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Reports and Surveys

I. AUTOMATION REPORTS

I.1. UK Manufacturers Buy Largest Number of Robots Since Records Began in 1978

Latest research figures from the University of Warwick (UK) show that UK manufacturers installed a record breaking 1,941 robots in 2001 – the largest number of new robots ever installed in the UK in any one year since records began in 1978.

This runs counter to much of the doom and gloom about UK manufacturing and shows that companies who are not afraid to use the latest manufacturing technologies still see the UK as a viable base for manufacturing.

The new figures, collated by the British Automation and Robot Association (BARA)* based at the University of Warwick also estimate that there are now around 13,500 industrial robots working in the UK.

The automotive industry is leading the way, taking almost three-quarters of the total number of new robots, but there has also been notable increase in the food and drink industry due to technological advances in palletising and packaging robots.

Figure 1 shows the UK annual robot installation figures, Figure 2 the installation figures split between the Automotive Industry and others. The installation patterns in the UK Industry shown in Figure 3 indicate the trends in the Metal/Mech.; Food/Drink; Rubber/Plastics; Electric/Electronic; and the Education/R&D sectors.

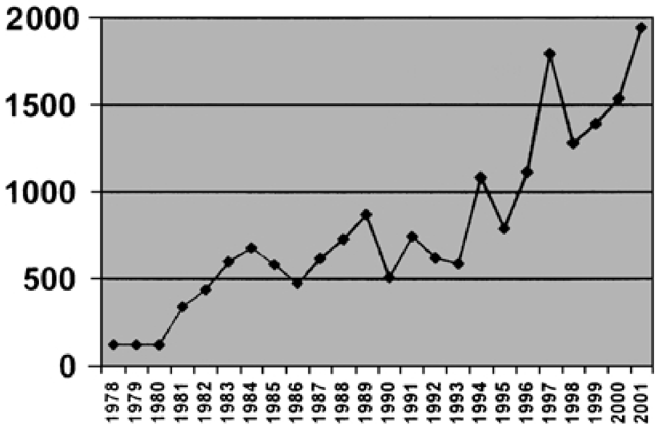

Fig. 1. UK annual robot installation figures.

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I.2 New Multi-axis Handling System – New Güdel Gantry Robot Series

Güdel Lineartec UK Ltd.* of Coventry (UK) have launched their new Gantry Robot Systems. The company describe the systems as:

> "Providing a fully programmable, 5-axis component positioning capability, the new Gantry Robot systems are ideal for complex, inter-operational component handling tasks, as well as for close tolerance manufacturing processes – such as welding, profile cutting, sealant application or other assembly operations.
>
> Units deliver maximum operational flexibility and versatility by combining the proven capabilities of Güdel's multi-axis gantry handling modules with optional 4th and 5th axis robot heads and ABB S4C Plus control technology. The system's hand-held control units use simple commands and incorporate an operator guided 'self-teach' facility. As a result, installations can be tailored precisely to customer requirements or easily re-programmed to meet changing operational demands.
>
> Further examples of advanced Güdel mechanical handling solutions were on show at MACH 2002 and included a 2-axis 'pick & place' gantry unit and a selection of gearboxes, guideways, racks pinions, carriages and rollers from the company's extensive drive components range.
>
> Designed specifically for installations requiring high speed, high acceleration or precise positioning of parts weighing up to several tonnes, Güdel handling equipment provides extreme positional accuracy and repeatability – making it the perfect choice for a wide variety of machine tool, automation and special machine building applications."

A member of the Swiss-based Güdel AG engineering group, Güdel UK develops and supplies modular-based solutions for positioning components weighing from a few grams to several tonnes with extreme accuracy and repeatability.

II. BRAIN–MACHINE INTERFACE

II.1. The ultimate human-machine interface?

Recent reports of new computing devices that can be controlled by the human brain have indicated the progress in what could be the ultimate human-machine interface. There have, of course, been many 'false dawns' and the reported breakthroughs have amounted to very little. The test is whether finally after the claims have been made the project does produce a viable device. The following reports are therefore more a discussion of some of the researches into this field and their impact on automation and robotics.

II.2. European Commission (EU) project

A project to develop what is called the Adaptive Brain Interface was initiated by the European Commission's Joint

* *See also Güdel UR Website*: http:www.gudel.com a free 360 pp guide is available.

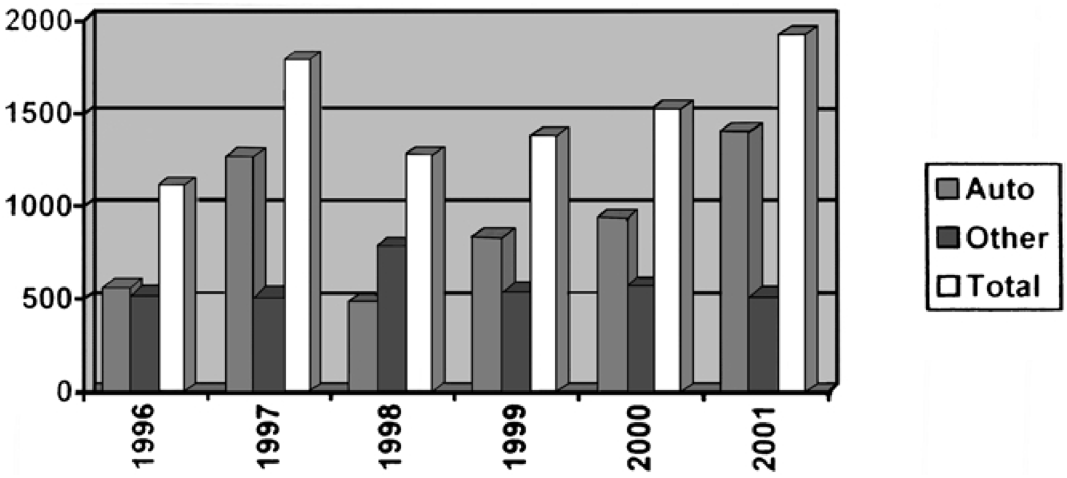

Fig. 2. Installation figures split between the Automotive Industry and Others.

