Robotica (1999) volume 17, pp. 113–120. Printed in the United Kingdom © 1999 Cambridge University Press

Reports and Surveys

ARTIFICIAL INTELLIGENCE AND ROBOTICS

1. Cricket Robot

The Department of Artificial Intelligence at the University of Edinburgh, Scotland, U.K., has developed projects that involve both Artificial Intelligence and Biology. One such project has resulted in the development of a cricket robot which is based on a model of the sensorimotor of a cricket, which is the grasshopper-like insect, the males of which produce a characteristic chirping sound. The robot moves like a female cricket responding to a male calling song. The project, it is claimed, has already provided important insights for *AI* and biology researchers into sensorimotor behaviour. Dr Barbara Webb (currently at the UK's Nottingham University's Department of Psychology) whose doctorial thesis inspired the project, says that:

> Doing statistically-validated real biological experiments with robots in this way enables robot designers to learn from animal behaviour as well as assisting investigations into animal behaviour.

Edinburgh's projects leader Dr John Hallam emphasises the value of this approach in robotics; he believes that:

> Animals have been engineered by evolution to survive in their ecological niche. Understanding their niche-specific behaviour greatly helps robot designers when making crucial decisions about the best mechanism for a task, such as responding intelligently to events in a particular environment.

Dr. Webb focused on the process used by female crickets to identify and locate singing males because it involves complex and subtle behaviour patterns, using apparently simple basic mechanisms. The female can distinguish a song from all other sounds and target a particular male, even when other suitors are chirping almost identical songs.

A report from the Edinburgh *AI* Department says that:

> The 'ears' of the cricket robot consist of small microphones and circuits designed to mimic a cricket's actual sound processing system. Robot 'ears' are constructed as an attachment to the commercially available Khepera robot. The attachment cricket hearing system is sold by the Edinburgh AI Department.
>
> In experiments, the robot consistently headed towards speakers playing artificial and real cricket songs, following a similar zigzag path to that observed in live crickets. A study was also made of the relationship between movement in response to a sound (known as 'phonotaxis') and the song's structure, which consists of 20 millisecond 'chirps' of about three 'syllables' interspersed by silence. Phonotaxis performance was found to depend on this structure and the song's frequency.
>
> A model of the cricket's neural processing system was developed to represent actual impulses, or 'spikes', generated by neurons in response to song syllables. This controlled the robot's movement to make it reproduce the cricket's known preference for syllables that are not too fast or too slow.

The development of this project is part of a Engineering and Physical Sciences Research Council (EPSRC) initiative. Further work in this area is continuing and a variety of uses of the project's methodology to assist robot design and biological research are being pursued by Drs Webb and Hallam. Currently, for example, they are considering the integration of a number of cricket sensorimotor behaviours into a robot that could have potential agricultural applications.

Pictures of the cricket on the Khepera-based robot developed by Drs Hallam and Webb with the help of research assistant Henrik Lund (now at the University of Aarhus), together with a prototype cricket robot made of Lego are published in the *EPSRC's Research File* (Impact, No. 19, 1998). The Web links for this project are:

www.dai.ed.ac.uk/groups/mrg/MRG.html
(Edinburgh Department of AI)

www.psyc.nott.ac.uk/aigr/people/bhw.html
(Nottingham University)

2. Intelligent robot dog

What has been claimed to be the world's first intelligent robot guide dog has been announced at Carnegie Mellon University in Pittsburgh, USA. If successfully completed the robot guide could change the lives of the blind and partially sighed, as well as offering a multitude of other potential uses.

It would be seen as one of the most sophisticated robots with a capability of helping its handler to navigate and at the same time providing the capacity to carry things. A statistic produced in the United Kingdom indicates that some 4,600 of the registered blind and partially sighed have guide dogs. The reasons given for what appears to be such a low figure

https://doi.org/10.1017/S0263574799001381 Published online by Cambridge University Press

is that some people are unable to look after dogs and others may be allergic to them. In Britain there are some 316,000 registered blind or partially sighed.

