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Reports and Surveys

1. AUTOMATION WORLDWIDE

1. Ant-sized robots for power plants (Japan)

A report from Japan indicates that several Japanese electronics companies are developing an ant-sized robot for applications directed at power plants. This is designed to produce a robot the size of an ant that will be capable of crawling around thin pipes to inspect and repair the system.

The robot is only five millimetres (about 0.2 inches) long and weighs just 0.42 grams (approx 0.0147 ounces). The designers claim that the prototype ant-robot is able to lift objects that are twice as heavy as itself.

There is little doubt about the potential for such machines in industry in general but particularly in the nuclear industry. The robots are expected to be in use soon and the companies involved in their development say that they will most certainly speed up inspection and repairs at electrical plants and in some of the nuclear stations.

2. World's first computer (UK)

Recently, more information about the world's first computer has become available. Indeed, it was not until the 1980s with the declassification of United Kingdom Government papers that the story of why it was built and what it achieved during the Second World War was revealed. The story of Bletchley Park in the UK where the machine was installed is now more widely known. Bletchley Park was known only as Station X and some of the finest minds in Britain were gathered there to begin work on ways to decipher codes. The site was chosen because of its equidistance from Cambridge, Oxford and London. Station X is said to have shortened World War II by two or three years. The world's first computer was called *Colossus* and its greatest success was when it finally broke the German code. Now Bletchley Park is to become, after all these years, a theme park dedicated to the achievements of the codebreakers. A museum on the site will be put under the control of the Bletchley Park Trust.

The trust was originally formed in 1992 to ensure that future generations did not forget the work of the team that cracked the German Enigma ciphers and developed the world's first programmable electronic computer. The Park itself is to become a 'living memorial to Second World War intelligence work, computing and cryptology through the creation of an integrated theme park of international repute. Many of the mathematicians and scientists who worked there later in their lives made important contributions to world science. It is true that World wars have had scientific spin-offs and many future great scientists seem to have been encouraged in their endeavours by their wartime labours and experiences.

3. Producing the 'instant book' (USA)

With the advent of electronic publishing and the development of communications systems such as the Internet many publishers and authors speculated on the demise of the 'book'. Most scientists have known that any information recorded in electronic memories can be printed out as a hard copy, as well as being viewed on a screen. The question asked, however, was would it be worth it? and what is the best way of accomplishing the print-out?

Now, a report from the United States describes how one company has achieved what it describes as the 'instant book'. Everyone knows that a book as printed on paper and bound, is not only a convenient way to make information available to the wider public but is for so many purposes far superior to reading from a screen of a computer or from printouts made from most computer printers.

Now an American bookshop has invented a way to print and bind volumes in 15 minutes to customers' orders. Borders, which is the second largest book chain in the United States, has announced a technology breakthrough that will enable its branches to print paperbacks immediately. The pioneering system is to be in operation in the U.S. for a trial period and then will go worldwide with the UK, for example, having the system installed in the company's four shops. The company say that:

> "If a customer wants an old or obscure book that is not in the shop, an assistant will scan the database of titles available from publishers and download the work on the shop's computer. One digital printer will print the text while another prints the cover. These will be put in a binding machine and the book sold for little more than a normal copy."

The report of this development (*The Wall Street Journal*, June 1999) says that the instant book is the latest attempt to compete with Internet booksellers which have recently gained a large share of the market in secondhand, remaindered and specialist books. Apart from the obvious advantages of being able to print texts off-line, saving of storing space and the possible large range of titles that could be stored on a database it has implications for anyone who distributes information. The system and its possible applications will soon become obvious and will undoubtedly have an enormous impact in the publishing area. When a refined

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system has been developed there will be no limits to its uses. Even hard cover texts could be produced and glossy magazines and journals produced as required by the vendor. In the case of scientific communication it holds out the prospect of textbooks and scientific papers being produced virtually immediately in a form that has been so successful and convenient since Caxton's time.

AUTOMATION & CONTROL SYSTEMS

1. Company Analysis

A recent report (June 1999) *gives an insight into the Automation & Control Systems industry. Under the heading 'Surviving or thriving' it gives an analysis of its wealth creation, which we are told is the only reason a company can justify its own existence. In their analysis the compilers of the report say that:

> 44% of the industry is consuming rather than increasing the wealth of the owners. This loss of wealth amounted to £90 million last year. In contrast these companies are being squeezed by the 40% of the industry rated *Strong* or *Good* (by the report's analysis) who are generating wealth.
>
> The latest results from this new analysis on the automation & control systems industry showed that out of the companies available for analysis, 150 have been rated as *caution* or *danger*. These companies must change radically or their survival will come into question. This is slightly worse than last year's results that showed 148 companies in financial difficulties.
>
> Perhaps it is no surprise that the smaller companies in the industry are getting squeezed the most. Almost 54% of companies making less than £1 million in total sales are under financial pressure compared to 38% of companies making over £5 million in total sales. This is exactly the same as last year with 54% of the smaller companies in financial difficulties as compared to 33% of the larger companies.
>
> On the control side of the coin, the latest results found that 40% of the automation & control systems industry was rated as financially *strong* or *good*. The report rates strong companies as companies that have been improving in financial strength over a four year period. Good companies are maintaining their financial strength but not improving.