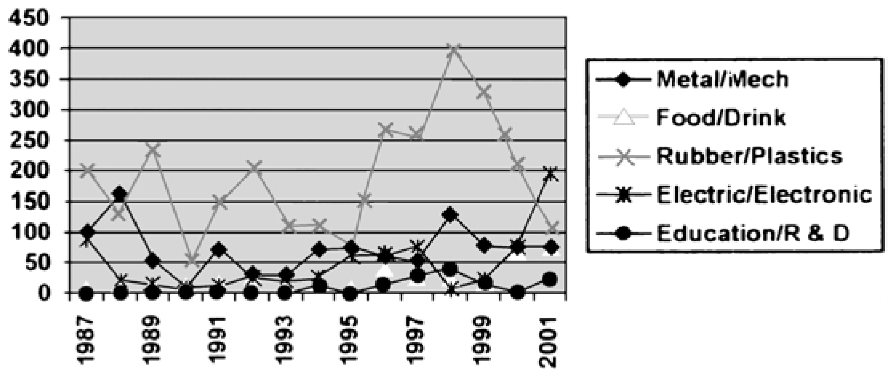

Fig. 3. Installation patterns by industry sector.

Research Centre, Ispra (Italy). Scientists involved with the project have produced an interface to a computer that they claim enables the system to 'read' thoughts and be controlled by the user's brain alone. Initially, as with other projects concerned with thought-controlled computer devices, the project developers see their research as being applied to produce systems to assist the disabled. The co-ordinator of the programme is Dr. Jose del Millan, a Spanish computer scientist, who has claimed that:

> "The key to our system is its natural and quick operation. Without any assistance a user can teach the machine to recognise his thoughts within one or two hours."

A project report outlines the function of the device; it says that:

> "ABI interprets the tiny electromagnetic signals sent out from the brain, 'training' its computer software to recognise thought waves and control a cursor to choose the letters of the message. The ABI costs some £1 million ($1.4 m) to develop and involved no surgery to implant devices in the head. Instead, electrodes are attached to a £150 ($210) plastic cap that is placed on the head of the user. The cap is linked by a cable to a personal computer which is loaded with Windows 2000 and some purpose-built software."

Obviously, the most important part of the project was to determine how the user's thoughts could be transferred to the computer and then be translated into control commands. We are told by the researchers that this is accomplished by a form of 'reverse psychology'. This is where the user must consciously think of three different concepts to produce different brain waves. The machine's software suite is designed to 'learn' the user's brainwaves and the user learns to think in a way that makes the machine react.

Professor Del Millan provides an example of a user's interaction with the system:

> "A severely disabled man was told to think hard about a rotating cube, moving his left arm (which he cannot do physically) and then relax mentally. He found it hard to get his brain to stimulate the computer to move around the keyboard. After three hours practice he found that he was able to compose a three word-19 letter message. He now believes the,system could enable him to retain his ability to communicate."

This particular user found the system so successful that he could, for example, use it to carry out many basic tasks without a carer being present.

II.3. Future developments

Dr del Millan looks to future developments and applications of the system when he says:

> "The system might eventually have applications for able-bodied people, but stressed that his team was not interested in delving into a user's innermost thoughts. We are only developing applications where the user consciously decides to issue a command to the computer.We are not exploiting the brain at the unconscious level."

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This is not the only such computer system that allows thought input and the research continues. The project has, however, succeeded in producing a working system which will considerably enhance the quality of life of disabled people. It also offers the potential for many other applications and developments in providing 'thought interfaces' for computer systems.

II.4. Developing emerging technologies

It is worth noting that the EU Commission has funded ABI as part of its £200 million ($280 m.) future and emerging technologies unit. Dr Simon Bensasson,who heads the unit, is reported as saying that one of its main aims was to back projects that were deemed too risky by the private sector. Other projects included research into:

- robots that can operate in swarms to tackle environmental disasters.
- 'teleporting' minute particles of matter between different points.
- technology to produce 'uncrackable' cyphers –quantum –code encryption.

Not only would a successful outcome to these projects, for example, be most rewarding but the spin-offs might be even more important. The philosophy of this EU unit, we are told, is that if a project is said to definitely work and the proposer is told to go to a bank for funding, if it has a high risk element then the unit is interested. It would appear that the Adaptive Brain Intertace project may have justified the unit's policy.

III COMPLEXITY OF COMPUTERS

The UK's Engineering Physical Sciences Research Council (EPSRC) is concerned that the complexity of computer systems is raising problems about their reliability and safety.

We are now dependent on computer systems and, in consequence, there is a corresponding pressure to achieve and assure increasingly higher levels of safety and reliability in such systems.

