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Reports & Surveys

AUTOMATED AIR TRAFFIC CONTROL SYSTEM

It is reported by the British Aerospace (BAE Systems) that their researchers have developed a revolutionary airborne computer system that, they claim, can land aircraft safely without the need of human air traffic controllers. The new system will allow a pilot to determine an aircraft's landing by pressing a button in the cockpit to initiate the computer system.

The new automated system will in future allow the aircraft's pilot to have much greater awareness and control on the ground as well as in the air. It will be capable of controlling all in-flight manoeuvres, even in bad weather or if there is poor visibility for take-off and landing, whether in daytime or at night.

The aims of this system are: to reduce human error; make substantial savings in fuel; and to increase flight safety.

British Aerospace has announced plans to introduce the system in three phases:

(i) Involves the in-board computer being used to determine the safest flight path to be identified by a human controller.
(ii) A full-scale trial introduction for the leading airlines.
(iii) Replacement of the air traffic controllers entirely by the system which will take all the decisions currently made by humans.

The first phase was successfully tested in March 2003. The second phase will see the system introduced for the lead airlines by 2008. The third phase is scheduled to be completed by 2020.

The Strategy development director, Alastair Hyndman for BAE Systems Avionics says that:

> "... the introduction of advanced computer technology was necessary because human air traffic controllers will soon be unable to cope with the volume of aircraft. European air traffic is forecast to increase by up to five per cent a year and is predicted to double by 2020, largely because of the growing number of low-budget airlines".

Commenting further on the current system of air traffic control he believed that it was overdependent on human judgements and:

> "The air traffic controller literally directs the pilot second-by-second through all stages of flight and landing. The pilot is essentially blind because the information on the air picture is held by the air traffic controller who bears all the responsibility for deciding whether there is a potential conflict. That's fine if there is just one aircraft to concentrate on, but at Heathrow an aircraft lands every 54 seconds".

1. Effects of automation on controllers

A great deal has been written about the effects of introducing automated systems and in particular what it means in terms of the loss of employment. In this particular case it is estimated that if the automated system is successfully implemented some 40,000 air traffic controllers will have their jobs threatened, worldwide. In the UK there are some 2,400 air traffic controllers dealing with approximately 5,500 aircraft that fly into and out of the country each day. In the first phase of the system installation controllers would still be required but the number of decisions taken would be reduced. Mr Hyndman is reported as believing that by 2020 the air traffic controller could become redundant. This suggestion has already been attacked by the Air Traffic Controllers' union, who claim humans will always be needed.

2. Phase-in of the System

Controllers have been blamed on many occasions for aircraft crashes with human error an obvious cause. During the phase-in of this new system BAE Systems Avionics say that:

> "We will be giving the pilot more information about the position of his near neighbours in the sky." "The air traffic controller, instead of giving second-by-second instruction, will simply need to identify the safest position for a craft to manoeuvre into. The computer then works out which path to take and the speed necessary to reach that position safely, with least fuel expenditure. The new system relieves the controller of the mental calculations they need to make and as such, would substantially relieve their workload".

3. System Summary

The Automated air traffic control system will manage: all in-flight manoeuvres, bad-weather and poor visibility take-off and landing, night or day. The system will manage aircraft taxi operations and run-way status. The control computers will, for example, be responsible for;

- In – flight spacing of aircraft.
- Lateral passing in flight.
- The use of the SIGMET radar data system to avoid bad weather.
- Vertical crossing of aircraft.
- Descent spacing.

4. System costing and implementation

The company plans to introduce the system which has so far cost £76 million, half of which has been funded by the European Commission. It will upgrade technology employed at the air traffic control centre in Swanwick, Hampshire (UK), which cost some £623 million and was opened in 2002. It is confident that air traffic control operations could be fully automated by 2020.

The company and the leading airlines, who will use the new system, have yet to convince air traffic controllers of both its viability and safety. Passengers and aircrew will also need the reassurance that such a system, which is designed to operate ultimately without human decision makers, is reliable

and safe even though there are possible technological failures during its demanding operations.

CARING ROBOTS

1. Robot Nurse

A report from Tokyo describes an innovative development by Mitsubishi Heavy Industries, of a robot nurse. The robot is described as 'child-like' and has been designed to combine the roles of nurse, companion, and security guard. The target group for this robot, we are told, is the growing ranks of elderly Japanese with no one to look after them.