The Carnegie Mellon scientist whose team is building the robot, Dr Sebastian Thrun, says that:

> It will be able to help people move around in a cluttered environment without bumping into things, just like real guide dogs can, and this will mean that some of those who have to live in care centres now will not have to do so. The robot dog is able to sense its surroundings using five different devices: sonar, which is similar to that used by bats and in submarines, laser range finders, infrared scanners, a camera linked to computer vision technology and simple collision detectors fitted behind the robots metal panels that form its body.

The research team also claims that the robot can respond to simple orders by word or gesture, is able to work out the best route to take and can then move around on its wheels avoiding collisions with furniture or with people who wander across its path.

What interests researchers and developers is the application of artificial intelligence (*AI*) in its central control computer. The *AI* systems allow it to construct a map of its home. In addition, it is believed that its ability to accept that it can make errors means that it is less accident-prone than previous designs.

Professor Thrun also says that:

> The robot can extract information from its sensors and use this to make decisions, but the key to its success is the ability to handle uncertain knowledge so it does not believe everything it sees and can accept the possibility that it could be wrong.

Much of the field work for testing the device was carried out in Germany where the development team worked with scientists from Bonn University to try out a prototype in a German museum. The device had to cope with crowds of visitors to the museum and, at the same time act as a guide to the exhibits. The robot prototype will also be tested next year, in a German hospital before the 'commercial version' is produced.

The Carnegie Mellon team believe that the new robot will be successful in the home and could also be used in shopping centres and offices. They hope to be able to increase its range so that it will be able to climb stairs and also be able to survive in the unpredictable world at large.

The reaction from guide dog owners and the Guide Dogs for the Blind Association (GDBA) in the United Kingdom to this new U.S. initiative has been mixed. The general feeling being that whilst robot technology could well be used to support the present guide dogs it was a long way from replacing them. Losing the friendship of a real dog, it was said, could not be compensated for by any technological benefits. Perhaps in the future the robot guide dog could be made to look more like the real thing so that, as with some of the current popular computer 'pets', people could develop a relationship with it.

There is little doubt that the Carnegie Mellon initiative in producing such a device will contribute to the advancement of new robotic research as well as providing a most sophisticated machine with many worthwhile applications in our society.

AUTOMATION AND ROBOTICS WORLDWIDE

1. Australia — Robot installations soar to new heights

526 robots were installed in Australia in 1997, according to the Australian Robotics and Automation Association Inc. (ARAA). This is a 110% increase above the 250 robots installed in Australia in 1996 and brings Australia's nominal robot population to 3,043 units.

According to the Association, last year's record numbers were due mainly to large orders from motor vehicle manufacturers. 307, or 58%, of Australia's new robots were bought by car manufacturers. A further 74, or 14%, of robots were sold last year to companies that make parts or accessories for motor vehicles.

For the same reason, spot welding was the dominant application of robots installed last year, accounting for 276, or 52%, of 1997 installations. 15%, or 77, robots were installed for arc welding applications, followed by 11%, or 58, robots used for palletising or packaging applications. (See Table I for principal application and industry sectors.)

Each year the Australian Robotics and Automation Association (formerly the Australian Robot Association) counts the number of robots installed in this country in the preceding year. This census is part of an international effort co-ordinated by the International Federation of Robotics and the United Nations.

Australia's robot census is based upon confidential information supplied to the Association by the country's leading robot suppliers. For purposes of this census, a robot is defined, in accordance with International Standard ISO

Table I. Robot installations in Australia in 1997 (ARAA estimate)

Principal Applications	# Installations	% Installations
Spot Welding	276	52%
Arc Welding	77	15%
Palletising/Packaging	58	11%
Material Handling	36	7%
Machine Loading/Unloading	18	3%
Sealing/Gluing	14	3%
Cutting/Grinding/ Deburring/Polishing	13	2%
Other	34	6%
Total:	526	100%
Principal Industry Sectors		
Mfg Motor Vehicles	307	58%
Mfg Motor Vehicle Parts & Accessories	74	14%
Mfg Fabricated Metal Products	40	8%
Mfg Food, Beverages, Tobacco	27	5%
Mfg Paper, Publishing	13	2%
Other	65	12%
Total:	526	100%

https://doi.org/10.1017/S0263574799001381 Published online by Cambridge University Press

8373, to be an automatically controlled, reprogrammable, multipurpose manipulator that is programmable in three or more axes.