For those companies rated as caution or danger the report offers the advice that immediate action must be taken to ensure their survival. These companies, it says, cannot continue to destroy wealth. The report states that:

> "Only 63 companies improved their rating out of caution or danger last year. Even though this shows that it can be done, for companies wanting to improve their rating radical changes must first take place. For many companies, what is essential is creating a return to profitability. This may mean serious cost cutting, job losses, and the like in the first instance before they attempt a push for greater sales."

In addition, this report by Plimsoll Publishing includes 692 individually analysed companies over 4-years of accounts. Also, it gives details of 150 companies which are under financial pressure and provides a survival plan for turning the company around by, it advises:

> . . . "adding a 5th computer generated future year bringing these companies back to a 10% return on assets. This artificial survival plan is designed to stimulate the thinking of the 'busy manager'. Some of them have a limited time in which to generate successful ideas."

In contrast, the report has found a band of companies to which many companies in the automation & control systems industry should aspire. It has named the Top 10 most successful companies in the automation & control systems industry. Success, a word often used yet difficult to describe, has been defined as those companies who have combined both financial strength and terrific sales growth.

The publication continues by stating that:

> This elite group of companies make up about one-fifth of the top percent of all companies in the UK. To be in with these companies, you would have to have a rating of 'Strong' on the Plimsoll Model, an average sales growth of 21%, a 10% average pre tax profit margin and an average of 16% return on assets. These are real wealth creators.
>
> The publication says what is obvious to most industrialists; that is the essence of competition is the survival of the fittest. To survive, your company will have to go up against 'the fittest'. They are stretching the boundaries of the industry. Not every company rated danger will make it next year. But trying and failing is better than never trying at all.

In their analysis the compilers have broken down the 692 companies of the automatic & control systems industry into five categories of performance based on their method of monitoring company performance which has proved to be successful in past assessments. It shows the grade and the percentage of those assessed viz:

- *In Danger* – 27.7%
- *Caution* to be taken – 16.5%
- *Mediocre* performance – 15.6%
- *Good* performance – 12.1%
- *Strong* rating – 28.0%

* '*Survival Pack, Second Edition 1999*' for the Automation & Control Systems Industry. Contains a bound book and electronic version of 692 companies in the industry that have been individually analysed. A separate bound book of all 150 companies individually analysed with a "survival analysis" for the fifth year. Published by: *Plimsoll Publishing Ltd., The Vanguard Suite, Broadcasting House, Middlesborough TS1 5JA, UK. Tel: 01642 257800. Fax: 01642 257806.*
(Note: Readers of Robotica are entitled to a discount of 5% when ordering the publication.

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2. List of Top Companies

The Plimsoil Publication claims that, based on its assessments, the 'top' most successful companies in the Automation & Control Systems Industry are:

1. Egemin UK Ltd
2. Europlacer (SMT) Ltd
3. Fanuc UK Ltd
4. Filtrona Instruments & Automation Ltd
5. J W Froehlich (UK) Ltd
6. KBC Advanced Technologies Plc
7. Modular Industries Ltd
8. Moore Products Co (UK) Ltd
9. Robot-Coupe (UK) Ltd
10. YSWIL UK Ltd

FUSION OF ELECTRONICS AND LIVING TISSUE

1. Silicon technology and biological material

At Stanford University, USA in its neurosurgery clinic a neurosurgeon, Gary Heit put an implant into the brain of a man who was suffering from a debilitating tremor, similar to that caused by Parkinson's disease. With one flick of a switch, we are told, the implanted chips in the brain were activated and the 79 year old man's tremor was 'turned off'. It is now, apparently, a fact that silicon technology and biological material, that is the 'hard-wiring' and 'soft-flesh', can now be combined, Heit is reported as saying that:

> "it is simply a lack of money that holds the field back from giving greater benefit to those debilitated by lack of brain function. A brain implant for an injured human being can cost more than $20,000, which is a trivial sum compared with the way it revolutionises patient's lives".

The neurosurgeons also say that patients such as the actor Christopher Reeve, who was paralysed from the neck down in a riding accident in 1995, could be enabled to walk again with the technology already available. It is suggested that a team of researchers would be able to implant an array of high-speed microprocessors which would be able to analyse brain activity and translate those impulses into electrical commands. These commands could be passed to a set of electrodes attached to the nerves that would stimulate muscles to perform a walking action.

2. Laboratory-on-a-chip

British researchers at the University of Wales, at Bangor, UK, having failed to find British backing are now working in the US on development of a silicon-biological interface. The research which they have pursued will now be developed by Aura Diagnostics of Mountain View, California, USA, a neighbour of Stanford University. They will commercialise the process and develop a 'laboratory-on-chip' which is capable of isolating cancer cells in tiny blood samples. The process uses electrical signals to manipulate biological molecules which will enable it to detect at an early stage cancers that are present in a sample. It could also provide simple, quick and accurate tests for meningitis and a means of regenerating, it is claimed, damaged tissues and organs. In another project the UK's Institute of Cancer has just developed its own 'cancer chip'. It is worth noting that it is the American companies, particularly those who have succeeded in information processing who are now engaged in applying their expertise to biology. Biochips are, for example, being produced by Motorola, the US department of energy's Argonne National laboratory, and Packard Instruments.

