some basic knowledge about ROS

- Programming skills in a ROS-supported language (ideally Python and/or C++)

- Background knowledge in machine learning and probabilistic graphical models would be a plus.

Project: Generating scene descriptions using NL

Supervisor: Prof Jeremy Wyatt, Dr Michael Mistry, Dr Nick Hawes, Dr Lars Kunze

(J.L.Wyatt@cs.bham.ac.uk, M.N.Mistry@cs.bham.ac.uk, n.a.hawes@cs.bham.ac.uk, L.Kunze@cs.bham.ac.uk)

The aim of the project is to realize an (output) interface that generates natural language descriptions of scenes. For example, after perceiving objects on a table the robot reports the following: "I have seen a cup, a bottle and a toy car on the table. The cup is almost at the center of the table. The bottle is left and behind of the cup. The toy car is very close to the bottle." Such information might be useful for generating reports in a security scenario or for helping vision-impaired people in a care home. Based on perception results and a scene analysis using qualitative spatial relations the student would develop methods that can generate compact scene descriptions using NL.

One of the challenges for giving a /compact/ scene description is to decide what information to report and what information to omit. Given the interest of the student the developed methods can also be implemented and tested on the real robot Bob.

In future work, the interface might be extended to provide also feedback to the robot: "No, the object left behind the cup is not a toy car, but a computer mouse."

Requirements:

- Background knowledge in NLP would be a plus.

- Some basic knowledge about ROS)

- Programming skills in a ROS-supported language (ideally Python and/or C++)

Project: Nanoscale Physics x 6

Supervisor: Prof Richard Palmer (r.e.palmer@bham.ac.uk)

Length: ~8 weeks

Up to six places are available for summer projects in the Nanoscale Physics Research Lab in 2013. Students will be fully integrated into the research group and will share an office with other researchers for the duration of the project. The projects represent an invaluable experience, especially for excellent students considering a PhD in nanophysics or a related discipline; many previous project students have gone on to PhDs in Birmingham and other leading Universities. The experiments are always difficult so the highest level of capability and motivation is essential. The typical project duration is 8 weeks, start date to be agreed but usually late June; remuneration to be negotiated. Please get in touch ASAP if you are interested.

In 2013 we expect to offer up to four places in the areas of: (i) atomic manipulation with the STM, (ii) atomic-resolution electron microscopy of nanostructures, (iii) super-abundant generation of nanocluster materials for photonics and electronics (supported by recent grant awards of £2.5 million) and (iv) nanowire production, *plus* up to two places in nanobiosensors, in collaboration with one of our spin-off companies.

An example of a possible project is below:

Remote control of atomic manipulation

Atomic manipulation is the extreme limit of nanotechnology [1]. The Scanning Tunnelling Microscope (STM) is employed both to manipulate individual atoms or molecules on surfaces - either by the application of mechanical forces or by the injection of electrons or holes - and to images the results with atomic precision. We are especially interested in non-adiabatic processes in which capture of an electron (or hole) from the STM tip suddenly projects the atom/molecule onto an excited quantum state potential surface which drives the dynamics until charge release. Recently [2] we discovered that electrons can be injected far away from the location of the target molecule, propagating across the surface in quantised surface electronic states, thus uniting (in principle) device physics with atomic manipulation (hence 'remote control'). The work was published in Phys Rev Letters and highlighted in New Scientist. This project will investigate the possibility of channelling the electrons in 2D along waveguides created by atomic manipulation on the Silicon (111) surface, along which electrons will be launched to drive atomic manipulation (cf. switching) events in pre-positioned chlorobenzene molecules. The experiments should also allow us to test our sub-surface electron transport ('submarine [2]) hypothesis. We think that, ultilmately, similar ideas can in principle be applied to biological molecules (proteins), where there is the possibility to achieve bond-specific surgery on individual molecules (in a liquid environment).

[1]   Sloan, P.A. and Palmer, R.E., Two-electron dissociation of single molecules by atomic manipulation at room temperature, Nature 434 367 (2005).

[2]   Sloan, P.A., Sakulsermsuk, S. and Palmer, R.E., Nonlocal desorption of chlorobenzene molecules from the Si(111)-7x7 surface by charge injection from the tip of a scanning tunneling

microscope: Remote control of atomic manipulation, Phys. Rev. Lett. 105 048301 (2010); *see also* Electron 'submarines' help push atoms around, *E.S. Reich,* New Scientist, 31 July 2010, p. 11.

Project: Nuclear Physics Studies Using the University of Birmingham MC40 Cyclotron

Supervisors: Prof. Martin Freer, Dr. Carl Wheldon, Dr. Tzany Kokalova (m.freer@bham.ac.uk)

The School of Physics and Astronomy possess an MC40 cyclotron capable of accelerating beams protons, deuterons, 3He and 4He. This is used for a variety of science from nuclear materials, radioisotope production to nuclear physics measurements. The nuclear physics group have an experimental setup which uses charged particle, semiconductor detectors, to study nuclear reactions. Their specific area of interest, in which they have international leadership is the study of the structure of light nuclei. Their experimental programme uses accelerators worldwide, from the US and across Europe. The work on the cyclotron is built around the examination of a phenomenon of clustering in nuclei, whereby the nucleons condense out into alpha-particles. Their recent work has helped solve a long-standing problem of the structure of a famous state in carbon-12 called the Hoyle state.

The internship would involve performing experimental measurements on the MC40 cyclotron and analysing the data. The student would get experience of state-of-the-art detections systems and associated electronics, operation of the cyclotron planning experimental measurements.

References illustrating research area:

[1]   Freer, M., The clustered nucleus—cluster structures in stable and unstable nuclei, Reports on Progress in Physics 70 (2007), 2149.

[2]   Freer, M., Casarejos, E., Achouri, L., Angulo, C., Ashwood, N.I., Curtis, N., α: 2 n: α Molecular Band in Be 10, Physical review letters 96 (2006), 042501.

[3]   Freer, M., Fujita, H., Buthelezi, Z., Carter, J., Fearick, R.W., Förtsch, S.V., 2+ excitation of the C 12 Hoyle state, Physical Review C 80 (2009), 041303, http://www.scholarpedia.org/article/Clusters_in_nuclei.