Almost all robots included in the latest ARAA census are utilised for manufacturing. Increasingly, technology is being developed to enable robots or near-robots to be utilised for non-manufacturing applications. For instance, the ARAA understands that 13 near-robots (not included in the above census) are currently being used in Australia to assist surgeons to carry out endoscopic ('keyhole surgery') operations. The International Federation of Robotics, with assistance from ARAA, is developing a standardised definition for 'service robots' and it is hoped that such devices will be counted in future censuses.

Australia's robots are overwhelmingly imports, principally from Japan and Sweden, with small numbers arriving from other countries. Of the 526 robots installed in Australia last year, the Association estimates that only 10, or 2%, were locally made. The ARAA's census indicates that 6 robots made in Australia were exported in 1997.

The ARAA estimates that the value of the Australian robot marketplace grew last year to $74,700,000, a 140% increase from the 1996 estimated market size of $31,100,000. This value includes, in addition to the robots themselves, the cost of other components and services provided by Australia's robot suppliers when installing a robot workcell. It does not include the cost of components and services provided by the customer or by third parties. The ARAA estimates that the mean price of a robot system installed last year, including such components and services, was $142,000.

The Australian Robotics and Automation Association is the national society concerned with the applications and implications of robots and related automation technologies. The Association's membership includes the country's leading robot suppliers as well as interested individuals.

2. Canada Robots at work for the oceanographers

A meeting of oceanographers held in Canada earlier this year to assess a seven year experiment were told of the role taken by the *A*utonomous *L*agrangian *C*irculation *E*xplorer (*ALACE*) robots that have been providing essential data.

There are more than 1,000 *ALACE* robots drifting freely through the world's oceans. Every two weeks they surface and beam information into space about the state of the sea. Having then completed the transmission they sink back down to a depth of 1,500 metres, where they drift along with the currents. The robots were but one facet of a huge experiment to determine the nature of the world's oceans. The experimental phase is over and scientists gathered in Halifax (Canada) to make the first attempts at putting this data together. This was the most comprehensive survey of the global oceans that has ever been undertaken. Called the *W*orld *O*cean *C*irculation *E*xperiment (*Woce*) it is part of the *Intergovernmental World Climate Research Program*. Its success so far is due to the improved resources made available. Satellite technology, in particular, has been of great help — researchers can now map the shape of the ocean's surface to within 3 centimetres. But of all the new developments, scientists say that the *ALACE* robots have been the most successful. Although the experimental phase is over more of the drifting robots are being deployed. Scientists say that there are plans to maintain a global array of 3000 of them as part of an ocean-observing system.

Further details can be obtained from *Woce* at: www.soc.soton.ac.uk/

3. Switzerland Highly-automated thermoplastic fiber placement process

The *ABB Corporate Research Centre* at Baden in Switzerland has reported on a new highly automated fibre placement process. Researchers Drs Ahrens, Mallick and Parfrey of the Centre have explained that:

> "The excellent specific stiffness and strength of carbon fibre reinforced composites makes them especially interesting for applications in rotating machines. Unfortunately, these materials have the disadvantage that their manufacturing process is labour-intensive, and thus slow and expensive. This drawback is overcome by the highly automated thermoplastic fibre placement process, in which impregnated thermoplastic tape is heated and then consolidated *in situ* under pressure. ABB has implemented the process in the laboratory with a 6-axis robotic system and is using it to develop new components for turbomachinery. The process is also of interest for applications in the aircraft and automotive industries."