2. Design and development

Mitsubishi have called the robot **Wakamaru**. It is a 3ft. 3in. robot that will market for about £5000–£6000. The designers say that:

- "It can speak with the voice of either a boy or a girl.
- Designed to provide companionship it will greet its owner as 'papa' or a similar affectionate name, when you arrive home.
- It can be set to remind forgetful people when it is time to take medicine, eat and to sleep.
- It can hold simple conversations based on a vocabulary of 10,000. This is claimed as the first household robot to be able to do this.
- In consequence, it can not only speak but can also understand answers and even act accordingly, it is claimed.
- It can ask its owner: 'are you all right'? If its owner does not move for sometime. If the answer is 'No' or there is no answer it will dial preset telephone numbers, transmitting images and functioning as a speaker phone.
- The robot will notify a security company if there is a loud bang or if an unknown person enters the house while the owner is out or asleep. (It can recognise some 10 faces)".

The design of **Wakamura** came from the robots Mitsubishi already produce for security environs. These are robots that are able to patrol secure areas such as nuclear power sites. Mitsubishi are very proud of the fact that the initiative to use this technology for a robot in the home came from one of their own employees.

3. Robotic systems help a caring society

There is a worldwide problem of providing care and security to the increasing numbers of the elderly in our populations. This is a world-wide problem that appears to be particularly acute in Japan. A nation that has been at the forefront of technology and certainly automation and robotics, has already harnessed its expertise to help solve the ensuing problems of an ageing society. Details of Japanese robotic systems designed for domestic purposes; for medical applications; for security duties; and for many other related tasks have already been publicised and the products are in the market place. The new initiative described in this report concentrates on the specific problem of how to help the growing ranks of the elderly who have no one to look after them. The result of this concern has been the **Wakamura** robot which has already received nationwide acclaim in Japan for its contribution to this problem. For example it has been noted that in Japan the life expectancy of women at almost 85 is the highest in the world. This increase is reported at a time when the modern Japanese family is no longer an extended one which has traditionally included the elderly. Nowadays the socalled Japanese nuclear family rarely see elderly parents because of the very long hours they work.

Technology is a contributory factor in tackling these problems. The new Mitsubishi robot, for example, has cameras implanted in its 'eyebrows' so that it can 'see' as it moves around an apartment. The resulting images can be transmitted to the latest mobile phones which can display the pictures. It means that family members or care supervisors can monitor homes of the elderly robot owners. Automation has an obvious role in a caring society.

CASE STUDY-ROBOTS FOR LAND ROVER

Our pre-occupation with the research and development of automation systems and the design of individual robots often obscures their ultimate uses. A question, may be, of seeing 'the big picture'. What the applications of these systems are and a study of their performance is an essential part of the feedback process. In consequence, this brief study of the supply of robots to **Land Rover** and their ultimate use may help. In two separate applications **Land Rover** had needs which the world's automation groups were asked to satisfy. They were concerned with the supply of industrial robots for use with in its Automotive Division. **Land Rover**, as is now well known, is Ford's Premier Automotive Group. These applications concerned robotic skid wash to eliminate paint build-up and robots for welding and associated applications.

1. Robotic skid wash

Robots to be supplied to blast away the paint build-up on Skid. The robotic skid wash-art designed to eliminate paint build-up and to give the ultimate paint finish. The industrial robots were to be supplied to the Paint Shop at Land Rover's manufacturing facility in Solihull, West Midlands (U.K.). The foundry-specification robots were to be used as high pressure water cleaners for the removal of paint build-up on paint-shop skids. The skids are moving bases that hold the car body as it travels around the paint shop.

The robots for this task were supplied by the ABB Automation Technologies Group. The group reports that:

> "Commissioned in February 2002, this innovative and environmentally friendly skid cleaning facility was designed by Land Rover's in-house engineers as a result of their search for an efficient and cost effective skid paint removal process. Key attributes required were the effective elimination of build-up of paint on the skid; a reduction in the number of skids kept in stock, and a measurable drop in environmental impact of the cleaning process.
>
> As part of Ford's Premier Automotive Group, Land Rover's range of prestige vehicles is synonymous with an immaculate paint finish, which can only be achieved in a contaminate-free paint shop environment. For many years, Land Rover has placed great effort and resources into keeping skids free from contaminates which inevitably build-up during the paint process.

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In the past Land Rover used a sub-contract operation for skid cleaning where the assemblies were baked at 350°C to remove cured paint build-up. As well as the cost of sub-contracting the operation, significant manpower resources were expended in loading and unloading the skids for delivery/return to and from the sub-contractor. Land Rover would send out between 50 and 80 skids each month, which also meant that a second set of skids were held in reserve to use while the other batch was being cleaned. Over time, there was unavoidable damage to the skids, as they were continually handled by forklift trucks and structural weaknesses were induced by the baking process.