The Research File of the publication *IMPACT* Issue 30 (2001) outlines a collaborative EPSPC project that is now tackling some of the problems encountered. In its introduction the report indicates that:

> "It is generally accepted in research and industry circles that, because of the impact of complexity, the most significant dependability problems arise in the software elements of computing systems. Consequently, it is unrealistic to expect that modern computer systems can be developed and implemented without faults being present, or that they can function without component failures occurring.
>
> Software fault tolerance based upon design diversity is one promising approach to dealing with such problems and could help in delivering more dependable systems. Mainly conducted between 1997–1999, as a collaboration between the Centres for Software Reliability at Newcastle and City Universities, the EPSRC-funded DISCS project (Diversity in Safety Critical Software) has tackled a number of problems concerning the achievement and assessment of design diversity."

It makes the point that the aim of the DISCS project was to give systems designers advice on how to exploit design diversity to the best advantage,and to assist those responsible for the evaluation of such systems. The research addressed two main issues:

- How to organise diverse software versions and their development processes in the most effective way.
- How to evaluate the reliability thereby achieved in a particular system.

At Newcastle University (UK) the researchers concentrated on two objectives:

- a better understanding of the factors, in architecture and in development, that help to achieve design diversity;
- providing design guidance for both the achievement and evaluation of diversity, with particular reference to safety and reliability.

The developing research covered the main life-cycle phases of system development which can employ diversity: starting from system and specification, through architectural design, and with the assistance in choosing effective structures for design diversity, to concrete design and coding. DISCS Principal Investigator at Newcastle, Professor Tom Anderson, summed up the strategy as:

> "We considered diversity-specific issues at system ievel (including system structuring), linguistic issues, and problems concerning provision of the runtime support necessary for such systems to function,"

We are told in the report that this research approach yielded four main strands of work:

> "• The Newcastle team developed a method for using a formal/semi-formal specification of safety requirements to guide the architectural design of a system and the selection of development methods;
> • It proposed an advanced object-oriented architecture for applying diversity in distributed and concurrent environments; this incorporates extended error detection features, exception handling, and recovery after the failure of a faulty version;
> • The team also devised improved methods for recovering from the data corruption that software problems can create (covering techniques for check-pointing, state restoration, persistence and stable storage that are applicable for a range of diverse architectures);
> • Finally, the team obtained a better understanding of how methods for enforcing design diversity can be chosen and applied in a more rigorous and effective way (so as to decrease failure correlation between versions)."

Currently, the two DISCS partners are working on a related topic, which is a similarly EPSCR funded project 'Diversity with off-the-shelf Components' which started in September 2000.

This project aims to bulld on the work of DISCS, unifying two previously separate areas of software engineering: Design, diversity and re-use of off-the-shelf components increasingly used in building systems, instead of only relying on bespoke software items.

The current project 'Diversity with off-the-shelf Components' is known as DOTS and more details are available on: www.csr.ncl.ac.uk/projects/dots/

Further Information
Information about the DISCS project and its work can be obtained by accessing: www.csr.ncl.ac.uk/projects/past/discs.htm/

IV. IMAGING PROCESSING

IV.1 Processing images and their interpretation
A report from the University of Manchester (UK) describes how their Imaging Science and Biomedical Engineering Department have developed a unified approach to face image processing. A large part of the human visual cortex, we are told, is devoted to processing face images. Indeed, this reflects the fact that faces play a central role in the way we understand and interact with the world. Much of our time is taken with identifing individuals, inferring their intentions, and augumenting verbal communication.

This section has reported on many occasions the developments in the use of automated face recognition in such applications as access control surveillance, criminal investigation, and coding. It has been obvious that existing technology is limited and that there is a need for systems to be developed that are more flexible and robust.

IV.2. Creating a natural human-computer interface
The creation of a natural human computer interface has been the goal of computer scientists since multi-access systems were introduced. In many ways, as most cyberneticians will accept, using a computer is still a very primitive operation. Keying-in data, for example, can hardly be regarded as a natural or efficient way of interfacing with a computing machine. Any process that makes interaction with a computer system more natural is to be welcomed. Obviously, efficient facial recognition systems have an important part to play in building natural interfaces.

In the long term it is believed that developing capabilities approaching those of humans will be the key to creating natural human-computer interfaces. This research report informs us that:

> "Automated interpretation is difficult because the scenes of interest are complex and highly variable. Also, most applications of interest involve the interpretation of video, rather than static images.
>
> The functionality required to tackle a broad range of applications can be expressed in terms of a number of generic capabilities: feature location and tracking, person identification, expression recognition, pose recovery, coding, and so on. It has been common to treat these as separate problems, but this is naïve since, in practice, they are interlinked. For example, a fully functional system for person identification needs to 'understand' expression change in order to ignore irrelevant within-person variation."

The key, we are told, to the approach taken at Manchester is to use a generative model of face appearance that takes into account all the main sources of variablity. Professor Chris Taylor and Dr Tim Cootes, who have developed this new unified approach, say that:

> "By varying a set of model parameters it is possible to generate a synthetic image of any person in any pose with any expression and so on. The model deals with variability in both shape and intensity and, because it would be very difficult to 'hand craft', it is learned by applying statistical analysis to a large set of training images. This results in a model with around 100 parameters, capable of generating photo-realistic face images demonstrating a full range of variability."

IV.3. Further Statistical Analysis
Further statistical analysis, we are told, can be used to partition the parameters into subsets that each control exclusively one aspect of variability-identity, expression, etc. As a spin-off of the work these models can be used directly in computer games and avatars. Professor Taylor says that:

> "Given a parameterised model of a face appearance, interpretation of an image containing a face can be posed as finding the set of model parameters that generate a synthetic face as similar as possible to that image.
>
> This is a difficult optimisation problem but an efficient solution can be found by exploiting the insight that a very similar problem is solved every time the face model is matched to an image containing a face. This allows the characteristics of the search space to be learned off-line, leading to a robust, or near real-time matching algorithm."