3. Biochips and Robots

The aim of this project is for the mass production techniques for 'biochips' to be developed. These are 'thumb-sized' wafers that carry information processing on the chemicals of life.

It is, of course, already accepted that unravelling the human code can provide ways of diagnosing and treating genetic diseases and cancers as well as giving an instruction manual for the assembly of the human body. What is a slow business, when attempted in the traditional laboratory, could be speeded up and made much more efficient.

Combining biochips with robots and computers, it is claimed by the US Argonne researchers, will enable one genetic variation among three billion DNA bits to be found in a matter of minutes, instead of the current conventional method which takes days. The biochip, it is said, will be produced like the microchip in a mass producing process by photolithography techniques. This will, of course, be a major change in operational techniques for the conventional biotech companies but it is a challenge that they will embrace because of the enormous marketing potential of such developments.

DNA chips are obviously going to change the future of medicine and could also change the way in which robotics researchers tackle their field. Linking humans and animals using these systems will bring into reality the cyborg, that is one who is enhanced by technology beyond the normal limitations and constraints. After that is achieved there appear to be no limits to the combinations of 'flesh and chips' that will be engineered.

INNOVATIVE SYSTEMS

1. Chip design

At the University of Leeds, Yorkshire, UK, researchers have developed a transmitter that uses a microchip the size of a match head. The transmitter can be contained in a box the size of a cigarette packet. The use of the new microchip will also, it is claimed, cut the signal radiation down considerably.

Research engineer Michael Roberts from Leeds University, who has developed the chip, says that it:

> "would make the transmitters we see in the countryside redundant and drastically improve reception in areas where it is difficult to get a signal. That is because the boxes could be attached virtually anywhere, on a lamp post, a bridge, the side of a building."

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The new chip is called a microwave mixer, and allows low-frequency signals to 'piggyback' on much higher electronic frequencies, such as those used for radar, which travel at faster speeds and without being distorted, allowing a receiver up to a kilometre away to decode the message.

2. Future applications

One of the problems in the United Kingdom and worldwide is that mobile phone transmitters, for example, require large and unsightly masts. Indeed, many such masts have been designed to look like trees but many mobile phone towers are around 80 feet high, often even dwarfing nearby trees. This development could make such masts a thing of the past. One company, Vodafone, has over 4,500 transmitters in the UK. They are said to have expressed particular interest in the new device.

3. Prototype system

The project leader of the Leeds engineering research group, Dr. Stavros Iezekiel says that:

> "Current technology sends slower signals that require larger, more powerful transmitters. We could have a prototype ready within a year and it could go on sale for as little as £100. The interface needed for the boxes would be fibre-optic and that network almost covers the UK at present."

If such an innovative system can be developed not only would we see the end of unsightly transmitter masts but also the introduction of a new technology when more and more communications networks are being put in place to cater for the worldwide demand for mobile phones and other signal receiving devices.

4. Engine development

A report from the Los Alamos National Laboratory, New Mexico, USA gives details of the development of what is described as an environmentally friendly engine that has no moving parts and is powered by sound waves.

Dr Scott Backhaus who is one of the inventors and a member of the National Laboratory Team developing the engine says that:

> "Conventional engines are limited by the laws of thermodynamics and their complexity. Typically the most efficient engines are the huge turbines used in power stations. Our small engine is actually 10% more efficient than the best turbine, largely because of its simplicity."

5. Specifications

The innovatively designed engine is made out of steel tubing and it is claimed that it is relatively inexpensive to produce. It is in fact a thermo-acoustic Stirling heat engine, based on the principle used by Robert Stirling in the 19th Century, who discovered that the cooling and heating of gases could drive a piston. The Los Alamos heat engine consists of a long baseball-bat shaped resonator which has an oval chamber instead of a handle. The engine is filled with compressed helium and when heat is applied to one end acoustic energy in the form of sound waves is produced. This it is claimed can be used to drive a piston which in turn can be the power to create electricity. Without any moving parts, the engine is maintenance-free.

6. Future projects

It is believed that sound could be the basis for the development of engines in the future. The Los Alamos team are now working on ways to use solar energy to power the engine. They are also currently considering a system that could use a car's exhaust heat to power it's air conditioning system. Researchers say that they are also discussing the development of a version of the engine that could be used for the dual purpose of generating electricity and also providing heating for domestic applications.

Such an environmentally-friendly device will obviously have many potential applications, and it is a source of much interest to scientific historical observers that the inspiration and the principle behind the development came from a 19th Century Scottish inventor.

MOLECULES FOR COMPUTATIONAL DEVICES

A report in *Chemistry in Britain* (March 1999, p. 18) describes how United Kingdom chemists have designed the first molecular units that can carry out complex logical functions of the kind used in silicon chips.