Land Rover designed its new skid cleaning system around robotic capability and invited suppliers to submit competitive tenders. As a Ford-nominated supplier, ABB was assessed for the project on its capability to supply bespoke industrial robots that could stand-up to the rigours of a wet, hostile environment.

Satisfied with ABB's credentials and relevant expertise and experience, Land Rover progressed with ABB in fully designing the facility.

The new robotic skid wash system was designed to take away the need to outsource the cleaning process and fit neatly and unobtrusively into the paint shop cycle. On a daily basis, the paint solids and other contaminates are now removed from the skids with high-pressure (800 bar), abrasive water and the ABB robots provide a robust structure to withstand the reactive force of the water jet. The skid cleaning facility, which is housed in a stainless steel acoustic chamber, is 15 m long by 6 m wide and is supplied by a network of 20 powered, roller beds. The cycle time of the skid-wash is just 38 seconds per skid, and the cleaning facility manages between 60 and 75 skids per hour.

Each skid incorporates a transmitter, which is essential for the manufacturing facility to monitor the location of each car body. In the past, this transmitter had to be manually removed when the skid was sent for cleaning. With the new skid-wash system however, the transmitter is permanently fixed and the robots are programmed to clean with care around the device.

The robots have complete versatility. The Range Rover, Discovery and Land Rover all have different underbody profiles and thus the skids come in a variety of different shapes. Also, the robots have to cope with a random sequence of skids, say a Range Rover skid and then a Discovery skid, so ABB has developed easy-change programming to accommodate this.

Since the installation of the new skid-wash system, all skid cleaning is carried out in-house and an audit is currently taking place to assess the extent of cost savings".

2. Welding Robots

Robots to be supplied (186) are to be used for welding and in associated applications; also, industrial robots for applications on Land Rover's next generation of 4×4 Models.

The suppliers of these robots for Ford's Premier Automotive report that:

"This is an on-going project and ABB Ltd believes it was selected by Land Rover to supply what amounts to 'an industrial robot army' because of its past successes and its offer of leading reliability and maintainability coupled with familiarity and connectivity. At this stage the 186 industrial robots that have been supplied and used in welding and other associated applications are part of a developing working relationship. The group will continue to co-operate with Land Rover. Whilst it is too early to report on the joint assessment of this venture the project is continuing".

NANOTECHNOLOGY INITIATIVES

Worldwide interest in atomic-scale robots has stimulated governments to invest in funding programmes for research in nanotechnology. In the United Kingdom a £90 million government initiative aims to keep Britain at the forefront of research this area of endeavour. Nanotechnology is now the term used to cover almost everything from superfast microchips to industrial applications such as developing anti-corrosion coatings. The UK's House of Commons (Parliamentary Body) held its first debate on nanotechnology in July 2003 in response to the level of government funding which has been scheduled over a period of six years. Indeed, Parliament's Science and Technology committee has conducted an inquiry into the programme. The chairman of this committee says that:

"Too often in the past the UK has been slow to react to new technological developments while our competitors have pressed ahead and reaped the rewards. We want to ensure that nanotechnology does not become yet another example".

It was noted at the time that the UK Government was spending only £30 million each year compared with the £400 million each in Japan and the US.

Already the world's media are frightening government bodies and the general public with stories that:

"Invisible machines called nanobots will soon arrive that are capable of consuming all in their way to build more of their own kind. They would ultimately subsume the world into a grey tide which they have called a 'grey-goo'".

These atomic-scale robots could well feature in any science-fiction story but in fact there is a very real purpose in pursuing research into their development and applications.

Recent articles give the following lay description of nanotechnology:

"Nanotechnology is the ability to manipulate matter at scales of billionths of a metre. Because atoms are around one tenth of a nanometre across (there are around 200,000,000,000,000,000 in the full stop at the end of this sentence) building a nanobot would be akin to building a robot with Lego. Thus a nanobot would not have a smooth surface, like the ones we are familiar with, but an eggbox-like texture".

Warnings about the evolution of nanobots have come from many sources. A book 'Engines of Creation' by Eric Drexler written in 1986 introduced the 'Grey-goo problem'. Another publication by the Canadian group Etc in early 2003 looked at the potential evils of nanotechnology and was called 'The Big Down'.

It is evident that to create a self-replicating nanobot would take, we are told, billions of atoms. The end result would not be a true nanobot it is concluded, but something much bigger.

There is no doubt that plans to help industry make use of nanotechnology research now have a priority and national nanotechnology centres are being set up worldwide.

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Commercial exploitation of the science is at hand and visionary applications of the use of nanomachines indicate great changes in the way that we tackle so many real problems. In reality, nanotechnology will provide us with new methods for releasing drugs and revolutionising our medical procedures. Other examples given are the production of more durable building materials; the creation of stain-resistant clothes; more efficient computer systems and many more worthwhile contributions to the increasing needs of our society.

