Cognitive Systems 2020

Foresight Brief No. 022

Authors: Jane Jackson   jane.jackson@dti.gsi.gov.uk
Sponsors: Department of Trade and Industry
Type: A national foresight project covering a particular issue and the S&T and socio-economic fields that on which it impacts and which impact on it.
Organizer: Foresight Directorate, Office of Science and Technology   www.foresight.gov.uk
Duration: 2002 – 2003   **Budget:**   €660,000   **Time Horizon:**   2020

Motivation

The objective of the UK Cognitive Systems Project was to produce a vision for the future development of cognitive systems through an exploration of recent advances in neuroscience, computer science and related fields, and their potential for future interaction.

Creating Dialogue between Activities in Biological and Artificial Cognition

The UK Foresight programme is a rolling programme of focused projects. 'Cognitive Systems' was one of the two pilot projects created when UK Foresight moved from a general panel based approach looking at all areas of science and technology to the more focused issues based projects. 'Cognitive Systems' was selected because it is an area of research where the challenges were such that different disciplines might profitably work together more effectively than in the past.

Cognitive systems are natural or artificial information processing systems, including those responsible for perception, learning, reasoning, decision-making, communication and action.

The objectives of the project were to:

- Examine recent progress in two major areas of research - artificial and living cognitive systems - and their related disciplines (including computer science, neuroscience, cognitive science, artificial intelligence) - to understand whether progress in understanding cognition in living systems has new insights to offer those researching the construction of artificial cognitive systems;
- Scope the likely developments in these fields over the next decade, and in particular to scope the likely rate of progress in our capability to build artificial cognitive systems;
- Articulate significant conclusions from this to a wider audience.

The Foresight Approach

Lord Sainsbury, science minister at the Department of Trade and Industry, chaired the stakeholder group which oversaw the project. Membership included business, academia and government.

The project explored the objectives using a variety of tools and mechanisms. As one of the first projects following the reshaping of Foresight, the project initiated a number of methods which have become the norm in subsequent projects. The project was supported by a small team within Foresight, and employed two leading experts – one in the field of neuroscience and the other in computer engineering to steer the project's exploration of the objectives, particularly in the relevant science and technology. A series of workshops defined the scope of the project and identified topics for eleven science reviews which fed into four grand challenges, presented at the InterAction Conference in September 2003.

The results of the conference and the reviews and challenges form the basis of the project's action plan aimed at taking forward the findings of the project and formalising the post project process which included the reconvening of the stakeholder group a year after the project finished.

Synergies between the Life Sciences & the Physical Sciences

In the life sciences, brain research benefits greatly from advances in technologies that can begin to monitor brain activity in 'real time' and at ever greater resolution. IT also continues to progress as ever declining costs, improved performance and mobile devices make massive amounts of computing power available to more users. The challenge for the future is how to make best use of it.

Research Challenges

In both the life sciences and physical sciences, progress may be rapid but there are challenges at a fundamental level.

In the case of IT, conventional 'engineering' approaches to problem solving are running into difficulties. For example, we will not be able to move from speech recognition to natural dialogue with machines simply by throwing computer power at the problem.

For its part, brain science could benefit from information processing techniques that are widely deployed in IT.

Researchers also need better techniques for measurement and analysis.

Addressing Public and Scientific Communities

Both areas also face a common challenge in explaining their work to wider audiences. Without an appreciation of what researchers hope to achieve, and how society can benefit from their work, it will be all too easy to lose public acceptance.

One task during the project was to elicit the views of the research communities involved. In particular, it was important to see if they agreed that there could be fruitful discussions between life scientists and researchers in computer science.

From the outset, the scientific community itself was in the driving seat for the project. The Foresight Directorate was the facilitator of a dialogue between, and within, the research communities.

The technical aspects of the project were in the hands of two scientific experts, one as the coordinator for the physical sciences and as coordinator for the life sciences. Both continued in these roles after the project formally ended.