The researchers say that once the model has been matched, its parameters summarise everything there is to know about the image. Because they are partitioned into subsets that deal with specific sources of variability, the parameters can be used directly to identify the individual, recognise their expression, determine their gaze point, and so on.

IV.4. Active Appearance Model
In summary, Professor Taylor says that

> "This approach has been extended to deal with video sequences by modelling the dynamics of the face model parameters, noting that whilst expression, pose and other characteristics can vary during a sequence, identity must remain constant – in real life if not in the movies. One consequence of this approach is that identity information can be integrated over a sequence, allowing a good estimate of appearance to be obtained even from poor quality 'Crimewatch' videos."

It is claimed that this 'Active Appearance Model' approach has been widely recognised as a significant breakthrough and is currently being applied to a range of challenging applications using UK Department of Trade and Industry (DTI) Link, European Union (EU) and commercial funding. These applications can be as diverse, we are told, as printed circuit board, inspection and medical image analysis.

Further information can be obtained from the Manchester University website: www.isbe.man.ac.uk

V. INTERNET INNOVATIONS

V.1. Voice over Internet Protocol (VoIP)
VoIP allows for the conversion of the waveforms of sound into packets of digital bits and transmits them down a line to the Internet, where they can be moved around the network. Once the packets get back to the computer at the other end,

they are reassembled and converted back into soundwaves. There are, of course, many obvious advantages; for example, the user need only pay for a local call to the Internet service provider, or alternatively if the user is permanently connected to the Internet the calls are effectively free. There are also disadvantages at the moment because there is poor call quality and gaps can appear in the connection. Domestic users would require to set up the system on their PCs.

V.2. New uses for VoIP

There are, of course, innumerable applications for such a system, particularly if most of us become computer users in our homes as well as at work. Unfortunately, the initial optimistic view of the uses for *VoIP* faded with the burst of the dot-com bubble. It could have resulted, for example, in people abandoning the telephone and using their computers to talk to each other by means of *VoIP*. But people stopped buying computers in great numbers and those that did appeared unenthusiastic about incorporating *VoIP* into their systems. It would certainly have revolutionised the way we communicated with other users and of course, in the way we would interact with both public and commercial services. We would deal directly with websites and request contact with a human in only the last resort.

V.3. Virtual Call Centres

The dream of not using the telephone and people using computers to talk to one another has yet to happen. Company websites, for example, were geared to do all the work previously carried out by the Call Centres. It failed to materialise but a new system has emerged in the Call Centre of today called Automatic Call Distributors (ACDs). Currently, Call Centres are equipped with two sets of wiring, for voice and data. The two are linked by sophisticated software links which instantaneously accept calls to the operator's phone line and send the caller's file through a computer. The designers of such systems report that:

> "*VoIP* allows voice and data to be sent over the same network. All is sent as data with the result that bandwidth and call quality problems are eliminated. The software that controls the Call Centre is, as a result, much simpler. The savings for a medium sized centre can be in the region of £350,000 ($514,500) a year because there would be no need to run a voice line to every operator/agent."

Interest in such developments have led researchers to predict the Virtual Call Centre which will use *VoIP* to connect callers to operators anywhere in the world, using the low Internet call rates.

V.4. Developing Systems

Analysts Datamonitor are reported as believing that:

> "The market is extremely immature. There are 50 'pure' *VoIP* call centres in Europe and the market was worth a tiny $4.4 million (£3 million) in 2000. The outlook is, however, bright and we predict that by 2005 there will be more than 3000 call centres, and revenues will have risen to $308 million (£209 million)."

Communications, for whatever purpose, would be so much simpler if unified messaging was adopted. For example, e-mail, faxes and text messages could be combined resulting in a much more flexible and efficient system.

VI. NEW PRODUCTS & PROJECTS

VI.1. Toshiba Machine releases two new SCARA robots

Toshiba Machine has released two new SCARA robots, the TH-250 and TH-350, which provide better accuracy and repeatability than existing SCARAs, and offer quicker cycle times and faster motion. The new SCARAs are so precise that they can even be used to good effect in the electronics industry, a company representative claims. Toshiba Machine also say that:

> "Both SCARAs feature absolute encoders as standard, dispensing with the need for a home return function. The TH-250 and TH-350 feature top-level speed, payloads of up to 3 kg and repeatability of ±0.01 mm. These robots are suited to applications in the handling of small components, such as electrical, precision and mobile phone and camera parts, assembly and test equipment. Other applications that demand similar precision are hard disk drive assembly, as well as very high precision work, such as optical lens grinding and watch assembly. Furthermore, this kind of precision and accuracy allows the user to place electronic components on PCB boards, or even handle the optical 'pick up' lenses used in CD and DVD disc drives.
>
> Both robots feature a built in PLC, which, regardless of robot operation and program, can control I/O equipment. The TH-250 and TH-350 robots can be programmed using a ladder sequence program and, as an option, can feature Ethernet, DeviceNet or Profi-bus connectivity. A further option is the Toshiba Machine teach pendant, an external switch pad that can be used to direct the robot through a sequence of movements."

These new additions to the existing range will mean that Toshiba Machine is amongst the largest family of mechanical arms on the market. The range will now extend from the TH-250 and TH-350, which have arm lengths of 250 mm and 350 mm respectively, and the general purpose SCARAs with arm lengths between 420 mm and 1050 mm, to the large palletising SCARAs, with a 1950 mm arm length and a payload capacity up to 70 kgs. Further options include Clean Room Class 10, for use in pharmaceutical or electronic manufacture, and ceiling mounting.