Nanotechnologists now have the task of convincing the public that there is more to their research initiatives than producing atomic-scale robots that will turn our world into 'grey-goo'.

MICRO-ROBOTIC SURGERY

1. Micro-robotic surgery in the UK

Reports over the last decade have frequently speculated about the future of what was initially called 'computerised surgery'. Predictions were made with the knowledge that the sophisticated systems that were designed to help or replace the surgeons were still at an early stage of development. Although surgical operations using computer systems have been performed in the USA, it was encouraging to read in the UKs media the headlines 'Robot performs heart surgery'. Although this statement is only partially true the journalist followed with the actual details (UK's Daily Telegraph, 2003), viz.

> "A patient whose heart bypass was performed with the aid of a robot left hospital just days after surgery, doctors said yesterday.
>
> Four incisions the width of pencils were made in John Cast's chest before mechanical robotic arms, guided by surgeons using remote controls, carried out the procedure. The retired physicist is one of the first three Britons to avoid the need for major invasive surgery through the use of the Da Vinci robot at St. Mary's Hospital in Paddington, west London".
>
> (UKs Daily Telegraph 2003)

This is, of course, a report of the very first UK surgery and a programme of using micro-robotic surgery continues.

2. Robotic surgery

Surgeons who have performed coronary artery bypass surgery use tiny robotically controlled instruments which eliminate the need to open up the patient's chest. This is a breakthrough which could herald the development of faster safer heart operations worldwide. It only involves one surgeaon using high resolution 3-D images to guide instruments to the correct part of the heart. This is in contrast to the traditional surgery where a team of 12 staff is needed because of the complexity of the procedure.

The totally endoscopic robotic coronary artery bypass operation is known as Tecab and experience has shown that recovery is much faster than would have been the case with conventional techniques. The robotic assisted operation consists of:

(i) Four one-centimetre incisions are made across the chest of the patient-these form the entry point for the stabiliser, camera and left/right arm tools. (The robotically controlled instruments).
(ii) The instruments are inserted through the rib cage. The camera gives the surgeon X12–15 magnification on a nearby screen enabling a fast smooth operation.
(iii) The left/right arms have ball joints which allows 'end-wrist' full rotational movement in micro-vascular surgery. (Source: Clemente Anatomy).

3. Effectiveness of the robotic-assisted operation

Mr Robert Casula who has pioneered robotic surgery at St. Mary's Hospital, London UK. and who has carried out a number of these operations has said that:

> "The surgery is unique. I think the benefits for the patient are very great. The will have just a small amount of scarring, and far less pain, with less need for pain-killers. There is also a reduced risk of infection and blood transfusion and they are up and about more quickly. The beauty of the operation is that is also preserves the lung and the heart function".

He does add a note of caution that it is still early days and we need to see far more patients in order to collect data on its effectiveness.

4. Future developments

The robot system behind the procedure is known as Da Vinci and it has the 'endo-wrist' movement which has been described. It is said to be as flexible as a human wrist and hold in this operation the micro-vascular tools in place as they perform the graft. The micro-vascular tools perform the surgery.

The benefits of micro-robotic surgery are now becoming apparent and undoubtedly we will see similar procedures developed for a variety of operations in the future. It is, of course, necessary to continue to 'fine-tune' the techniques and to constantly monitor the results.

ROBOTS THAT MIMIC NATURE

1. Snake-like robots

Researchers at the University College London, UK who are funded by the company BAE Systems who are involved with military technological and aerospace developments, have built a snake-like military robot. Its function is to provide a military reconnaissance system with a capacity to slither across the battlefield even after being damaged.

Currently, a protype has been built with the aim of producing a low-cost model for military use.

Design and function. Called the 'snakebot' it uses artificial muscle segments to wriggle over the ground, and is designed to house intelligent software that can plan other ways of movement if any segment is damaged. Its basic function is to act as a high-tech reconnaissance tool to be dropped into enemy sectors to gather intellience about the opposing forces and their positions.

Readers may well ask why such a design has been chosen for this work. The researchers say that this is because its ground-hugging position would make it very difficult to be seen and for it to be effectively destroyed. They also

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believe that its slithering movement can deal with much more varied terrain than, say, the conventional wheeled or tracked device.

It is made from a string of modular units that are designed to mimic a snake's vertibrae, each of which has been given three wire 'muscles' that stretch over its whole body. The muscle fibres are made to contract when an electrical current is applied and then to spring back to their original shapes when it is turned off so that the robot can be propelled forward.

