



Foresight Cognitive Systems Project

Applications and impact

Lights that come on when there are prowlers about can hardly lay claim to intelligence, but they are an early step on the way towards cognitive systems with increasing powers to sense, understand and react to the world around them. Imagination is the only limit to the technologies that could arise from our growing understanding of how living cognitive systems behave, and the ability to use that knowledge in the design of artificial systems.

Knowledge transfer

Cognitive systems – natural and artificial – sense, act, think, feel, communicate, learn and evolve. These capabilities exist in many forms in living organisms. For example, ‘systems’ as diverse as colonies of ants and human brains achieve sophisticated adaptive behaviours. As computing power grows, and pervades more and more devices, there is growing interest in transferring our understanding of natural cognitive systems to the challenges of building ‘smart things’.

Medicine and health, education, transport and how we wage wars will all change as information technology becomes more ‘cognitive’. At the extreme end, would you welcome the idea of connecting your brain to the Internet?

Artificial cognitive systems are taking computing in many directions – each involving huge areas of commercial and societal activity. While it is unwise to rely on predictions of the shape of things to come, considering potential applications does at least show us some of the areas where we need to anticipate the outcomes, desirable and undesirable, from the arrival of artificial cognitive systems.

A networked world

The core components of computing and communications are becoming cheap enough for ‘anything’ to connect to the web. In the short term that means smart phones, TVs, cameras, hi-fi, car navigation. In the near future, look for the Internet presence of any artefact for which there is a reason to connect – if it makes sense for a coffee cup to be online, it will be.

The move to put everything on line is changing the model for computing. A web designed for people to seek information is changing to become an ‘Ambient Web’ that can accommodate objects that need to interact. One development here is of ‘agents’, autonomous software entities that can act and react with each other in a distributed environment.

How will we regulate and police systems in which bits of software do our bidding, booking holidays for us, participating in on-line auctions or taking the steering wheel of our cars, for example?

While we may be able to predict how an individual agent or piece of technology will behave, we cannot forecast the outcomes of all the possible interactions of many millions of semi-autonomous devices. How are we to devise systems that can cope with such unpredictable emergent behaviour? We have already seen early examples of this, in programmed trading on stock exchanges, creating cascades of unintended transactions.

A personal digital environment

Much of the change we will see will come from our ability to carry a growing number of simple and capable devices, a move toward a personal digital environment (PDE), with fully connected technology at the scale of credit cards, jewellery, glasses, spectacles, wristwatches and so on. There will be intelligence in anything that is most convenient in our personal environment.

One likely development of the PDE is the mobile medical monitor. It starts with a PDA reminding you to take your pills but quickly moves on to devices that can tell asthmatics about air conditions or monitor the cardiac status of heart patients.

Bionic beings

The use of imaging techniques to map brain activity while people undertake controlled tasks is increasing our knowledge of which parts of the brain do what. One consequence of this knowledge could be feedback devices to monitor, and let us control, the brain's state when learning new tasks. Other possibilities include implanted chips to treat a wide range of cognitive dysfunctions, such as autism or Parkinson's disease.

Other implants could control prosthetic devices, raising the prospects of devices in which individuals engage with sophisticated real-time feedback to influence the performance not just of their brains but of their bodies. Robotics is set to become a key driver of prosthetic technology because there is intrinsic scientific, technological and commercial interest in giving autonomous machines the sensory, movement and control capabilities of humans and animals.

Like many other potential technologies involving artificial cognitive systems, these medical applications – a tiny glimpse of what could be possible – raise numerous ethical, social and legal issues. They could also change our relationships with the technologies we use.

The cost and availability of advanced new medical technologies is bound to emerge as a major concern for public policy.

Transport skids into dilemmas

Expect to see equally challenging issues in transport and other key areas of life. Today we are accustomed to the idea that an anti-lock braking system (ABS) can help us to operate our car more safely. Car manufacturers are already researching advanced forms of vehicle control and driver assistance that will radically change how we drive.

Artificial systems can learn and tune control algorithms over millions of hours of simulated and real driving. It can surely only be a matter of time before we start to prefer automated control to the human variety. But what happens if the best way for 'intelligent' vehicles to save lives in a crash is to make matters worse for one driver?

Even without having to tackle such dilemmas, we will face many issues of investment and risk management. Testing, responsibility and accountability will all need to be radically re-thought. What will it mean to take a driving test on a vehicle that is more competent than you are under many circumstances? Will cars limit your ability to control them to the expertise level you have built up through actual driving?

We will face similar challenges as artificial cognitive systems make inroads into entertainment, education and military activities.

An artificial new world

At some point in our evolutionary past, humans entered the 'cognitive niche', fundamentally changing their relationship to the world around them and the rate at which they could develop their culture. The artificial world is about to do the same, with humans as partners in the process. The effects will be equally far reaching.

Further details

This Brief is based on "Applications and Impact", a review written for the Foresight Cognitive Systems Project by Bill Sharpe, Appliance Studio Ltd, Bristol (<http://www.appliancestudio.com>). This paper, other Research Briefs, Research Reviews and details of the project, are available on the Foresight web site at:

<http://www.foresight.gov.uk/cognitive.html>