VI.2. Social Interactions can solve Technical Problems

The Research File of the UK's Information Technology and Computer Science Update – *IMPACT* (Issue 30, Sept. 2001) reports that 'Natural' evolution for business can be taught. It suggests that Companies should be able to organise themselves in a way that allows them to continuously adapt to a changing commercial environment. If an organisation, it says, is sufficiently fluid, it can reduce the periodic need for expensive and disruptive restructuring which often ends in failure.

One of the United Kingdom's leading Information Systems Departments, at the London School of Economics

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(LSE) was awarded a major three-year grant to work with Shell Internet Works, Rolls Royce Marine and BT Brightstar (BTs new business incubator) to investigate ways of introducing this 'change' concept into a range of different business settings. The project, called the *Integrated Complex Social Systems (ICoSS)* project, has received funding from the UK's Engineering and Physical Sciences Research Council (EPSRC). The ideas for the project, we are told, come from Eve Mitleton-Kelly, the LSE's Director of Complexity and Organisational Learning Research Programme.* In addition a multi-disciplinary group of international advisors from academe and business will also contribute different perspectives, knowledge and expertise to the project.

The key to the work, it is reported, lies in 'complex adaptive Systems' which are described as:

> "A complex system is one in which the system's many constituent components are intricately inter-related and a change in one element causes changes throughout the system in ways that are difficult to predict. In many biological systems, such complexity enables the system to adapt to changes in its environment – hence complex adaptive systems."

Eve Mitleton-Kelly says that:

> "The fact that these systems can change and adapt is crucial and if we can understand how organisations of humans function as complex adaptive systems we can then change the way we think about them and how we manage organisations."

One of the most important characteristics of a complex adaptive system is that it can self-organise, rearranging itself in response to changing circumstances.

VI.3. Real–life Applications

An example of the sorts of creativity that can arise in this way has already been observed in earlier researches. A global banking company had a tight deadline to implement a new strategy to deal with the introduction of the new European Currency, the Euro. This required urgent updating and reconfiguring of the company's entire computer system. Dr Mitleton-Kelly describes the circumstances and the results:

> "Quite spontaneously one of the local project managers did something which made all the difference."
>
> "He invited all the business project managers and the systems developers to meet each other one afternoon on a regular basis. These are people who do not normally feel comfortable talking to one another and were initially not very happy to do this. But gradually they started making connections with each other. The banking people began to understand the problems and issues faced by the computer people, and vice versa, This simple opening up of channels helped get the task done efficiently and quickly. The social interactions provided solutions to the technical problems".

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The researchers are aware that all organisations consisting of humans are necessarily complex and that the key is to exploit the advantages of complexity, the ability to adapt and self-organise.

Dr Mitleton-Kelly believes that:

> "The main thing is to identify the barriers that allow the beneficial aspects of complexity to emerge, and then remove those barriers. Traditionally many managerial approaches have served to stifle these benefits of complexity. What happened in the banking example was that people were allowed to self-organise, to create new relationships."

It is by working closely with companies that the research team will be able to examine how adaptive complexity might be allowed to flourish in a situation where two companies are merging, where there is restructuring, and in an 'incubator' – an 'ideas factory' – where employees are encouraged to dream up innovative ideas for new business. Mitleton-Kelly says that:

> "One of the big advantages of allowing complexity thinking to flourish is that you should no longer need constant interventions to impose change. People themselves should be able to change and evolve with the external environment because of the inherent fluidity and adaptability of the organisation."

The research team report that they hope to identify some generic conditions or enabling frameworks that will help an organisation to create new ways of working and relating, as well as frameworks specific to the companies collaborating in the project. The main aim is to try to change the way of thinking about an organisation. They believe that it is a conceptual framework, not a case of laying down strict rules or coming up with a particular recipe.

The programme is active and was launched last year when 30 participants including representatives from all the industrial partners as well as advisors met at a meeting opened by the Director of the London School of Economics, Professor Tony Giddens.

VII. PROGRESS IN AI

There are now so many groups worldwide concerned with Artificial Intelligence (*AI*) that it is beginning to be extremely difficult to assess both their importance and the validity of their contributions to what has in the past been regarded as a very controversial research area. It was not so many years ago that in the United Kingdom an assessor appointed by the government research councils wondered whether there was any future in what was called 'Machine Intelligence'. He was very sceptical about backing state funding for research in the area. Since then the cloak of respectability has been placed over what became known as Artificial Intelligence. Now, of course, there are so many facets to *AI* that researchers have been anxious to improve their own standing by inventing new titles for their works. What was once known as *AI* has now changed into many different specialist subjects that denote new endeavours in different areas of study. At the recent *AISB '02 Convention* held at Imperial College, London (UK), for example, there were six different symposia on what was loosely called *AI*,

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running at the same time! Their titles alone showed that the new researchers of the past decades have produced new research groupings that have rapidly become specialist. Some of the worldwide groups concerned with *AI* and which reflect its progress over the last two decades and reflect the expansion in its coverage are discussed in the following sections.