The research team have also written their own software which aims at testing a variety of combinations of muscle contractions until a suitable one is discovered. The computer program then adopts it in the same way as genetic mutations are formed. The University College London research team is led by Drs. Peter Bentley and Siavash Haroun Mahdavi who are continuing to develop a prototype to produce a useable device for the demanding military operations.

2. Robots that walk on water

A research team at the Massachusetts Institute of Technology (MIT), US., have built a metal robot that, it is claimed, walks on water. Called the Robostrider it is about 9 cms (3.5in.) long and designed to mimic the action of insects that skate on the surface of water.

Design Criteria. The robot is designed from metal with its legs made of steel wire and its body of aluminium. It is powered by a system that uses an elastic thread.

The concept of building Robostrider was formulated after the MIT mathematicians solved the problem of how some insects glide across water. The team is said to have wanted to prove that they had understood properly, the physics behind the insects' almost impossible movement when skating over a pond. Initially it was thought that the insect simply made waves but the MIT team used high-speed video footage to show that the insects use their legs like rowing boat oars, creating swirling vortices below the surface that propel them forward. The creatures are kept afloat by their hairy legs and the viscoity of the water's surface. Dr. Michael Dickenson, one of the research team said that 'It is the rearwards motions of these vortices that propel the animal Forward'.

Mathematical Analysis. The report of the project was published in Nature (2003) by the MIT team and this contained the mathematics that define the motion. Further details of the project are included in this scientific account in which they write:

> "Robostrider travels half a body length per stroke in a style less elegant than its natural counter part. This analysis enabled the design team from MIT to create a robot that is much larger than the observed water skating insect. The research team of Dr. John Bush and his colleagues are continuing to use the analysis of the pond insect's natural talent as a water skater in their creation of robotic systems such as their Robostrider".

3. Robot silkworms

More attention is paid nowadays to understanding the mysteries of nature than ever before. Not least amongst those who have found a new interest in creatures great and small is the researcher in robotics who is intent upon mimicking nature. We have reported numerous examples where the actions of bees, snakes, fish, spiders, and many more creatures have been mimicked by scientists who after analysing their habits and movements have produced 'copycat' robotic systems.

Artificial spinneret. In a recent report Oxford University (UK) researchers describe what is claimed to be the first artificial spinneret. It mimics spiders and silkworms and has been developed to spin synthetic silks. Professor Fritz Vollrath and Dr. David Knight of the university have patented the artificial spinneret. They comment that:

> "We can use nature's ingenuity to help us develop new processes and materials with quite exceptional properties in an eco-friendly way".

A company called Spinox has been has been set up by the Oxford researchers and its aim is to produce by automated means high performance fibres using their spinning process.

Race to produce commercial versions. It is reported that laboratories around the world have raced to produce the first commercial versions and the markets eagerly await the results.

It is well known that the properties of spider silk are quite remarkable. The golden silk spider (Nephila) can make what is called dragline silk which has the property of having a greater tensile strength than steel. The first artificial spinneret has been developed to spin synthetic silks for sutures, artificial ligaments, parachute cords and products such as bullet resistant clothing. Up until now scientists, although successful in introducing spider silk proteins which have tended to form insoluable clumps, have not been able to produce artificial materials that possess the properties of spider silk. Now this revolutionary artificial silk can be made in an eco-friendly way by a laboratory's automated spinning wheel.

ROBOTICS WORLDWIDE

1. Japan

Self-parking vehicle. No one can say that the Japaness research groups are not productive. Their researches resulted in developments and applications in their industries that are both innovative and marketable. The Japanese company Toyoto has recently announced its 'self-parking car' and claims it is the world's first. They have launched a car that parks itself without the driver having to touch the steering wheel.

The researchers have, they say, perfected a system which utilizes electrically operated power steering and an array of sensors that combine to guide the vehicle when reversing into a suitable space for parking.

The innovative system has been installed into Toyota's Prius saloon car which went on sale in Japan on the 1st September 2003. The vehicle has been priced at some £12,900 and includes the 'intelligent parking system' as an optional extra. Its availablity in Europe will be late 2003 and the price will be some £18,000. Readers will also be

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interested in the car because it is one of the new breed of 'hybrid' vehicles that in this case runs on both petrol and electricity. Toyota has since 1997 been developing such hybrid cars and claims to be the first producer to market a mass-produced hybrid vehicle. Indeed, it says that it has already sold 120,000. The combination of an eco-friendly vehicle and one with an innovative 'intelligent' parking system provides a challenge to its rivals, worldwide.