Further details of the process can be obtained from the ABB Corporate Research, 5405 Baden-Dättwil, Switzerland. Dr Markus Ahren's email address is: markus.ahrens@chcrc.abb.ch

CONSCIOUS COMPUTERS

In an address to the British Association for Advancement of Science Professor Igor Aleksander, Imperial College, London (UK), who is a leading researcher in artificial intelligence, believes that by the year 2040 we will feel guilty when we turn off a personal computer. Such machines, he says, will probably be conscious — they will possess a consciousness of their own. Addressing the *British Association for the Advancement of Science* at Cardiff, UK in September 1998 he said that:

> In forty years' time we may feel a pang of guilt when we turn our computers off. By then we wouldn't think of buying a computer that wasn't conscious. In fact, their consciousness should be indistinguishable from ours.

Such a computer, we were told, would not feel intimations of mortality when it was turned off. It will know that its back-up stores are still functioning so that it is not being eliminated. He said that:

> The term "machine consciousness" is very important. Consciousness of anything we build will be particular to the hardware, technology or software that the thing is made of.

https://doi.org/10.1017/S0263574799001381 Published online by Cambridge University Press

The principles of how artificial consciousness would emerge, he believes, are not many miles away from how real consciousness emerges from real systems. Machine emotions started with the ability to run away from situations and to approach others, which he likened to fear and pleasure. From those, it might be possible to develop more subtle machine emotions. He stated his overall aim as:

> . . . not to produce highly-strung computers. The point is not to make robots that go around being depressed. That has been done beautifully by Douglas Adams. The point is to understand what happens to humans when they get depressed.

1. Magnus system

Professor Aleksander has been carrying out research at Imperial College for many years and his work is recognised worldwide. To back up his latest theories he has designed a computer program called *Magnus*. This system, he claims, already shows some evidence of consciousness. At the *British Association Science Festival* at the University of Wales at Cardiff, he spoke about the system having

> . . . a sense of where it has come from and where it would like to go. It sometimes make arbitrary decisions. In human beings, we might call that free will. It would probably use language and be quite responsive to vision, so that you could show it things you are describing. Science fiction is way ahead of us in this, but that is only because it can look ahead and see what is possible. The big change is that a conscious computer might answer a problem by saying, 'I see what you mean, but I think we should do X, Y or Z. It could conceivably disagree with you and argue. When a computer starts using the word 'I' in that context then we will know that it is fully conscious.

The *Magnus* system has shown that to some extent, it could feel the quality of things — such as 'redness' or 'ballness' when visualising a red ball. This concept, known as Qualia, has traditionally been used by philosophers as proof that consciousness is a human condition that can never be replicated in a machine. *Magnus* has a million neurons and is tiny compared with even small specialised parts of the brain. It is, of course, hoped that such technology will lead to conscious computers.

Readers will recall that it was the author Douglas Adams who thought-up the depressed robot he called 'Marvin the Paranoid Android' in his radio play *The Hitch Hiker's Guide to the Galaxy.* Professor Aleksander, however, reiterates his belief that what we need to do is not just to build such robots but to try to understand what happens when humans get into that condition.

2. Main challenge

The main challenge that he identified was that of learning the structure of language for the development of thinking, talking computers. He summed up some of his ideas by saying that:

> At the moment we talk to these systems and they talk to us by drawing pictures on the screen, but that is just a question of technology. The thing is it is going to be pretty unsurprising when it happens. At the moment you can buy a piece of software for £25 that enables you to talk to a computer. It does not understand anything, but one day it will.

Most scientists involved with this work will support this view. There is no doubt that many of the advances we are talking about will come to fruition in the next millennium. One of our problems, however, is that we give the impression to the public at large that there are already systems that are capable of performing such functions. There is no doubt that Artificial Intelligence will require many major breakthroughs before such goals can be achieved.

