Department of Artificial Intelligence
University of Edinburgh

Collaboration Opportunities in Artificial Intelligence

Department of Artificial Intelligence
University of Edinburgh

Kinds of Collaboration

A wide variety of kinds of collaboration are possible with our Department. These range from low cost, exploratory kinds, like student projects or playing the role of 'industrial uncle', through to much closer collaboration, like product development.

In all collaboration arrangements intellectual property rights and confidentiality are a matter of negotiation between the parties. The University of Edinburgh has developed a body of good practice in these matters to cover most situations.

Industrial Seminars

We run a regular series of industrial seminars in which people from industry are invited to speak to our students about the kind of work they do. This is intended to inform students about the job opportunities at the end of their degrees. It is a good opportunity to make informal contact with students and members of staff. Our Department covers any travel and subsistence expenses incurred. If you are interested in giving such a seminar then please write to the "Industrial Seminar Organiser" at the address below.

Student Projects

You are invited to propose student projects at undergraduate or masters level. If a student takes up your proposal, you would then co-supervise the student together with a member of our academic staff. Our undergraduate projects are part time from October to May each year and our masters projects are full time from May to September. Project selection takes place in the Spring. A proof of concept might emerge from a student project that could serve as the basis for a more substantive collaboration.

CASE Studentships

It is also possible to co-supervise PhD projects. This is a much more ambitious project lasting three to four years and requiring original research. It would make possible a more extensive investigation of a problem of interest to you. Usually collaboration would take the form of a CASE Studentship. These are organised by the research councils and require the collaborating company to make a small financial contribution to the student's support and the student to spend a significant period of time each year working on its premises.

Collaborative Projects

Many funding agencies support collaborative projects, *e.g.* the EC Framework IV, the research councils, the DTI LINK schemes, *etc.* These range from joint support of the research teams of both the industrial and academic partners, to the industrial partner playing an unfunded 'uncle' role, overseeing the work of the academic team.

Industrially Funded Projects

Where the work required is 'near market', the industrial partner in a collaboration is usually expected to fund the academic partner. Such a project would be a natural culmination of prior, more exploratory collaborations.

Affiliates Schemes

Affiliates schemes enable industry to monitor academic research which is of potential commercial benefit. Members receive regularly briefings on recent developments, research papers, short courses, *etc.* We are involved in two such schemes. Our sister organisation, the Artificial Intelligence Applications Institute (AIAI), runs a scheme which covers the whole of Artificial Intelligence. We are also a member of EDINAS, the Edinburgh Informatics Association, which covers all of information technology and computer science.

Consultancy

Members of our Department have a wide range of skills and are able to provide many different forms of consultancy. This includes: giving expert advice, subcontracting of implementation work, provision of short courses, *etc.* The kinds of consultancy we can offer are described in the pages in this brochure.

Address for General Enquiries

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Department of Artificial Intelligence
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Genetic Algorithms and Neural Nets

Researchers Involved

Dr. Peter Ross.

Outline of Research

Genetic algorithms for optimisation problems, constraint satisfaction problems, timetabling, scheduling etc. Neural networks for classification, pattern recognition etc.

Potentially Marketable Techniques

We have some proven GA techniques for handling large timetabling problems and complex job- and open-shop scheduling problems and have been applying them to some large commercial problems. A range of further GA, genetic programming and neural net techniques have been successfully applied to various decision problems, for example in medical domains. Nearly all the GA work has been built on my PGA software.

Collaborative Projects

We'd be interested in almost any sort of collaborative project that involves GAs and/or neural nets, eg for control tasks, diagnosis, classification, scheduling and so on.

Consultancy Services

Advice, short courses, all kinds of consultancy on GA and/or neural net topics.

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Relevance in Large Knowledge Bases

Researchers Involved

Louise Pryor.

Outline of Research

The advent of information technology has led to an information explosion. It is now possible to keep track of and store vast amounts of data. This leads to two problems: (1) Retrieving the required information and (2) extracting relevant information.

The approach that I take to the first problem, that of retrieving information, derives from the paradigm of case-based reasoning (CBR). The motivation for CBR is that, when deciding how to proceed in response to a problem, good guidance can be had be considering what happened in the past in similar situations. For example, meteorologists rely heavily on past experiences when coming up with weather forecasts: they have large databases of historical weather maps showing such information as temperature and pressure, find those that are similar to the current weather map, and then see how the weather developed in the historical cases.

The development of such systems depends critically on being able to describe the current situation and past cases in a way that facilitates judgement of similarity. However, retrieval systems can significantly extend the resources available to managers and employees by providing easy access to relevant information.