VII.1. Society for the Study of Artificial Intelligence and Simulation of Behaviour-AISB

The Society for the Study of Artificial Intelligence and Simulation of Behaviour* claims to be the UK's largest and foremost Artificial Intelligence society. It is one of the oldest established such organisations in the world and has an international membership of 500. It has a quarterly newsletter, a bi-annual journal and runs events and conventions. The conventions in particular are well attended and give an indication of current trends in *AI*; for example, at the recent event the following were regarded as some of the most important topics to be discussed in *AI* and formed the basis of the Convention. They were proposal-driven from the international *AI* Community and, in consequence, must be regarded as an indication of current trends and interests. They were:

- Adaptive Agents and Multi-Agent Systems
- Automated Reasoning–the gap to be bridged between theory and practice
- *AI* and Creativity in Arts and Science
- *AI* and Grid Computing
- Animating Expressive Characters for Social Interactions
- Intelligent Agents in Virtual Markets

The six topics became the convention's symposia. The sessions on Automated Reasoning followed an established line of research and constituted the Ninth Workshop in a series of similar meetings. There is no doubt about the relevance of *AI* studies in their broader forms to innumerable applications in a range of areas that, of course, included automation and robotics.

VII.2 AI in Austria

The Austrian Research Institute for Artificial Intelligence** (Österreichisches Forschunginstitut Für Artificial Intelligence – OFAI) is a research Institute linked to the University of Vienna and sponsored by the Austrian Federal Ministry for Education, Science and Culture. The Institute informs us that their strengths in methodology are:

"– the extraction of knowledge from large collectons of data or texts or from time series, and their representation in the form of rules, decision trees or in other graphical forms,
– the support of decision makers by developing expert systems – rule, case or model based – or by complex neural networks, with user-friendly interface,
– language processing, both of spoken and written language, especially text understanding and language generation,
– the development of information agents for filtering or retrieving information from the Internet,
– the development of emotional personality agents to direct virtual characters for TV, film or interactive installations such as e.g. computer games or museum exhibits."

In addition, the Institute believes that its organisational strengths are many and can be summarised as:

"– experience in team work with 46 companies and 83 research institutes from 19 countries,
– cooperation as partner or prime contractor in 21 successfully completed multinational projects in research and development programs of the European Union, which have led to marketable products,
– our team, consisting of 26 graduates of computer science, linguistics, doctors of technical science, teachers and professors at the Technical University as well as at the University of Vienna, who have many years of experience in our area."

The research and application areas currently pursued are given as:

"– Natural Language Systems
– Knowledge Based Systems
– Neural Networks
– Machine Learning and Data Mining
– Intelligent Software Agents and New Media
– Constraint Logic Programming
– *AI* and Society"

Some of ÖFAI's current European Union (EU) projects are:

- INQUAC – Innovative Quality Control Methods for Rotating Machines Using Artificial Intelligence Methods (BRITE-EURAM III Project of the EU)
- METAL – A Meta-Learning Assistant for Providing User Support in Machine Learning and Data-Mining (ESPRIT-LTR Program of the EU)
- FASTY – Faster Typing for Impaired Persons (IST-Program of the EU)
- SAFIRA – Supporting AFfective Interactions in Realtime Applications (IST-Program of the EU)
- Sol–EU–Net–Data Mining and Decision Support for Business Competitiveness: Solomon European Virtual Enterprise (IST Program of the EU)
- The Naturalness of Synthetic Speech (COST Program)
- SELECT – Strategies for European LE-Enhanced Communication Training (Language Engineering Program of the EU)
- EUROMAP II – European Opportunity Mapping Telematics – Language Engineering Program of the EU
- MOSART – Music Orchestration Systems in Algorithmic Research and Technology (IHP – Program of the EU)
- Member of the following Networks of Excellence of the EU: Compulog, Language and Speech, Machine Learning, AgentLink, ILPNet-II and NEuroNet (Austrian Managing Node).

* Information about AISB http://www.aisb.org.uk and contact can be made through: admin@aisb.org.uk

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Most of the technical reports from the Institute are available as PostScript and PDF files via:
www <http:33www.oefai.at/oefa/tr-online>

VII.3. UK AI Specialist Group

The British Computer Society (BCS) has a specialist group, now called the *Knowledge-Based Systems and Applied Artificial Intelligence Specialist Group*.*

Many readers will be familiar with the work of this active Group of the BCS. Orginally known as the BCS Expert Systems Specialist Group, this Specialist Group was founded in 1980 and covered rule-based expert systems. Research and development in this area has moved on in over two decades and to reflect the expansion of its coverage it is now called: *The Knowledge-based Systems and Applied Artificial Intelligence Specialist Group*. A recent account in the *Computer Bulletin* (Sept., 2001), a publication of the BCS, explains its new role and coverage; it informs us that:

> "That coverage now ranges from intelligent agents to natural language processing, knowledge management, knowledge representation, inference, reasoning, artificial intelligence languages and machine learning – including neural networks, genetic algorithms and data mining.
>
> 'A substantial proportion of the membership is from industry, and the group provides a valuable forum in which the academic and industrial communities can meet,' says chairman Max Bramer. 'The group covers technical advances and shows how this advanced technology is applied to business problems.'
>
> As part of its leading role in the field over the last two decades it has organised an annual series of international conferences since 1981, and since 1992 it has been a member of the European Co-ordinating Committee for Artificial Intelligence, which represents societies in over 25 countries.
>
> In line with its membership balance the group launched a series of workshops last year looking at applications of knowledge-based and intelligent systems in the new millennium.
>
> 'Given the large industry membership the workshops are a valuable forum for discussion, review and identifying new opportunities,' Max Bramer says. 'They can have a technology or applications emphasis. Members are encouraged to submit workshop proposals, including the aims and scope, names of potential participants and location suggestions.' Successful proposals get funding to minimise the cost to participants, plus help with publicity and the opportunity to print selected submissions in the group's quarterly journal, *Expert Update*.
>
> These are interesting times for the group. It is bidding to host a major world conference, the International Joint Conference on Artificial Intelligence, in Edinburgh in 2005. The significance of the bid is reflected in the fact that the conference was last held in the UK in the late 1960s.
>
> Another big departure for the group is the launch of a new annual competition, the BCS Prize for Progress Towards Machine Intelligence.
>
> 'We feel that this has the potential to grow into a high profile international showcase for some of the most exciting software and hardware developments in the world,' MaxBramer says."