The 'intelligent' system for parking was demonstrated in Tokyo last September (2003) by the company's President Fujio Cho who sat in the driver's seat of the Toyoto Prius with his hands in the air whilst it parked itself. Mr Cho believes such hybrid cars fitted with the latest electronic gadgetry will raise the company's annual production to some 300,000 by 2006 and will be the key to its future strategy.

Although other vehicle manufacturers, worldwide, are currently launching hybrids the introduction of automated systems such as self-parking cars will become obvious selling features. We now await the launching by both Ford and General Motors of their hybrids which are currently expected. Whether they will match some of the innovative systems now available in Japanese products is yet to be seen. There is no doubt that the future vehicles will have highly sophisticated systems and self-parking will become self-steering which, in turn, will be linked to the currently developed satellite navigation systems. We have already discussed in these columns the prototype systems that will, using 'Satnav' control the speed of vehicles by plotting their position on the roads. Most important in our current concern with both the growing demand for eco-friendly vehicles and with increasing congestion on our roads will be the ability of governments to control the use of vehicles with high-tech systems that will enable their progress to be monitored and costed according to society's perceived needs.

2. Sweden

Robot for office tasks. A report from the Royal Institute of Technology in Sweden gives details of a research project that is tackling the issue of distance, both physical and emotional. Dr. Kerstin S. Eklundh is leading a group of researchers who have built a robot that can accomplish office tasks. The researchers write that:

> "Users can communicate with it by speaking to it or by clicking on a graphical interface on a computer. The researchers believed that having both modes of interaction would be important in an office, where workers might be too deeply immersed in other tasks to speak to a robot.
>
> The office assistant is a doll on a mobile platform. It has no facial features but can make simple head and arm movements."

The design was chosen by Dr. Eklundh and her colleagues to give users the sense that they were working with a reliable transportation agent. In one interaction they have programmed, a user can ask the robot to bring coffee from the kitchen. The 'doll' tilts its head in a gesture of attention. To express its understanding of the command, the robot repeats the command as a question:

> "User Command: Get the coffee from the kitchen
> Robot: Get the coffee from the kitchen?
> User reply: Yes please
> Robot: Going to get the coffee from the kitchen".

The programmers believe that it is important to give a clear indication about where it is heading and what it is going to do next. The project is continuing and valuable information is being obtained with the researchers learning a great deal from the interactions.

3. United kingdom

New research centres in the UK. Further funding has been made available in the UK so that innovative manufacturing research can be supported. The second tranche of Centres has now been strengthened by two new ones at Imperial College, London and at Heriot Watt in Scotland.

(i) Imperial college centre. The Built Environment Innovation Centre (BEIC) at Imperial College began operations in April 2003 and plans to carry out an ambitious interdisciplinary programme. The Centre will draw on engineering, management and social sciences in order to tackle real-world empirical problems, focusing on the development of new technology in the production and the use of their built environment. BEIC's work will be located in the field of engineering, design, and innovation management associated with long-lived complex capital assets and infrastructures. The grant to BEIC is some £3.27 million. Professors David Gann (principal investigator) and James Barlow are the Centre's directors[*].

(ii) Heriot-Watt centre. Heriot-Watt's Centre supports UK manufacturing industry with applied and fundamental research in plutonics technology and digital tools for manufacture. The Centre has a diverse portfolio of projects that range from laser processing of materials through photonics-based sensing of manufacturing processes to Mems, 3-D modelling, texture characterisation, and virtual reality for design assembly processes. Its work is supported by industrial collaborators that themselves range from multi-national corporations to small high-tech start-up businesses[**].

(iii) Novel computational clusters. The UKs Engineering and Physical Sciences Research Council (EPSRC) has funded the establishment of 16 novel computational clusters' which aim to improve understanding of the organisational process in complex systems. The clusters, we are told, will bring together researchers across the engineering, physical and life sciences to study how alternative systems may organise and process complex, dynamic and uncertain information. This, we trust, will also consider the complex processes involved in the fields of automation and robotics, although there will, of course, be a transfer of knowledge. The Engineering and Physical Sciences Research Council (EPSRC) inform us in their publication *Connect* (Sept. 2003, Issue 15) that:

> "The core funding was a result of a successful bid by the EPSRC to the 2002 spending review, and has been matched with funding from the engineering, ICT, life sciences, and mathematics programmes.

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> This is a new approach to addressing multidisciplinary research problems. Each of the 16 clusters will run for six or 12 months, operating mini-networks with the aim of preparing a small number of innovative research, proposals to bid against the novel computation funding.