The second problem, that of extracting relevant information, arises because of the sheer volume of data that is produced. Much of it is usually insignificant, but some of it may indicate potential problems or opportunities. The problem is to recognise which are the relevant points in the sea of information. I am working on the development of techniques that will indicate to their users information that may be significant and its potential significance. Such a system would act as a filter on incoming information, suggesting analyses that might be productive.

Collaborative Projects

Colloborative projects would be welcomed in either of the two tasks described above. I am currently looking for application areas in which to continue the research. Initial involvement from the partner would be to discuss possible user requirements and to provide example data for undergraduate or MSc projects. Larger scale projects could be discussed.

Consultancy Services

My especial area of expertise is in the insurance industry; I have practiced as an actuary in both life and general insurance.

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Department of Artificial Intelligence
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Mobile Robotics

Researchers Involved

Dr John Hallam, Dr Gillian Hayes, Dr Barbara Webb, and about 15 research students.

Outline of Research

All aspects of autonomous mobile robotics, especially robot control, navigation round office environments, skill transfer between robots, vision systems for mobile robots.

Our work is concerned with the practical aspects of getting mobile robots to move safely around unstructured, indoor environments. The environments can vary on a short timescale so it is necessary to build robot control systems which are both reactive to the unexpected and able to take advantage of fixed structures that are reliably present. This has applications from parts transport to mail delivery to wheelchair enhancements.

The skill transfer work addresses the inefficiency of getting an individual robot to learn a number of skills from scratch; it is more efficient to have a number of simple robots with one skill each pass on their combined knowledge to a complex robot. This has applications in all tasks in which collaboration and interaction between a number of robots are involved.

Collaborative Projects

We are currently looking for collaborative projects on skill transfer between robots and for application domains for our work on navigation. Initially we would be looking to discuss application requirements with industrial partners, leading to joint student or contract research projects.

Consultancy Services

Advice, short courses, and consultancy on robotics problems and sensing systems applied to manufacturing, indoor delivery or mobility problems.

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Department of Artificial Intelligence
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Industrial Vision Using Range Data

Researchers Involved

Dr. Robert Fisher, Dr. David Eggert, Dr. Philippe Fillatreau, Mr. Andrew Fitzgibbon, Mr. Mark Wright, Mr. Dibio Borges, Mr. Edvaldo Bispo, Mr. David Wren.

Outline of Research

The group's research covers several areas:

1. Range data sensors: these are increasingly used in advanced manufacturing processes
2. Automatic construction of CAD models from shown examples: main application is reverse engineering
3. Analysis of constructed buildings: analysis and revision of CAD models of buildings when differing from the actual construction
4. Using visual cues to identify graspable surfaces and grasping configurations of unknown objects: needed for emergency retrieval or clean-up operations
5. Surface patch inference from range data: creating CAD surface descriptions from range data
6. Surface shape inspection from range data: comparing local surface shape to model requirements
7. Industrial 3D object recognition: identifying 3D objects as they pass down a conveyor belt

Potentially Marketable Techniques

Several of the group's projects are approaching marketability:

1. Range sensor innovations: particularly in the area of rejection of spurious data due to specular reflections
2. Industrial 3D object recognition: the system is recognising complex irregular objects and estimating positions to less than 1 mm (accuracy depends on sensor accuracy and object scale). Speed improvements and large scale tests are needed for commercial use.

Collaborative Projects

We would like to develop contacts with companies interested in:

1. Surface shape inspection from range data.
2. Analysis of constructed buildings.
3. Automatic construction of CAD models from shown examples.
4. Industrial 3D object recognition.

For the first three areas, we would like to collaborate with companies interested in exploring potential applications, extending techniques and staff development. Student or collaborative contract research would probably be best, as the projects are relatively open-ended.

In the fourth area, the technology is more developed, so we would be interested in collaborating with companies interested in exploitation. This suggest DTI "Link" type projects.

Consultancy Services

General consultancy on machine vision problems. Part-time subcontracting work done by PhD students.

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Natural Language Front-Ends

Researchers Involved

Graeme Ritchie.

Research interests

Natural language front-ends, particularly to databases; morphological analysis; mathematical properties of linguistic mechanisms.

Potentially Marketable Techniques

Intelligent user interfaces could be developed from this work.

Consultancy Services

Advice available on various issues involving natural language processing.

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Natural Language Generation for Technical Documentation

Researchers Involved

Dr Chris Mellish, Dr John Levine, plus about three research students whose work is closely related to this area.

The Technical Documentation Problem

Although automation of product design is making some progress through the use of CAD tools and databases, in general the computer support that a technical *documenter* gets goes little beyond a word processor. This means that producing documentation by current methods generally has the following problems:

Maintainability. Updating the documentation to take into account a change in the product, or reusing it for another one is difficult.

Duplication. The same information may need to be included in several documents, e.g. for readers with different levels of expertise or different tasks.

Consistency with product. There is no easy way to determine whether the documentation correctly reflects the latest status of the product.