Rising to the Challenge

Research Manifestos can Guide the Scientific Agenda

The project commissioned researchers, brought together from the life sciences and physical sciences, to develop proposals for areas of science that could benefit from fertilisation of ideas across traditional disciplinary boundaries. Known within the project as 'Grand Challenges', Foresight's challenges share the ambition of the UK Computing Research Committee that "The grand challenge should be directed towards a revolutionary advance, rather than the evolutionary improvement of legacy products that is appropriate for industrial funding and support." The Foresight commissions also shared the belief that "The ambition of a grand challenge can be far greater than what can be achieved by a single research team in the span of a single research grant." Building on the Research Reviews commissioned for the project, the OST commissioned groups to work up Grand Challenges on:

- Memories for life, which includes the use of cognitive engineering to offset memory loss due to aging or disease
- Localisation in animals and artificial systems
- The role of rhythmic activity in the brain
- Neuro-computational approaches to speech and language

The Department of Trade and Industry commissioned these reviews as representative proposals for presentation at the InterAction Conference. Many more ideas came up at the Foresight workshops.

The project has shown that a dialogue between life scientists and physical scientists can provide valuable insights into the future direction of research into cognitive systems. It has also shown that researchers in these areas are enthusiastic about the possibilities of collaboration, and are keen to move ahead.

Conclusions

Key Issues to be Considered

The project identified a number of issues for further attention:

- **Facilities:** Brain research depends increasingly on access to large and expensive equipment, for functional magnetic resonance imaging, for example. Any follow up to the foresight project should consider the case for such facilities.
- **Training:** Future research in cognitive systems will need contributions from researchers who are comfortable working across traditional disciplinary boundaries while still being experts in their own field. This could be encouraged through "cross discipline" PhD students with supervisors from the life sciences and physical sciences. For established researchers, fellowships could provide opportunities for life scientists to acquire knowledge of the physical sciences, and vice versa.
- **Funding:** The Cognitive Systems Project has shown that there are exciting opportunities in research across disciplinary boundaries. While there is certainly a case for investigating the possibility of further funding mechanisms, the Research Councils and other organisations have already shown interest in discipline breaking research and are likely to reflect this in future funding decisions.

The project did highlight the need to enable cross-disciplinary proposals to be assessed on equal terms with proposals of more traditional structure. The community is working to overcome some barriers, by creating a pool of referees, for example.

- **Public Debate:** Research in natural and artificial cognitive systems has enormous social implications. If society is to appreciate the possibilities, to accept novel applications and technologies and to influence their development, it is important to debate the issues in advance.

New Directions for Research

With no promise of funding, the community ran five cross disciplinary workshops to see if it would be possible to draw up high quality cross disciplinary proposals in five key areas identified by the project. Costs for the venues were covered by Foresight and Engineering and Physical Sciences Research Council. Over 150 scientists were involved in these workshops. One group has also written an additional state of science review on an area not covered by the main project – robotics.

In parallel, the Wellcome Trust offered funding to take forward research on cognitive systems if it was match funded. This provided the basis for a discussion with the Research Councils on how best to support research in this area.

In response, four Research Councils together with the Wellcome Trust issued a highlight notice seeking cross disciplinary proposals in response to the cognitive systems project. Fifteen proposals have already been received. There is also specific encouragement for bids on cognitive systems under the Medical Research Council/EPSRC discipline hopper scheme.

Widening Interest in Collaboration on Research on Cognitive Systems

A network has been set up on memories for life funded by the EPSRC and led by a small group who were involved in the project.

The Royal Society of Arts is using the information from the reports as the basis for a Design Competition it is running with the Royal College of Arts.

The British Computer Society has run a series of three meetings to foster debate with a wider community of scientists and business people. The BCS commented that there was no way that you would have got such eminent people from both communities involved in a meeting of this type if it had not been for the Foresight project.

Ongoing Activities

The project has highlighted the potential social implications of cognitive systems. The Royal Society, British Association, Royal Academy of Engineering and Academy for Medical Science have drawn up a proposal to explore the potential future social ethical and legal implications of cognitive systems. Their aim was to trial a process which might have wider application for future emerging technologies so there could be public engagement at the early stage of the development of new emerging area of science.

The Council for Science and Technology has asked that an assessment should be made of whether:

- The project approach is adopted by others to nurture emerging cross disciplinary research,

- The innovative interdisciplinary appraisal method introduced by the Research Councils and the Wellcome Trust leads to high quality projects within the current funding mechanism, and

- Projects of this type are a good base for public engagement on emerging areas of science.

These longer term outcomes will be assessed in two years.

Sources and References

All the above information is based on the Foresight Cognitive Systems reports which are available at www.foresight.gov.uk