This research integrates work carried out earlier with the successes of performing the basic logical functions such as AND and NOT. This led to the functions being able to complete more complex tasks and gave hope that they could be the basis for molecular computers which would be many times more powerful and faster for their size than silicon-based devices.

Dr Prasanna 'AP' de Silva of the Queen's University, Belfast, Northern Ireland, UK, is a leading researcher in the field who has spent more than a decade designing such systems where the molecules form the basis for computational devices. The report says that the:

> "new molecules use chemical inputs and light as output, visibly demonstrating their so-called NOR and INHIBIT logic behaviour. NOR represents the integration of NOT and OR, while INHIBIT is equivalent to a special combination of AND and NOT. If there are there inputs then a signal will only be produced if they are '000' for the NOR logic gate and '110' for the INHIBIT gate. The designed combination of many logic gates of this kind allows circuits to execute calculations.
>
> A bipyridyl group acts as a receptor within a 'fluorophore-spacer-receptor' system in which an anthracene fluorophore is the output device that gives a glow when stimulated. This system can complex either hydrogen or zinc ions (or H or Hg). This is its input. According to de Silva, either one of these ions will quench the output glow, which gives the molecule its logical NOR behaviour. An output signal is only produced when neither hydrogen nor zinc is present."

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For the INHIBIT function the researchers built what is described as a deceptively simple molecule with four inputs. INHIBIT, de Silva explains in the report, is a normal AND gate with an extra disabling input. When this input is live the entire AND operation is disabled so the input goes through a NOT gate before the AND.

Details of this operation and the INHIBIT truth table are published in *Chemistry in Britain* and the behaviour described fits the INHIBIT 'truth table' which is to be published in the *J. Am. Chem. Soc.*

There is no doubt that since the devices described are not hard-wired as conventional circuits are they will have many unique applications which will cover a whole range of endeavours.

PSYCHOLOGY AND AUTOMATION

1. Computer users and computer solutions

A new strategy for solving problems using a computer has been outlined in a publication from Compaq. The advice given is not concerned with the actual problem but rather with the way in which the computer user should approach its solution. Inevitably, therefore, it is the approach of the psychologist. In this case it is given by Dr. Robert J. Edelmann who presents ten rules for dealing with problems that require solving on a computer. They include:

(i) Give the computer time to overcome the problem itself before taking action.
(ii) Work through the problem – though if you then fail to find a solution do not keep trying.
(iii) Now involve the computer specialists.
(iv) Do not physically attack your PC – it will only make the problem worse.
(v) Do not shout or swear – it could be detrimental to you in the long run.

These are but a representative selection in Compaq's answer to what is described now as 'Computer rage' following the arrival of the term road rage. It includes a report that says that about a third of workers in finance and manufacturing are interrupted at least once a day by computer problems and had to wait at least an hour before the problem was resolved. This is a Mori survey statistic that was included in the report. Road rage we know takes various forms; in computer rage we are told users frequently resort to kicking computers in their frustration. One of the causes reported by more than a quarter of users polled was the incompatibility between hardware and software. It seems that 22% state that computer specialists sorted out the symptoms given to them about the failure of the users attempt but disregarded the under-lying causes. Dr Edelmann's advice can be obtained for the price of a phone call. If telephoned four options are available to callers:

(i) People who have ignored his advice and physically or verbally have abused their computers.
(ii) Those who blame themselves for the machine's failure.
(iii) Users who hate computers with a passion.
(iv) Those who try to sort things out but make things worse.

The first impression of the Compaq approach using a psychologist is that it was not a serious one. Unfortunately, as the Mori survey indicates it is becoming a real problem in its own right as more and more people become computer users. Many are not only untrained in their use of such a facility but they also have a mistaken belief in the capability of computers to solve their problems. This together with the wide ranging types of personalities of human beings will without doubt provide psychologists and computer specialists with an ever increasing work load in the future. When one in four people under 25 admitted in this survey to physically assaulting their computers and one in six said they felt like taking their frustrations out on colleagues or office furniture then 'computer rage' is no figment of the media's desire for headline news. Mori research* has coined the phrase 'technology-related anxiety' to describe the stress suffered by many office workers because of their believed 'shortcoming' of their computers.

Already it is reported that it is the 'shortcomings of computer' that has led many workers to question whether they are more of a burden than an asset. One in eight employers, this survey suggests, had been observed bullying staff in their computer departments.

2. Behaviour managing

Dr Scott Morgan, Professor of Business at the ADL School of Management at Boston College, USA and Visiting Professor at the Rotterdam School of management in the Netherlands argues that the big changes that companies make ultimately fail because those companies do not properly understand the need for changes in behaviour that underpin long term success. He believes that:

> "The pace of change is accelerating for most organisations. Competitive success is increasingly being founded on an organisation's ability to change faster and more efficiently than their rivals.
>
> "However there are too many companies that do not understand that to ensure change leads to sustained success, companies need to look beyond short-term gains in productivity. Though change on paper may look convincing it is what is happening underneath in ways of working that is more important. It is these unwritten rules of behaviour that companies need to understand and confront if deep-seated, perhaps antipathetic attitudes are to be altered."