* Further information about the group.
The Knowledge-Based Systems and Applied Artificial Intelligence Specialist Group is at www.bcs-sges.org, and can also be contacted via Max.Bramer@bcs.org.uk. Details of the new competition are at www.bcs-sges.org/miprize/. Workshop proposals can be submitted to Alun Preece at apreece@csd.abdn.ac.uk

VIII. SOFTWARE DANGERS

There is now considerably more awareness about computer safety and, in particular, concern about providing software products that could endanger people in the workplace.

Reports from the UK say that software companies could face criminal charges for selling products that endanger people in the workplace. An ongoing investigation is currently taking place under the aegis of the UK's Health and Safety Executive (HSE). The HSE is working with the government's Department of Trade and Industry on a potential amendment to the Health and Safety at Work Act 1974 which at present does not cover software suppliers that cause injuries at work because of a fault in their technology. Computing systems have come a long way from the days when software was simply another name for a computer programme that produced a result on a printer. Now software can control almost any system: animal, human or machine and, in consequence, cause enormous problems in the workplace if it contains faults.

The results of the current UK discussions will be examined before any formal HSE initiative materialises for a change in the law. Other countries worldwide face the same legal challenges and changes in their laws will also have to be carefully considered.

We are told that this issue has emerged because people realised during the preparation for the changes in software for the millennium that chaos could result in the manufacturing, healthcare transport and many other software reliant sectors. All are vulnerable to software bugs, however, at any time and so the liability of software companies needs to be ascertained. Until earlier visions of 'proven software' materialise all users of software need to be vigilant about the way in which it is used and the reliance to be placed on its performance and results.

IX. UN ROBOTICS SURVEY (2001)

IX.1. Summary

The United Nations Economic Commission for Europe released its *2001 World Robotics Survey (UNECE, 2001)** and indicated that 2000 was a record year for robot investment with an increase of 25%. It also reported that for the first part of 2001 it continued to boom in Europe but started to tumble in North America and Asia. The summary provided in this 360 page in-depth analysis asked and answered the following questions which will provide background information for those who are working in the field of automation and robotics:

* It should be noted that the survey was compiled in cooperation with the International Federation of Robotics and jointly published. *Robotica* is the official journal of the IFR.

- **How many robots are now working out there in industry?** Worldwide at least 750,000 units, of which 389,000 in Japan, 198,000 in the European Union and 90,000 in North America. In Europe, Germany is in the lead with 91,000 units, followed by Italy with 39,000, France with 21,000 and the United Kingdom with 12,000.
- **What are the forecasts for 2004?** Some 975,000 Worldwide of which 447,000 in Japan, 3000 in the European Union and 116,000 in North America.
- **How large were the robot investments in 2000?** 2000 was a record year with almost 100,000 new robots being installed worldwide, representing an increase of as much as 25% over 1999, says Jan Karlsson responsible for the publication. 47,000 robots were installed in Japan while in the European Union some new 30,000 units were added to the stock, compared with 13,000 units in North America.
- **And for the first half year of 2001? Has the recession hit the robot industry?** Yes and no. In Europe, robot investments continue to boom, showing an increase of 11% over the same period in 2000, while robot investments in North America fell by as much as 28% and by 10% in Asia, continues Jan Karlsson.
- **Why invest in robots?** In the last decade the performance of robots has increased radically while at the same time prices have been plummeting. A robot sold in 2000 would have cost less than a fifth of what a robot with the same performance would have cost in 1990. Profitability studies have shown that it is not unusual that robots have a pay-back period as short as 1–2 years.
- **And not hire people?** In Germany, for instance, the price of robots relative to labour costs have fallen from 100 in 1990 to 35 in 2000 and to less than 20 when taking into account the radically improved performance of robots. In North America, the relative price had dropped to 26 and to as low as 12 if quality improvements are taken into consideration. Falling robot prices, increasing labour costs and continuously improved technology are major driving forces which speak for continued massive robot investment in industry, concludes Jan Karlsson. Even in developing countries like Brazil, Mexico and China, robot investments are staring to take off at an impressive rate.
- **How many robots per employee in the manufacturing industry?** Almost 300 per 10,000 employees in Japan, 120 in Germany, 95 in Italy, about 80 in Sweden, 60 in France and about 50 in Spain, North America, Switzerland and Benelux (the figure for Japan includes all types of robots while for all the other countries only multipurpose industrial robots are included).
- **In the car industry?** In Italy and Germany there is almost 1 robot per 10 production workers.
- **Are we seeing any service robots in our homes?** Lawn mowing robots are about to have their commercial breakthrough while the market introduction of vacuum cleaning robots has been delayed until 2002/2003.
- **How are service robots for professional use doing?** Medical robots, underwater robots, surveillance robots, demolition robots and many other types of robots for carrying out a multitude of services are doing very well. A stock of some 10,000 units was estimated at end 2000. In the period 2001–2004 another 30,000 units are projected to be added to the stock.

IX.2. World market for industrial robots surged by 25% in 2000. . .

