

Centre for Intelligent Systems and their Applications

CISA undertakes basic and applied research and development in knowledge representation and reasoning, and puts this into practical use through its Artificial Intelligence Applications Institute.

Research Challenges

The following are examples of major research challenges that CISA researchers have accepted and are now pursuing with government and industrial funding.

Knowledge lifecycles. Old fashioned knowledge-based systems tended to be simple, self-contained and of limited importance to business success. Their modern counterparts are often complex, interacting with other systems and may be business-critical. This means that we must provide "joined up" engineering which links the various stages in use of knowledge (from acquisition to decommissioning) and enables us to support these in concert. Through projects like the AKT-IRC (see information sheet) we are developing this sort of engineering and the theories needed to understand it.

Model integration. Normally our choice of representational styles and inference systems is conditioned by a particular style of modelling which we believe appropriate to the problem in hand. The ability to choose models appropriate to problems is a prerequisite for engineering but the proliferation of seemingly different models inhibits the development of unifying principles across similar types of problem. Through projects like AKT and I-X we are building the frameworks necessary to develop and share different types of problem-specific model through common underlying representations.

Agent-based engineering. It is hard to build a multi-agent system and predict accurately what its behaviour will be. Even harder is the task of building an individual agent which will "do the right thing" within someone else's multi-agent system. The nub of the problem is that agent systems are not allowed precise expectations about the integrity of their environment or the reliability of the other agents with which they must interact. This demands that we bring engineering precision to "soft" concepts like negotiation, argument and belief revision, and that we understand how macro-behaviours of multi-agent systems may emerge from micro-behaviours of individual agents. We are doing this through projects like SLIE and I-X.

Planning and activity management. We are exploring representations and reasoning mechanisms for inter-agent activity support. Planning and acting rationally are key capabilities for intelligent behaviour. The agents may be people or computer systems working in a coordinated and perhaps mixed-initiative fashion. We are exploring and developing generic approaches by engaging in specific applied studies. Applications include crisis action planning, command and control, space systems, manufacturing, logistics, construction, emergency procedural assistance, help desks, etc.

Intelligent Interfaces. We are researching and developing intelligent multi-modal interfaces that can provide support to user tasks, languages, locations and capabilities. Projects such as GhostWriter, O-Plan and I-X are a basis for this work. Applications include multi-lingual and cell phone support for maintenance and emergency procedures.

Automated Reasoning. Representation and reasoning underpin all aspects of knowledge-based systems. We conduct basic research on the formalisation and automation of argumentation in mathematical and common-sense domains and applied research on the construction and verification of safety and security critical ICT systems. Our applications work has included: the automated verification that computer hardware meets a specification of its intended behaviour, the automated synthesis of computer programs to satisfy their specifications and the automated finding of attacks on security protocols. Our collaborators include companies building: secure hardware modules for bank ATMs, embedded systems in automobiles and "free flight" aircraft control systems.

Technologies

CISA deploys technologies associated with its research through its applications institute: Artificial Intelligence Applications Institute.

Our engineering work is driven by experience gained in real applications. It has two general aims: to define what "engineering" means when the raw material is "knowledge"; and to act as a conduit between theory and application - spurring the former and innovating the latter. We do this by seeking generic approaches to application challenges in the following ways:

Streamlining theory for use. We produce "lightweight", pragmatic versions of theoretical systems that retain all of their formal integrity and most of their computational power but which have been adapted to suit standard styles of engineering.

Fitting our systems to industrial processes. All current volumes of the Yellow Pages for British Telecom have an improved layout produced much more rapidly and flexibly through our knowledge-based layout language and algorithms.

Building applications which are used profitably. The UK Royal Air Force Logistics Expert Provisioner is claimed by the RAF to save £30 million per year by preventing over-ordering of spare parts for aircraft. All copies of the British Telecom Yellow Pages in the UK are laid out using innovative software created at AIAI.

Making the world a safer place. We have developed systems for advising on hazardous waste disposal and providing medical advice in distant lands. We are working on the next generation of advanced emergency response aids at levels needing local, through regional to international response.

Shaping engineering standards. We had a key role in producing the NIST Process Specification Language standard.

Publishing in areas that matter to other disciplines. We have publications in mathematics, psychology, education, bioinformatics, simulation and environmental sciences as well as in the applied AI literature.

Achievements include: development of automated fuzzy rule induction tools which have been adopted by the financial service sector for consumer modelling; pioneering highly targeted, human-oriented applications of computational logic to the early design of systems, attracting the interest of the formal methods and requirements engineering communities; and leadership in the approach to process and plan representation in the emerging NIST Process Specification Language standard. Some highlights from the long list of deployed systems produced by AIAI or with its assistance include: RAF Logistics Expert Provisioner, which prevents over-ordering of spare parts saving £30m/annum; EASE for Windows, a knowledge-based system for assessing workplace risks arising from potentially hazardous new substances, with hundreds of copies in European regulatory authorities and chemical companies; widely deployed systems for the World Health Organisation for tutoring in anaemia/malaria risks, and health quality assurance advice for China; and Formation, a knowledge-based "layout design language" that is currently used to lay out all new Yellow Pages volumes for British Telecom. This group is a partner in the "Advanced Knowledge Technologies" IRC (Sect. 2.10) which is stimulating both theoretical and applied development.

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