Dr Scott-Morgan continues his argument by saying that:

> "These unwritten rules are in themselves logical and only by understanding their logic will companies be able to ensure continued business success. It is deep behavioural change that is needed in order to sustain never-ending change. This means understanding and

* Rage against the machine – Mori Survey.

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implementing things like genuine teamwork, cross-company cooperation, customer orientation and the encouragement of creativity and innovation. By understanding the chains of logic which inform behaviour we can then see what needs to be changed to remove the behavioural barriers to managing never-ending change."

3. Organisational Behaviour

Organisations need to study behaviour, not only of their members or employees but also of themselves. In an address given by Drs Graham Wilson and Hanna Gilli of the Corporate Psychologists International at a recent Human Resource Development event organised by the Institute of Personnel and Development* they developed the theme. Under the title 'Behaviour: developing the unconscious' they claimed that 'Big Mind' organisations are the future.

They discussed how, though the 1990s has been a decade that has challenged old models of how to work and live, much of this reinterpretation has been hollow. This is because the processes of the whole mind have been poorly understood and analysed. Living within a solely conscious orientation means living in exile from the rich part of ourselves that adds colour, verve and creativity. The key objectives of life should be about feeling effective and alive rather than merely materially successful while living in a frenetic whirl of activity.

Hanna and Gilli say that:

"People need to be aware of the potential of their unconscious. Managers need to realise that the unconscious will guide people's actions as much as the conscious part of their mind. Top organisations will be able to unlock people's unconscious potential and move from being a small mind organisation to operating from a 'big mind' perspective.

They describe how they identify conscious and unconscious behaviours, how these are influenced by organisational culture; what issues are often kept outside the official agenda, and what is really being communicated. They also explain how a team can identify blocks to progress and enable participants to work with synergy and flow.

In summary they believe that:

"Successful organisations should be capable of more than the sum of their parts. To enable this to happen any organisation needs to develop strong trust relationships between workers and managers. Organisations which develop cultures that encourage contributions and which pool strengths can be described as 'big mind' organisations. This means that they are able to see reality as extending beyond the bottom line."

* For details about the *Institute of Personnel and Development* (IPD): The Institute of Personnel and Development (IPD) has nearly 100,000 members and is the leading professional institute for those involved in the management and development of people. IPD House, Camp Road, London SW19 4UX, UK. Tel: 0181 263 3434. Website: http://www.ipd.co.uk.

4. Body language at work

A consideration of what is commonly called 'body language' may well be worthwhile. A book published* on the subject provides information about a fascinating subject that is important for anyone who deals with people. We all do, of course, but this text could be helpful for managers in industry or business who may, for example be engaged in the selection or appraisal of colleagues or staff. The author is Professor Adrian Furnham, Professor of Psychology at the University College, London, UK.

At a recent presentation address on 'Body Language at Work' he argued that body language had its limits. Body language has been hailed as the salvation of those seeking to spot a compulsive liar through the give-away blink of an eye or the odd shuffle in a chair. But Professor Furnham has warned us that the truth is not always in the twitches of the torso. He has argued that misconceptions about body language has led to it not being used properly. He believes that:

"Body language is an important way to back up verbal communication, but a lot of nonsense has been written about it that simply isn't supported by the facts. For example, people may move around in their chair because they are uncomfortable, not because they can't be trusted. However it has been proved that some body language signals can be relied on for clues about what is really going on. For example, studies of known liars – from conmen to politicians – have revealed important non-verbal signs that can identify clear cases of lying.

Professor Furnam puts forward five tell-tale body language signs that he believes indicate when a person may be being economical with the truth:

- A decrease in the frequency of hand gestures. This is most noticeable in extroverts.
- Hand-to-face contact increases – especially nose-touching.
- An increase in body shifts or squirming.
- A rise in hand shrugs, as if disclaiming responsibility or proclaiming ignorance.
- An increase in micro-expressions of the face, such as brief but detectable expressions of surprise, pain or doubt.

Professor Furnham adds that:

"The bottom line is that, even for the trained expert, it is often very difficult to detect liars. We have videotapes of famous spies lying; of murderers who pretend to be victims appealing for help; of politicians telling bare-faced lies in close-up. They succeed in fooling hundreds of people. Watching every body movement closely can also lead to misunderstandings. When meeting people face-to-face we gather verbal (what they say), vocal (how they say it) and visual clues (what they look like). But paying attention to foot-

* *Body Language at Work* (£5.95 48pp) ISBN: 0 85292 794 0. IPD books can be ordered direct from business bookshops or Plymbridge Distributors Ltd (UK) on 01752 202301.

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tapping or changes in the pace or tone of a voice can mean we pay less attention to equally interesting and important material – what is being said. So beware the recruiter who claims to be good at 'reading' body language and spotting liars in an interview. It could be true – or a self-delusional porkie!

ROBOTS WITH MUSCLES

1. Prototype devices

At the Aerospace and Mechanical Engineering Department of the University of Arizona, Tucson, USA, a prototype device with the name Biomorphic Robot with Distributed Power, or more simply called Birod, has now been completed. it is a basic model of the robot and consists of a 12 inch box which is supported by two legs in the front and tow rear wheels that are situated at the back of the device. These are without any power. Already the prototype is to be updated and the latest model will have four legs which will allow the robot to walk over obstacles which would stop the motion of any wheeled vehicle. The model also has infrared vision that will allow it to operate in the dark.