CYBORGS AND BIONICS

1. World's First Cyborg? (Chip used in experimental implant in human)

A leading researcher, Professor Kevin Warwick of the Department of Cybernetics at Reading University (United Kingdom), claims to be the world's first Cyborg, that is, part human and part machine. He has had a silicon chip implanted in his forearm, which he says opens doors and switches on his computer which greets him with a recorded message.

It means that as he moves around the Department of Cybernetics at his university the data encoded on the chip detects his position via sensors and displays it on any screen in the departmental network so that he can easily be found.

It is not suggested that this in itself is a great advance — the same effect could well be achieved perhaps if the chip was positioned anywhere on his person — but it does have, however, the added bonus of dramatically publicising an important application of the use of such systems. In this context, for example, it could allow the chip to be programmed to inform the wearer of any relevant information stored on a networking computer system. Prompts could be sent out within a building quite easily, to indicate that e-mails or any down-loaded information have been received and are awaiting attention. Diary prompts about meetings, engagements and any reminders could be transmitted to the implanted chip.

Professor Warwick had a chip which was sealed in a glass capsule about an inch long and a tenth of an inch in diameter, implanted under local anaesthetic by his own doctor. The implant was not, in this instance, kept indefinitely, but there are now techniques for the implantation of small chips under the skin for long-term operations. In this case as Professor Warwick walks through the doors of his department a pulsed radio signal generates a current that activates the chip. This then transmits data which is picked up by the computer network in the building.

https://doi.org/10.1017/S0263574799001381 Published online by Cambridge University Press

Professor Warwick says of his work:

> "I'm making a point. Cybernetics is all about human beings and technology interacting. In future, all buildings will have intelligence built into them. The idea of a man enhanced by a chip has been science fiction so far. Now it is science fact. In five years' time we will be able to do chips with all sorts of information on them. They could be used for money transfers, medical records, passports, driving licences, and loyalty cards, for example. And if they are implanted they are impossible to steal. The potential is enormous."

The potential for such innovative technology is, of course, too great to assess. It would appear that what was science fiction today is the reality of tomorrow. That the human can be part robotic and robots part human is apparently an achievable goal. This is well illustrated by the application of Bionics described in the next section.

2. Bionic Man — World's first Bionic Arm?

A report from the Princess Margaret Rose Hospital, in Edinburgh, Scotland (UK) describes how a bionic limb has been fitted to man who lost his arm to cancer. He becomes, specialists at the hospital say, the first person in the world today to use a bionic limb.

The arm is fully flexible and it costs about £100,000. It has been designed to enable its recipient to carry out everyday tasks. This includes, it is claimed, the ability to tie his shoe laces. The carbon fibre arm has the world's first motorised shoulder, rotating wrists and contracting fingers the developers say. It contains pressure sensors, imitation skin and a microchip that translates thought processes from the brain.

Electronic pulses travel through sensors to motors and gears that control the wrist, elbow and hand. Development of the arm has taken three years and the project team was led by Dr David Gow. He said that one of their problems was that existing and currently available components needed for the development proved to be much too heavy. Technologists had the major task of reducing them to a size that would enable them to be fitted into the bionic device.

3. Future Developments

At a time when reports of hand transplants fill the media such advances in bionics might well be overlooked, but their importance remains because they illustrate the beginnings of the integration of humans and machines in a most realistic way.

These initiatives are but some of the advances in both Cyborgs and in Bionics. The first experimental project from Professor Warwick publicises the real possibilities for the development of Cyborgs, whilst the application from Edinburgh provides an example of the world's finest bionic limb that is in everyday use. Both provide us with an insight to the future relationships that will be forged between humans and robotic devices.

MICRON-SIZED MACHINES

Micron-sized machines provide a wealth of opportunities for those involved with research and development in robots and automation. One of the world's leading teams developing such micro-electromechanical systems, micron-size machines, is based at the US's *Sandia National Laboratories* at Albuquerque. There the Intelligent Micromachine Department is managed by Jim Smith. This department together with a research group at the University of California at Berkeley (US), are extremely active and have already built a prototype that functions as a clock. This minuscule machine performs the same function as quartz crystals which is the traditional technology used in timing devices in all electronic digital uses. Micromachines are, however, made from polysilicon, which is the same material used in manufacturing integrated circuits, the building blocks of digital electronics. This means that micromachines and integrated circuits can be constructed on one chip. Researchers suggest that if viewed through a powerful microscope the timing device prototype looks exactly like a double-ended tuning fork. It consists of two very fine strings or tines (ten would fit on a pinhead), which are anchored in parallel to actuator frames the size of red blood cells.