Readers can find further details about the 16 clusters on the website: www.epsrc.ac.uk

(iv) High-speed communication worldwide (New high-speed optical network). At last, work to design and develop the next era of high-speed optical networks for communications between researchers around the world is moving ahead at an increased pace. The United Kingdom, for example, can expect to have its own presence on the evolving network of super-networks. In England, the Higher Education Funding Council (Hefee) has already announced a £6.5 million grant to fund **UKLight**, a point of presence facility in London that links with **NetherLight** in Amsterdam and **StarLight** in Chicago. A progress report on the UKs involvment says that:

> "The UK will join several other leading networks creating an international experimental testbed for optical networking. In addition to the Dutch and US networks, these include the Canadian academic network Canarie, Cern in Geneva, and NorthernLight in the Nordic countries.
>
> UKLight will connect Janet, the UK's research and education network, to the testbed and also provide access for UK researchers to the Internet2 facilities in the USA via Starlight. The management of the programme will be provided by Ukerna (UK Education and Research Networking Association), which manages. Janet on behalf of the Joint Information Systems Committee, JISC".

More funding is obviously needed and since this collaboration has received so much support, it will undoubtedly be forthcoming. A wide range of interests from e-science to engineer, including automation and robotics, will benefit from such networks that link both national and international endeavours.

4. United states

(i) Robots with emotional appeal. Can a robot have emotions? Can a robot recognise emotions? These are questions asked in robotics and artificial Intelligence Laboratories worldwide. In particular, the researchers at the Massachusetts Institute of Technology's Artificial Intelligence Laboratory USA., are determined to answer them. Dr. Cynthia Breazeal and her colleagues have spent hours talking to **Kismet**, a robot that is programmed to recognise basic emotions in a human voice and can respond through mechanically-driven movements of its eyes and mouth.

Kismet, we are told, has for years been treated as a baby. The researchers have waved toys in front of it and spoken to it in a loving way. Now Dr. Breazeal and her fellow researchers report that Kismet could tell the difference between being scolded, praised or comforted by listening to the tone of an instructor's voice. By refining Kismet's responses, the research team hope to enable it to develop new behaviour through social interaction. Dr. Breazeal says that:

> "When people interact with a young child they may have a lot of prosody in their voice, exaggerate their facial expressions, slow down their gestures, all to make it easy for the child to understand them. If we are willing to do this for infants and even pets there is no reason why we would not do the same for robots that have emotional appeal".

This is, of course, all part of the thesis that robots must be acceptable to people and possibily able to learn from them.

SMART SYSTEMS

1. Technology fights supermarket crime

In the UK. supermarkets have always been enthusiastic about using the latest technology to enhance their services. They now have elaborate computer systems to deal with the choice, purchase, supply and distribution of the goods to be retailed. In-store use of computerised systems is now the normal way of doing business and greater refinement is being made to the systems at hand to check and handle goods. Some very sophisticated systems for the replacement of the conventional customer check-outs have been installed and are on trial. Shop crime, however, remains a real loss-maker for most stores. It is not a matter of credit-card crime or cheque fraud because these crimes will be slowly reduced by the universal introduction of chip credit cards and the use of pin-numbers instead of signatures. The problem we are told is shoplifting, a problem faced by the whole of the retail trade.

2. Smart goods systems

UK Supermarkets answer to shop theft is to utilise more advanced high-tech systems. Many retail oulets are now considering the introduction of 'smart CCTV' systems which will automatically photograph customers as they remove valuable items from shelves. Millions of pounds worth of goods are lost annually to shoplifters who apparently, are making off with small but valuable items. The Centre for Retail Research, Nottingham, UK have identified a packet of razor blades (worth £4) as the most stolen item in Britain. They are expensive and small enough to be easily hidden. They serve as an excellent subject for trials of a system where each packet is fitted with tiny microchips and antennae. When a customer picks up a packet, the chip sends a signal that causes a CCTV photo to be taken. If the customer then fails to pay for the item at the till where a second picture is taken, the image is retained for use by the security staff.

It will be interesting to see how effective the system is and how long it will take for some criminal to find a way, if it is at all possible, to circum-navigate it.

Meanwhile supermarket chiefs are said by the media to have great hopes that the new technology will help to curb what is a surprising multimillion pound loss in razors and other small but valuable items. Where the system has been installed, and some were implemented last year, the thefts have dropped dramatically.

3. System developers

The microchips were developed by the Auto-ID Center, at the Massachusetts Institute of Technology (MIT), Boston USA., as part of a multi-million-pound industry-funded 'smart-tag' project. The tags contain microchips that transmit signals to receivers built into the shelves around the store. In addition

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to crime prevention because the tagged goods are tracked in-store, retailers can also use the system when they need to restock shelves and generally be used to speed-up the checkout process.

4. Future use and new smart systems

Whether such systems will become common place in retail and other outlets will obviously depend on the outcome of the trials. It is obvious that when more than £1.7 billion worth of stock is stolen from Britains supermarkets alone, each year, countermeasures would be a prudent investment.