Developing its muscles. The support for the development of this robot is once again sourced in space research and space exploration. So many new robotic systems which will be of immense use in a wide variety of applications start as part of the space projects that are financed by the US Government agencies. In this case a walking robot which is to have artificial muscles instead of wheels is being developed for the purpose of exploring terrains in space. It is expected that this project will ultimately produce a robotic system that can be used to explore Mars and other planets that have been targeted for further investigations. What is so unusual about this system is that the machine being developed will contain no gears or servos but will be propelled by using 'shiny wires and springs', which the developers say will contract like muscles when electricity flows through them. They have been given the name 'muscle wires', we are told, and are designed so that they respond in milliseconds and are able to carry 17,000 times their own weight.

2. Links with biological systems

The leader of the Birod research team at the University of Arizona, Professor Kumar Ramohalli believes that Birods are much simpler than the robots that have emerged so far. He also says that the team aims at imitating biological systems so that, for example, the robots can produce bursts of power when required whilst retaining a capacity to recoup energy when at rest. In addition, the fact that the design of Birods is not based on complex machinery makes them light and reliable.

A look at nature reveals the many creatures that have this make-up and show the characteristics desired by the designers of Birods. The team at Tucson cite the cat as such a creature that has the behaviour they seek for their new devices. It, they say, is able to lie around for much of the time and then, when required to chase or catch prey it produces the short burst of energy it needs. Many other creatures are able to do the same and they act as models to be cloned in machine form to meet some of the needs of this new breed of robots.

The project continues with new prototypes envisaged until a final robotic system is achieved to meet the demanding role of the biomorphic robot in its exploratory work in space. There is no doubt of the role too, if a successful design is achieved, of a walking robot which has distributed power. Many earthly applications are also in dire need of such devices so that they too are equipped with artificial muscles instead of what are now regarded as the traditional wheeled design.

ROBOTS IN HEART SURGERY

1. New US robotic surgical systems

The Zeus robotic surgical system produced by the American company Computer Motion*, reported in this section (*Robotica* **17**, Part 2, 1999) is now ready to perform heart surgery. Costing £500,000 it is already installed in US hospitals and in several centres in Europe. In the United Kingdom the first hospital to receive the system is the Royal Brompton and Harefield NHS Trust Hospital. This hospital is a National Health Service (public hospital service) which is situated in West London. Work is in preparation there for the new robotic system to take over from the existing team. Perhaps a better way of reporting it, we are told, is to say that heart surgeons will control the robotic machinery that will enable the UK's first coronary bypass to be performed by remote control.

2. First UK surgical bypass operation

The hospital spokesman says that the cardiac surgeon John Pepper will be the first to sit behind the controls when the Zeus system is used for heart bypasses. Mr Pepper believes that the system should improve the quality of the results and speed recovery. The system has tiny probes which can carry out operations by remote control through three small incisions in the patient's chest. They are so tiny that they can move around in the smallest of spaces and, we are assured, without the fear always present when a human operates, of a hand shaking. We are told that even the finest surgeon may produce a small tremor in his/her hands. In such a bypass operation a section of the artery from behind the breast-bone is used to replace blocked arteries. To do this is a very challenging and precise job and it is now claimed that the robot system will eliminate previous human error.

3. How the system will operate

The operator of the robotic system will wear a headset that shows a three-dimensional image of the heart and its surrounding tissue which is transmitted by a tiny camera and light which is introduced into the patient's chest through a 5mm hole. The operator can use voice commands to make

* Further details about *Computer Motion*, the company that produces the Zeus robotic surgery system can be obtained from their home site: www.computermotion.com/.

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the camera move and show different views. The instruments to be used in the operation are held on the end of two equally fine tubes. These we are told are only about the thickness of an ordinary knitting needle. The instruments are placed into the chest cavity through the small incisions in the chest. They are controlled by the surgeon who is operating by two hand-grips which can be squeezed and moved to manipulate them. Both their position and movement is displayed on a screen in three dimensions by the controlling surgeon through the headset. It is important to realise that the operation is controlled by the surgeon who remains in full control throughout the operation. Patients need to know that, despite early media reports, this system does not perform any parts of its action in an automated mode.

Obviously this method of performing such operations has many advantages. The 'keyhole' techniques will be of great benefit to the patient. This, it is said, spares the patient having the large incision normally needed for open heart surgery. This consequently eliminates the scar and reduces the pain, with the patient's recovery being accelerated. One feature of the system that most hospital managers will appreciate is that the whole operation can be completed by one surgeon without any assistants being at hand.

The need for such a robotic system becomes apparent. Mr Pepper of the UK hospital where the first operations will take place is reported as saying in *The Times* (London, June 1999) that:

> 'Today if you went back to 100 bypass patients a year after the operation, you would find that in about eight of them the new artery was not working. What this means is that only 92% of the bypass operations actually work. The robot should push that up to 98%, I hope. The joins should be better. You could come into the hospital tomorrow, have the graft done the same day and leave the following day. You could be back at work, within a fortnight. At present it takes a couple of months, at least'.