Consistency with standards. The documentation may have to conform to standards, as regards the style of writing (e.g. vocabulary) or the content.

Translation. The documentation may have to be produced in several natural languages, which is an expensive and possibly unreliable process.

Optimal use of multimodality. Most real technical documentation needs to provide pictures as well as text and needs to be integrated with facilities such as hypertext.

Natural Language Generation

We believe that efficient documention production will only be possible when there is a repository of machine-readable knowledge about the product that is being used to check and manage normal product development. The distance between this knowledge and documentation can then be bridged by natural language generation (NLG) technology. We are in a good position to advise on appropriate techniques for knowledge representation and to develop the appropriate NLG techniques that will enable documentation to be produced as a side-effect of normal product management.

If documentation is produced automatically by NLG, it can be regenerated at any time, which means that it need never get out of step with the underlying knowledge. It also means, for instance, that documentation can be automatically tailored to the needs of specific users and more easily generated in different languages.

Collaborative Projects

We have worked with Racal Research, Racal Instruments and Inference Europe on a project (IDAS) that developed a system for generating online help for users of automatic test equipment. Our work with Racal continues, with Intelligent Applications and the University of Sussex as other collaborators, in a project (CORECT) producing a system that supports the design of complex technical devices, including the generation of appropriate design documentation.

We would like to make industrial contacts for all kinds of collaboration. Collaboration could start, for instance, with suggesting an MSc project in which the use of NLG could be investigated using a real example of interest to a company. We are also interested in finding possible collaborators for European-funded projects, and indeed we have contacts that would facilitate the formation of a consortium to work on multilingual NLG.

Consultancy Services

We offer consultancy services to companies considering the use of NLG or other knowledge-based techniques to improve their documentation production. For instance, we are currently working with the Military Aircraft Division of British Aerospace and Dassault Aviation to investigate the application of artificial intelligence techniques to the production of technical documentation.

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Environmental Applications of KBS

Researchers Involved

Mandy Haggith, Helen Pain, Dave Robertson, Edjard de Mota, Alberto Castro, Robert Muetzelfeldt (Institute of Ecology and Resource Management), Mike Mineter (Department of Geography).

Outline of Research

Environmental decision making often requires input from a diverse range of experts, and knowledge of various environmental factors. Knowledge Based Systems (KBS) can help to make relevant information available to decision makers and assist with the management of environmental knowledge. Our research concerns the application of KBS to environmental problem solving, and the development of new techniques to support users of environmental knowledge where existing techniques are inadequate.

Previous major projects include the ECO project, (automatic program sythesis techniques to provide support for ecological simulation modellers), and the Indigenous Knowledge project, (acquisition, representation and use of indigenous knowledge about agroforestry in developing countries). Other smaller projects include the exploration of conflicts in multiple environmental knowledge bases; the use of temporal logics in ecological simulation modelling; context sensitive data retrieval for environmental emergency planning; representation of knowledge for hydrological design; tutoring systems for resource management; and qualitative modelling of ecosystems.

Collaborative Projects

Collaboration with industrial partners would be welcomed either as providers of data to our projects, or for small scale projects involving the application of KBS techniques to environmental impact assessment, environmental auditing, emergency response and natural resource management. We can provide expertise in KBS, and are seeking real-world domains in which to evaluate these techniques. Collaborators which are currently information providers, (eg: agricultural advisors) may find some of these techniques useful for enhancing their information provision. Collaborators with environmental problems may benefit from the experience of tackling them with the latest information technology. We have found in the past that new collaborations are most effectively forged by means of a student project - either an MSc project, running from May to September, or an Honours project, from October to May - which enables both parties to assess if further work would be of mutual benefit.

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Requirements Specification

Researchers Involved

Peter Funk, Jane Hesketh, Nam Seog Park, Dave Robertson, Maria Vargas-Vera, Wamberto Vasconcelos. Our main international collaborative links are with the Institute for Informatics in Zurich and with the Artificial Intelligence Institute in Barcelona.

Outline of Research

We are interested in providing formal systems for expressing some types of requirements in problem domains and harnessing these to assist in the construction and maintenance of specifications. Most conventional requirements descriptions are stated informally. Our job is to identify parts of the requirements engineering process which can most usefully be represented in a formal way and to apply these appropriate formal methods to realistically sized problems. Some of our research interests are given below.

Representing generic techniques in specification construction: In some specification languages it is possible to write a wide variety of specifications using only a few standard, high–level techniques. By constructing environments in which specifications are built using these high–level structures we can, in appropriate domains, produce substantial improvements in the speed with which users can produce complex specifications. We have built systems to support this activity in the domains of ecological modelling and Prolog teaching.