1. Developing applications

A report in the journal *Science* (July, 1998) gives details of the work of scientists who have developed a molecular propeller that suffers no wear. Researchers at *IBM's Zurich Research Laboratory* in Switzerland and their co-researchers in France and Denmark have described this great advance in the development of nanomachines. Dr James Gimzewski of the Zurich Laboratory has described the propeller as being only 1.5 nanometer (just over a millionth of a millimetre) across. He believes that it could pave the way towards the development of machines, memories and calculators of molecules. He is quoted as saying that:

> We do not envisage a molecular cuckoo clock but in ten years it could prove useful in computation of memory storage.

What the team have synthesised is a propeller-shaped compound which was used to form a single layer on a copper surface. Within this layer some molecules acted like propellers, with others as bearings. When heat was applied, they began to rotate. This rotation can be seen through a scanning tunnelling microscope, that is one that is able to scan a surface with a tip so sharp that it may end with a single atom. The researchers say that each of the propellers rotates so fast, at around 100 million times a second, that it appears as a blur. First assessments suggest that the rotor seems to be 'wear-less'. This, the team believe, will be a great advantage when they have the task of creating gears and motors. It is believed that the motor will also help the scientific world to test ideas concerning the Second Law of Thermodynamics. This, as readers will know, rules out perpetual motion machines. We are told that no matter how carefully we design such a machine, a little of its useful energy will be converted into randomness, such as the jiggling of atoms.

https://doi.org/10.1017/S0263574799001381 Published online by Cambridge University Press

Dr Gimzewski is said to believe that there is an argument over whether the Second Law holds true in all circumstances at the level of atoms and molecules. He says that:

> With a single molecule we could hope to investigate this fundamental issue. The effort is part of a wider drive to use pollen-grained parts in everyday devices such as watches, televisions and computers. These measure at least 1,000 times larger than the propeller, but wear out.

The report in *Science* also included STM images which show the molecules immobilized and also spinning (at 100 million revolutions per second). The structure of the six-lobed 'propeller' molecule was also displayed. This is, of course, the beginnings of research work that has tremendous potential but we have been cautioned that the fruits of these endeavours will not be immediately available in marketable forms.

NEW STUDIES OF THE BRAIN

1. Studies of the human

Attempts to understand the workings of the brain have received much encouragement by current studies. One recent report concerned with understanding facial expressions illustrates some of the important contributions that scientists are making to our understanding of its functions. So many of these advances in our understanding have been transferred to artificial intelligence applications where attempts to mimic the brain's working have proved to be most fruitful. Two studies are discussed here; understanding facial expressions, and monitoring the brain as it learns.

2. Facial Perception

Dr Andy Young, who is Professor of Neuropsychology at the University of York (UK) and president of the *British Association*, has written, with Vicki Bruce, the book *In the Eye of the Beholder: the Science of Face Perception**, it was no surprise therefore to see that the latest insights were presented by neuroscientists and psychologists at a symposium and exhibition of the British Association at their Science Festival at Cardiff (UK), in September 1998. In Professor Youngs' report of the symposium published in the UK's *Daily Telegraph* (9/9/98) he writes:

> We are all experts when it comes to faces. When we walk along a crowded street we may pass hundreds of people yet the unexpected face of a friend is recognised instantly. When we look at an advert in a magazine we know whether a face is male or female, old or young, even though we may never have seen it before. We can tell from people's facial expressions whether they are tired, apprehensive, angry, sad or happy, and their direction of gaze reveals whether they are interested in what we are saying. These skills have been honed over hundreds of thousands of years of evolution because they are so important. The ability to read a face can start a war, end a love affair or save a life. But how do we do it?