Computer Motion, the company that has developed the robotics system say that the robot could be used on the 'beating heart' where operations can be carried out which would eliminate the need to connect the patient to a heart lung machine. Initially, in the UK applications the robot is to be used for bypass operations, and at the Royal Brompton Hospital in West London, on some 70% of the workload associated with them. Later uses are planned and include mitral valve replacements.

4. Learning to use the robotic system

The experiences in the UK of hospitals undertaking keyhole surgery before they were fully prepared to undertake it, must influence the way such a robotic system is introduced, not only here, but worldwide. It has been estimated at the Royal Brompton Hospital, UK, that it could take 70 hours to learn to use the machine. Mr Pepper, from that hospital, is said to have practised intensively the techniques that are required. He has learned, we are told, how to use the machine to make tiny stitches using a rubber glove that has been stretched over a frame. Then he moves to operating on a dead pig's heart and finally, on cadavers, before taking on a live patient. This is forecast to be at the end of this year. With this experience of learning the techniques for such operations the Royal Brompton Hospital plans to run courses to introduce and train UK surgeons in these new techniques.

The impact of robotics on medicine and in particular on surgery has astonished even the most futuristic of researchers in robotics and automation.

ROBOTS IN AUSTRALIA

1. Australian robot sales

347 robots were installed in Australia in 1998, according to the latest annual survey of the Australian Robotics and Automotion Association Inc. (ARAA).* The new additions bring Australia's nominal robot population to 3,390 units. However, the Association has no information about how many older robots are still in use.

As the following graph Figure 1 indicates, last year's robot installations continue a long-term trend of rising robot use in Australia, although the number of robots installed in 1998 declined from 1997. 1997 was an exceptional year for robot sales because of the large number of robots acquired by the automotive sector.

The ARAA estimates that the Australian robot marketplace had a value last year of $43,130,754. Value is defined as the amount paid for a robot and for ancillary equipment and software provided by the robot supplier. It does not include the cost of work on a robot system carried out by the customer or by third parties.

The principal applications and principal industry sectors of robots installed in Australia last year are given in the following table (Table I). For the first time ever, the number of robots installed in Australia for palletising and packaging applications exceeded the number installed for welding.

This reflects the increasing use of robots by the Australian food industry for applications such as packaging biscuits and chocolates.

The ARAA estimates that 14 of the 347 robots installed last year were manufactured in Australia. Japan continues to be the major producer of Australia's imported robots, followed by Sweden.

Annual survey

ARAA's annual survey** of robot installations is part of a worldwide collection of robot statistics co-ordinated by the International Federation of Robotics (IFR) and the United Nations. Following IFR guidelines, and in accordance with international standard ISO 8373 for 'manipulating industrial

*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. Regarding the ARAA please contact Dr Alex Zelinsky, President. Telephone: (02) 6279 8840. Fax: (02) 6279 8688. e-mail: alex@keating.anu.edu.au

** For further information regarding this survey please contact Michael Kassler. Telephone (02) 9967 5755. Fax (02) 9967 5890.

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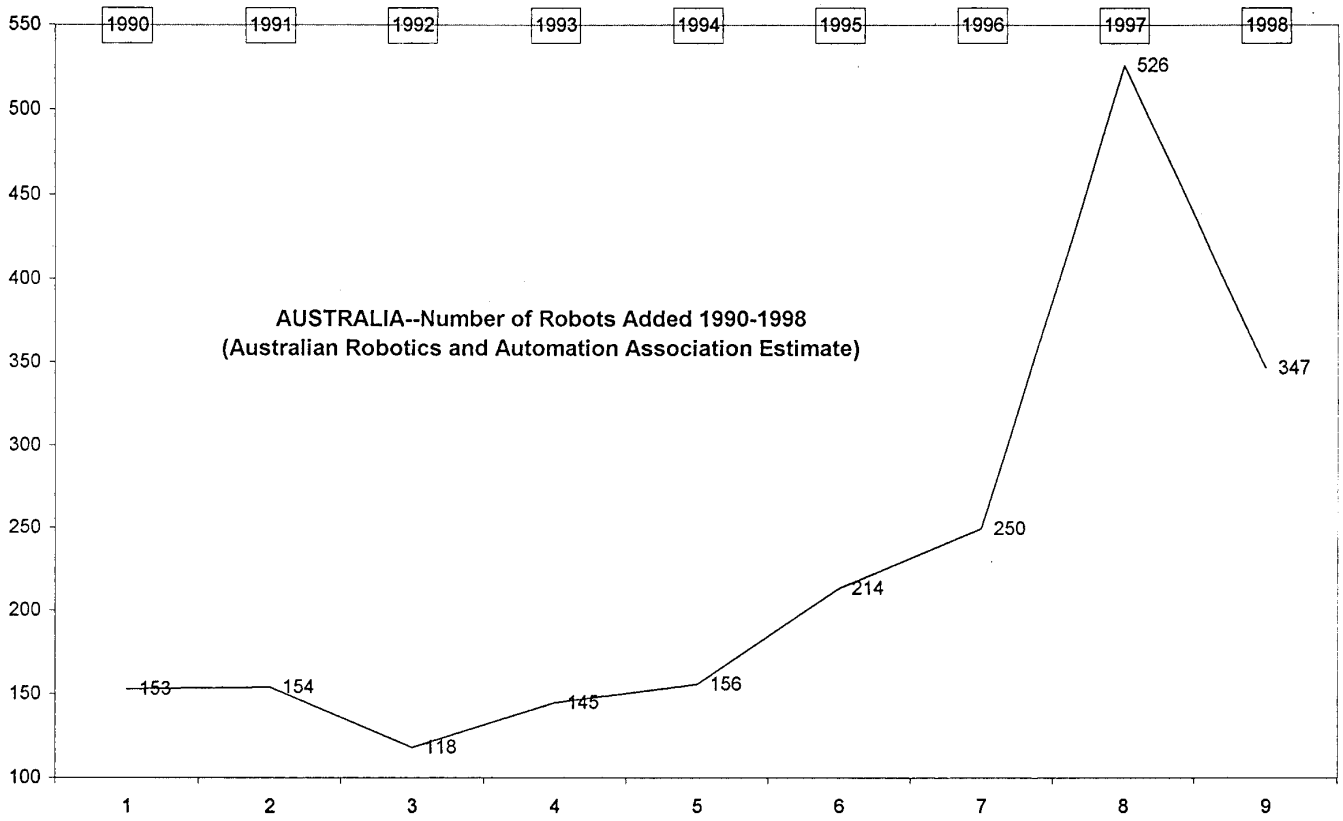