With such enormous losses each year one wonders what the global loss would amount to? Perhaps the programme that aimed to place a coded micro dot in all manufactured or retail items will yet prove to be feasible.

THOUGHT-CONTROLLED ROBOTS

1. Background developments

Reports in this section have over the decades referred frequently to the development projects and the research being carried out in 'thought-controlled' machines. Many examples have been described and it is now, finally accepted, that it is possible for humans to control machines using the functions of their own brains. Such developments have indeed been aptly described it would seem, by both scientists and media reports as 'truly mind-boggling'. It is difficult to believe that it may be possible to communicate, for example, with a computer at such a level of sophistication that full understanding can be achieved.

So far projects which have finally produced prototype devices and machines have been described but with varying levels of performance. Several of the reports showed how such systems would be invaluable for disabled people. Scientists are perfecting such systems and they are becoming increasingly sophisticated.

More recent research has been reported in the *New Scientist* (2003) by Professor José Millan of the Dalle Molle Institute of Artificial Intelligence, Martigny, Switzerland, and fellow researchers at the Swiss Federal Institute of Technology and the Centre for Biomedical Engineering, Barcelona, Spain.

2. Design concept

The report of the research outlines the details of a robot that can be steered by the power of thought and which, it is claimed could, one day, allow quadriplegics to move motorized wheelchairs using nothing but their own brains.

The developers describe their device as one that can move ahead or turn left and right, and is one that is controlled using a skullcap lined with electrodes that monitor the user's brainwaves. The developer's claim that with only two days of training it is easy to steer the wheelchair and that the system has been through trials which confirm this. The concept in itself is as previously described, not a new one and the test of its applicability is whether in the next stage of refinement of their system it will offer more than basic thought commands. If this is successful then unprecedented freedom of movement and mobility will be on offer to people who are paralysed from the neck down. It will also make available research into 'thought-controlling' systems which is quite obviously applicable to numerous other areas of endeavour.

3. Current control systems

Most readers will be familiar with the systems in current use for controlling wheelchairs automatically. These include blowing into a tube or with a chin-operated joystick. Such systems are obviously limited in use and the possibility of a functioning thought-control system is very attractive. For example, a spokesperson for the Spinal Injuries Association says that "It is a very positive step. The psychological benefits it would offer are huge".

4. How the system works

In contrast to some of the earlier systems where electrodes had to be surgically implanted in the brain of the user this new robotic system can be controlled using brainwaves that can be detected through the skin and, in consequence, offer a more viable method of control. The team of researchers led by Dr. Millan have designed a skullcap which is lined with electrodes that pick up electrical activity on the scalp, in a similar way, they explain, to electroecephalographs that are used to monitor the brain. The system then relies on a computer to analyse these signals before deciding which ones should be transmitted to the robot. It is then that the robot comes into action to carry out the desired movements. The range of movements can, of course, become extremely comprehensive. This we are told, is now one of the main tasks of the research team in their future programme.

5. A future with the 'thought-machine'

As indicated in the background section of this report, using the different frequencies of brainwaves is not new. Since the 1960s it was recognised that the alpha, beta and theta types have a link to different hertz levels that can be associated with different mental states. We can learn to produce these different types of waves at will, using feedback such as light or tone. The use of biofeed or neurofeed is often used to treat attention deficit hyperactivity disorder and other conditions. What appears to be an advance in these systems is the use of an electrode cap instead of the invasive implanted electrodes. This allows the monitoring of these brain waves through the skin. In this application two days training was all that was necessary to learn to control the prototype wheelchair for basic movements. We are likely to see this technique used in other researches. The monkey with a brain implant that could move a cursor on a computer screen in trials at Brown University US; the human who did a similar trial at Emory University in the US; and the earlier experiment in Georgia which allowed people to manipulate computer cursors can now be re-assessed in the light of the Swiss and Spanish initiatives. There is little doubt that we can now look forward to further experimental programmes and hopefully to further research advances that will one day see humans control systems by thought alone. Today, however, we need to be much more realistic and appreciate that whilst it appears feasible for humans to interact with machines using 'thoughts' we need to know a great deal more about the brain before we can expect anything but a basic interaction that may be confined to a series of simple commands. It

is encouraging, however, to note that in the Swiss/Spanish initiative that the program designers used neural network software, which is, of course, modelled on the way that the brain processes information, and which can then be trained to recognise complex brainwave patterns in real time. This gives hope that more 'mental states' can be recognised in this way and lead to the production of more sophisticated systems. Further details have also been published in a report in the *New Statesman* (2003).

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