Researchers are asking the question whether the brain has developed regions which are specialised for the task of face perception and whether these areas analyse all the social signals we get from the face or just some of them. The current thinking is that the brain does, indeed, allocate the task of face perception to a number of specialist brain areas that are located on distinct neurological pathways. It would seem that these pathways have been revealed by examination of those people who have had the misfortune to have a stroke or other disease that damages particular parts of the brain. At the Cardiff symposium these were discussed at length.

3. Parts of the brain identified in different types of recognition

Professor Young provides some information which relates the parts of the brain that have been identified in different types of recognition. They include parts that enable facial recognition of known people, recognition of expression of disgust, and the recognition of fear and anger.

We are told that the incredible specialisation of the brain raises a more profound question concerning our conscious experience and sense of self. That is, if our brains depend on diverse regions or neurological pathways with specialised functions, why does not the world seem more fragmented to us?

Dr Young sums his report by saying:

> 'What makes the neuropsychological findings so counter-intuitive is that we get no sense, when we gaze at a face, that our perception is anything but unitary. The effort to reconcile our single consciousness with the diversity of specialist areas in our brains will be potentially fruitful for those of philosophical dispositions.

4. Monitoring the brain as it learns

Studies of how to monitor the brain as it learns are meeting with success. Experiments conducted by Dr. Paul Fletcher of the UK's Institute of Neurology, London, have shown how it is possible to monitor the brain as it learns, revealing which parts are active as a memory is laid down. If the research is successful Brain Scanners could, in the future, be used to test the effectiveness of teaching methods by monitoring how children and other subjects memorise information.

Dr Fletcher has found association between areas that control awareness, located in the brain's frontal part and the hippocampus, the activity of which is linked to memory. The technique, it is reported, will be used initially to detect early signs of dementia, which affects memory.

In the future, Dr Fletcher believes it might be possible to gain enough knowledge about brain activity to show the process of learning and whether it was taking place efficiently. The implications of this in the real world of education and training must be obvious, and they have far reaching consequences, but the work is still in its infancy.

* A. Young and V. Bruce, *In the Eye of the Beholder: The Science of Face Perception* (O.U.P., Oxford, £25).

https://doi.org/10.1017/S0263574799001381 Published online by Cambridge University Press

INNOVATIONS IN ROBOTICS AND AUTOMATION

1. Robots for undersea expedition

A study of the Atlantic seabed will rely on data gathered by robots. The European Union expedition to study the seabed of the Porcupine Abyssal Plain which is some 250 miles south-west of Ireland, will use a dozen robot vehicles or Landers that will spend several weeks in the ocean.

The robots will have the task of gathering data and photographing fish and other creatures about 5,000 metres below the surface. In addition, they will measure biological changes in sediment and note geological changes. They will also study the organic matter which has fallen from the surface. Researchers from Aberdeen University, Scotland (UK), are to lead the expedition and five of the machines to be used have been developed at the University's Department of Zoology. This number includes one that will go to the deepest level.

Researchers say that the hope to film abyssal fish, including grenadiers, cut-throat eels, cusk eels, shrimps and sea cucumbers. The leader of the expedition Professor Monty Priede believes that

> 'The use of Landers is extremely exciting as it should provide us with the most comprehensive insight to date of marine life beyond depths normally accessible to divers'.

The advantages of using robots at these depths and for this work are obvious but despite their use worldwide such applications are still new and experimental in some respects. The possibilities, however, of using such data-collecting robots at these depths are enormous and even more sophisticated machines are envisaged by pioneering marine researchers and robotics designers and developers.