Fig. 1.

robots', the robots counted in this survey have at least three programmable axes. The survey does not include 'service robots', such as those used to assist surgeons to carry out endoscopic ('keyhole surgery') operations, for which a standardised definition is still being developed.

ROBOTS CONTROLLED BY THOUGHT

1. Controlling machines by thought

Reports in this section have provided details of some of the latest advances in 'thought-controlled' machines. At first the concept of any devices being controlled by the brain of a human being or animal appeared to be greeted with derision. Scientists have now not only demonstrated that this is possible but have produced working systems. It is now established that a human can command devices remotely using the brain. Thinking a switch 'on' or 'off' or wanting a door to be opened is possible, and each day more and more sophisticated systems are being built around the interpretation of activities that occur in the brain.

This has always been regarded as a SciFi scenario, and hardly part of the real world of possibility. Without claiming

Table I. Estimate of robot installations in Australia. The ARAA estimate of robot installations in Australia was as follows:

Principal Applications	# Installations	% Installations
Palletising/Packaging	110	32%
Arc Welding	64	18%
Material Handling	43	12%
Machine Loading/Unloading	23	7%
Spot Welding	15	4%
Sealing/Gluing	14	4%
Other	78	22%
Total:	347	100%
Principal Industry Sectors		
Mfg Fabricated Metal Products	68	20%
Mfg Food, Beverages, Tobacco	64	18%
Mfg Motor Vehicles Parts & Accessories	55	16%
Mfg Motor Vehicles	27	8%
Mfg Coke, Chemicals, Plastic	24	7%
Other	109	31%
Total:	347	100%

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systems have been developed that are capable of fully interpreting even the least complex thought, simple actions can be linked to activity in certain parts of the brain and can, consequently, be monitored. We are still in the area of research that has achieved the capability of identifying simple desires but there are hopes for much more and there are projects worldwide that have the aims of developing systems that can identify and analyse the thoughts not only of humans but also of animals. Initially the brains are wired-up, as opposed to those systems where electrical patterns from the brain can be received and stored for analysis. Two reports from research centres in the U.S. give us an indication of the current state of development in this area.

2. Progress of current research

At the Hahnemann Medical College, Philadelphia, USA, a team of researchers led by Dr John Chapin have wired up the brains of rats so that they can move a robot arm by thought alone. This, the scientists say, brings nearer the prospects of developing a thought-operated computer or prosthetic limbs being controlled by the mind.

In this experiment six rats were trained to press a lever bar that operated an electric robot arm that is able to bring them water. In their findings the research team say that they found that the bar-pressing paw movement was preceded by a burst of activity from a group of neurons in the brain of the animal; this had been recorded by electrodes that had been implanted in the brain. Then they developed a system that allowed the brain cells to operate the robot arm directly, without the paw having to move the lever. Signals from the implants were fed to a computer and used to generate the current needed to power the arm. The rats, it would appear, could then obtain their reward simply by thinking of pressing the bar. It is reported that after a short while the rats learnt the trick and stopped going through the motions of pressing the lever or pressed it less often.

These results have been written-up in the *Nature Neuroscience* (June, 1999) journal. The researchers say in their published findings that the results raised the possibility of restoring movement to paralysed patients by allowing their brains to control external devices, or even their own muscles.

Dr Eberhard Fetz of the University of Washington, USA, has commented in the same journal about this research. Working at the School of Medicine in Seattle, he believes that this research has far reaching implications. He pin-points the technical problems of recording the output of the brain cells as being one of the main problems to be solved.

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