According to this annual survey, World Robotics 2001, which was published by the *United Nations Economic Commission for Europe (UNECE)* in cooperation with the *International Federation of Robotics (IFR)* the World market for industrial robots surged by 25% in 2000. This was ". . . mainly as a result of skyrocketing sales in Japan, the Republic of Korea and the European Union".

After two years of falling or stagnant sales, there was a sharp recovery in Japan in 2000. Sales of all types of industrial robots surged by 32% over 1999, reaching almost 47,000 units (see table I and figure 1).

After plummeting sales of robots in the Republic of Korea during the "Asian crises" in 1997 and 1998, sales had a robust recovery in 1999 and 2000, +70% and +95%, respectively. It should be noted, however, that robot figures for the Republic of Korea and Japan include dedicated industrial robots, which are not included in the statistics of most other countries.

In the European Union, sales of multipurpose industrial robots rose by 20% in 2000 to just under 30,000 units. The highest growth was recorded in Sweden with 56% over the 1999 level, followied by Spain with 39%.

Stagnated sales in the United States . . . Between 1995 and 2000, the robot market in the United States was booming every second year and, in the years in between, it was flat or falling. In 1995, 1997 and 1999, it increased by between 28% and 37%. By contrast, in 1996 and 1998, the market dropped by 5% and 13%, respectively, while in 2000 it was almost flat (+1%). However, the highest sale of multipurpose industrial robots, in their strict definition, ever recorded was in 2000 when it reached almost 13,000 units.

Europe and the United States are rapidly catching up with Japan. In the early 1990s, installations of multipurpose industrial robots in the European Union and the United States only amounted to about 20% and 7%, respectively, of Japan's installations of (all types of) industrial robots. By 1999, those shares had risen to 69% and 36%, respectively. In 2000, however, the corresponding shares had dropped to 63% and 28%, respectively, as a result of booming sales in Japan.

First half of 2001 – continued growth in Europe but plummeting sales in North America. Looking at the first half of 2001, the ECE/IFR quarterly survey on the order intake of industrial robots, which includes most of the world's largest companies, showed that the worldwide order intake decreased, bv 7%, compared with the same period in 2000. This figure, however, hides some major differences between regions.

While Europe still has an expanding robot market (11%), it is plummeting in North America (–28%), mainly because of falling demand from the electronics and telecommunication-equipment industry. In Asia the market is also fallinq, –10% in the first half of 2001. In the remaining part of the world, the robot market was almost flat (+2%).

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IX.3. Robots for professional use-installations 2000

Except for domestic robots (so far, mainly lawn-mowing robots) and entertainment robots, almost all service robots installed up to 2000 and inclusive are robots for professional use. The major application areas for professional robots are underwater robots, medical robots, demolition robots, mobile robot platforms for multiple use, laboratory robots, and cleaning robots.

Of the total number of service robots for professional use installed up to the end of 2000, underwater, robots with their 3,000 units accounted for 29%. Thereafter followed demolition robots with 22% and medical robots with 15%. Laboratory robots had a share of 10% while agriculture robots, mainly robot milking systems, made up 6%. Cleaning robots made up another 4% while the aggregate "all other" had a share of about 14%.

As the unit values differ very significantly between various application areas – from some hundreds of thousand of dollars for underwater robots and medical robots to a few thousands of dollars for laboratory robots or a few hundreds of dollars for domestic or entertainment robots – market data, expressed in terms of value in US dollars, might differ quite substantially from market data expressed in number of units. Underwater robots account for over 60% of the total estimated market value, this high share being a result of their high unit value.

IX.4. Service robots for personal and private use – installations up to end 2000

Service robots for personal and private use are recorded separately, as their unit value is only a fraction of that of the many types of service robots for professional use. They are also produced for a mass market with completely different marketing channels than those of service robots for professional use.

So far, service robots for personal and private use are mainly found in the areas of domestic (household) robots, which include vacuum cleaning and lawn-mowing robots, and entertainment robots, including toy and hobby robots. Sales of lawn-mowing robots have started to take off very strongly and should continue to see booming sales. The market potential is very large.

Vacuum cleaning robots were supposed to be introduced on the market at the end of 2000. The market introduction is now pushed forward to the first half of 2002. If the technology provides what it has promised, at a competitive price, and if there is a sufficient degree of consumer acceptance, then this can be a very large market with annual sales in the order of 100,000 units.

As for entertainment robots, the figure recorded here might significantly underestimate real sales. The merging technologies of PC and entertainment robots can become a very substantial business area in the near future.

IX.5. Projections for the period 2001–2004 – service robots for professional use

Turning to the projections for the period 2001–2004, the stock is forecast to increase by some 30,000 units, the largest increase being in small cleaning robots for professional use.

Other application areas with strong growth are medical robots with almost 5,000 new robots being added, underwater robots (3,000), surveillance and security robots (1,800), refuelling robots (1,100) and robotic systems for milking (1,000). These figures should, however, be seen rather as market potentials than actual sales forecasts.

IX.6. Projections for the period 2001–2004 – service robots for personal and private use

When vacuum cleaning robots are introduced on the market in the first half of 2002, sales could, provided the price is right, take off at such a rate that, by the year 2004, a couple of hundred thousand units or more could have been sold. This forecast is, however, very unsure.

Regarding lawn-mowing robots, a huge increase in sales (more than ten times) is forecast for the period 2001–2004. The market is very "promising" and these kinds of robots are rapidly gaining acceptance from customers. A projection of 40,000 units might very well be far too low. The market for entertainment robots is forecast at some 200,000 units, which also might be far too low.

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