"Mining" specification techniques from existing specifications: The most obvious source for patterns of specification is in existing specifications. We have constructed a system for extracting limited classes of patterns from existing Prolog specifications, thus allowing them to be re–used for different tasks.

Driving specification from past cases: A considerable amount of the expertise of specification is derived from the experience of previous cases. We are experimenting with systems which can store specifications and/or requirements conditions in a simplified form and use this to suggest which previous cases might be worth looking at when building a new specification. Part of this research is to support the interpretation of building regulations. Another part is to promote the reuse of telecomms specifications.

Making specification design more accountable: When we wish to revise a specification it is necessary to investigate what parts of the original requirements might be affected by the alterations. We are investigating this problem for safety shutdown systems in oil production platforms. Our current prototype controls system design by referring to parts of system requirements documents. The points at which the requirements have been used to influence the choice of schemata are used to denote how the original designer took these requirements into account when constructing the specification. This information can then be used to suggest which parts of the requirements might be invalidated by alterations to the specification.

Translating symbolic specifications to a sub–symbolic level: Although specifications expressed in a symbolic style are usually more convenient to read and manipulate, some domains may demand specifications at a sub-symbolic level (for faster run times or to enable inference using simpler components). We have developed automatic translation mechanisms from a symbolic specification language to a sub–symbolic language. This allows users to work at the symbolic level and have their descriptions "compile" to a sub–symbolic level.

Potentially Marketable Techniques

Every major industrial organisation has a need for high level descriptions of specifications: for programming systems; hardware descriptions; simulation modelling; business process modelling *etc.* We specialise in determining which parts of the specification process may be amenable to formal treatment and, using this analysis, we construct systems to support these formal methods. Many of the techniques involved in this process are marketable, as are methodologies for the analytical and design phases.

Collaborative Projects

We have experience of collaboration with industrial partners in a variety of styles: as co–investigators on research grants (*e.g.* our work with The Scottish Office on authoring/interpretation support for building regulations); as industrial "uncles" (*e.g.* our work with Shell Ex.Pro. on systems for accountable design of safety systems); as sponsors of PhD students (*e.g.* in the investigation of very high level telecomms sketches, sponsored by Ericsons); or as the originators of MSc projects (*e.g.* IBM's support of a prototype system for developing BSDM business process models). We aim to extend our range of industrial involvement in future and will be happy to discuss potential opportunities.

Consultancy Services

We are open to offers of consultancy in the form of: advice on suitability of problems for the types of formal treatment described above; training in appropriate techniques; surveys of the technology; or for limited prototyping exercises.

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Reasoning about Computational Systems

Researchers Involved

The Mathematical Reasoning Group consists of: Dr Alan Bundy (professor), Dr Alan Smaill (lecturer), Helen Lowe (lecturer, Napier University) plus 3 research fellows; 3 visiting fellows; 1 Royal Society industrial fellow; 6 PhD students, a computing officer and a part time secretary.

Outline of Research

Our research interest is the automation of processes of mathematical reasoning, especially theorem proving. The main applications are to the synthesis, verification and transformation of software and hardware. For instance, automated theorem proving systems can be used to verify that an electronic circuit meets a specification of its intended behaviour. This can give an assurance that a circuit design is correct before fabrication. It is now possible to verify complete microprocessors. Verification of complex circuits usually requires interaction with a human user who is highly skilled in the kinds of proof involved. The role of the human is to guide the automated theorem prover in the choice of proof rules to apply. Our contribution is to try to automate much more of this process than has hitherto been possible. To this end we have developed a technique we call *proof planning*, in which an outline of the proof is first formed and then used to guide the proof search. Where human interaction is still required proof planning enables this interaction to be in higher level terms than is normally possible.

Potentially Marketable Techniques

We have developed a collection of automated reasoning tools.

MOLLUSC is a generic proof editor. It can be readily adapted to become a proof editor for any logic. A proof editor allows a human user to interactively build a proof in that logic. Alternatively, MOLLUSC can be driven by computer programs called *tactics*.

CLAM is a proof planner. It builds a plan for a proof which can then be used as a tactic to drive MOLLUSC.

BARNACLE is a cooperative front-end to CLAM which allows a user to interact at the level of the proof plan.

Collaborative Projects

Our systems have been extensively tested on standard problems from the literature, with promising results. We are now looking for industrial partners to see if our technology will scale up to problems of industrial interest. The role of the industrial partner would be to provide verification, synthesis or transformation problems of interest to them. The benefits to them would be an exploration of the potential for formal methods of system development in their business. Companies already using interactive theorem proving might like to experiment with the use of CLAM to drive their proof editor. Collaboration is possible at a wide range of levels.

Consultancy Services

Our research group has been active in automatic theorem proving since 1971 and has an international reputation for its work. We are able to offer advice on the applications of automated proof, especially to formal methods of system development.

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