2. X-ray vision from computerised scanners

The United Kingdom *Defence Evaluation and Research Agency* (*DERA*) has predicted that the new radar system they are developing will enable users to see through walls, trees and underground. The Agency we are told, has been working on the revolutionary x-ray vision system for many years and that now they believe it will transform close-quarter combat and special operations by making hidden enemy positions visible and rendering camouflage redundant. The system would also have many other obvious applications, both in military and non-military areas. One such immediate application is to detect buried landmines. The new radar system is to be miniaturised to give a video display on a helmet-mounted visor. It is designed to give, for example, a visual snapshot inside rooms of dense foliage. It uses low-frequency radiation which can penetrate obstacles that can be several feet thick. This means that it can be used to see through fog and mist on the ground. Currently, night vision devices and thermal imagers are unable, we are informed by the agency, to penetrate under such conditions.

If the device is mounted on an aircraft it would be able to map underground bunkers and troop positions, so that overlaid with thermal imaging pictures this innovative technology will soon make it impossible to hide anything on the ground. Researchers at *DERA* say that even the slightest movement behind dense vegetation can be detected. In a test of the system a person breathing was shown to stand out dramatically.

In relation to the detection of mines *DERA* plans to build a test balloon which would scan suspected minefields from a position some 1000 feet above the ground. They claim the device will pick up even the tiniest details of the mines.

Obviously at this stage of development there are problems to be overcome. Two outstanding ones are:

(1) Shielding the sensitive equipment and its hand-held scanner from electrical interference.
(2) Development of ways of filtering out 'clutter' from the pictures.

The last problem arises because the pictures show every detail and some novel ways to filter them are being used, to provide the user with a tailored image.

It is, of course, important to realise that although the innovative system has been developed for military uses, the 'spin-offs' to other areas of activity and endeavour can also be recognised.

3. Robot Stealth Lobster and other creatures

Innovative research programmes sponsored particularly by government defence establishments are developing superbugs and replicas of animals using techniques from robotics.

Whilst it sounds like something from a science fiction movie it appears to be a serious research project that is designed to produce superbugs which may be animals, snakes or fish implanted with electronics for use in military situations, or build robots that imitate them. When the project was announced earlier this year it was greeted with a great deal of scepticism. Now more details have been released of specific projects being carried out by military research groups in the USA and in the U.K. Research is concentrated at the US *D*efence *A*dvanced *R*esearch *P*rojects A*gency (DARPA*) and at British military research agencies. The US Navy has also a programme called 'biomimetics'. The US and UK scientists are planning, we are told, to use invertebrate animals, snakes and fish implanted with electronics to enhance their military capability. For example:

- bees, beetles, moths and lobsters — to be used to identify chemical and biological weapons as well as certain agents such as landmines
- fireflies — UK scientists are interested in what makes fireflies glow at night; they are full of enzymes and would make good chemical agent detectors.
- Several species of fish and heat-seeking snakes, which catch their prey using infrared detectors, are being investigated for their usefulness.

In the US Navy's biomimetics programme replicas of marine animals are being built. They are developing a robot crustacean called the 'Stealth Lobster', to gather intelligence on hostile shores. A spokesperson says:

> We are investigating the innate behaviour of marine animals to develop an eight-legged ambulatory vehicle

https://doi.org/10.1017/S0263574799001381 Published online by Cambridge University Press

based on the lobster, intended for remote-sensing in rivers or the ocean bottom. It will be a new class of underwater vehicle that may be adapted for operations in a variety of habitats.

DARPA has an Internet forum site which invites research institutes to join in what they call the 'Controlled Biological Systems' experiment. One fascinating study is that of using bees. A directed swarm of bees, we are told, could roam into hostile territory and on return to their hive be scanned for traces of chemical or biological agents. The University of Michigan has already successfully steered beetles electronically to perform tasks such as picking up a cardboard hoop. This research has been called 'biobotics' by the research director Dr Selden Crary. Birds we are told are the next to be investigated in this research programme. The use of animals has already caused controversy and several animal welfare groups are monitoring the development of this innovative research.

Professor R. H. Rudall
Norbert Wainer Institute and University of Wales (UK)

https://doi.org/10.1017/S0263574799001381 Published online by Cambridge University Press