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Book Reviews

COMPUTATIONAL INTELLIGENCE IN DESIGN AND MANUFACTURING, by Andrew Kusiak, Wiley, New York, 2000, xx + 535 pp., ISBN 0–471–34879–1 (hardback, £58.50).

The term "Computational Intelligence" is used to denote what is more usually termed *A.I.*, or at least a subset of it. Presumably the author has a (probably defensible) semantic objection to the more usual term. Most of the chapters of the book deal with aspects of design and manufacturing that are amenable to systematic treatment, and another three deal with topics of an essentially *A.I.* nature.

In his Preface and first chapter the author refers to the need for modern manufacturing industry, in its competitive environment, to be rapidly adaptable and, as he puts it, agile. He argues that this requires overall computer control, and he particularly stresses integration of all aspects. He sees product design integrated with the planning of production facilities, and with the many other aspects to be considered such as liaisons with suppliers, distribution, marketing and customer relations. An enterprise is not sufficiently agile if, for example, it finalises the design of a product before starting to plan how to make it.

In the integrated computerised management system that is visualised, the necessary data processing and decision-making are likely to be intractable by algorithmic means and this is where the heuristics and other features of an *A.I.* approach are needed. This is implied by the reference to computational intelligence.

There is some correspondence to the representation by Beer[1,2] of an enterprise as a viable system with the human nervous system as a paradigm. This is without special reference to computerisation, but there is a similar emphasis on integration. It is also interesting that heuristics were applied to an aspect of production planning in a very early paper[3] in the *A.I.* literature.

However, despite the enthusiastic advocacy of integrated operation based on *A.I.* techniques, the subsequent treatment in the book is disappointing in this respect. Of the three chapters devoted to essentially *A.I.* topics, one is on Knowledge-Based Systems, one on Neural Networks and one on Data Mining. In each of these the respective topic is developed in the management context, fairly comprehensively on the whole though at least one weak spot is the treatment of "resolution" as a strategy for an inference engine on page 38. However, the treatments do not support the claim of an integrated approach based on *A.I.* The chapter on Neural Nets, for example, ends with description of an application to fault diagnosis, which is undoubtedly valid and useful but unrelated to overall system integration.

The book is written in textbook style, with exercises for the reader at the end of each chapter (without provision of answers). It is based on material taught by the author and on his experience in consultancy. The criticism levelled here, that he has not fully achieved his vision of full integration through machine intelligence, is tempered by the reflection that his students are encouraged and equipped to work towards it.

Apart from the issue of full integration, the book has a wealth of material on systematic approaches to production planning, including choice of equipment, factory floor and warehouse layout, various aspects of scheduling including the assembly-line balancing problem, and supplier evaluation. One chapter has the enigmatic title of "Kanban systems", where "Kanban" is a Japanese word meaning "visual record" and is a way of supporting the just-in-time production concept.

Much attention is given to "agility", or the ability of a company to supply a variety of products quickly and at low cost, an aspect that is readily illustrated by reference to car production and that requires choices between early and late differentiation in production. Here, aspects of the emphasis on integration can be seen in a practical context since the required flexibility can be allowed for in design of the product as well as in the arrangements for its manufacture, and considerations of marketing and customer relations also enter.

Allied to the matter of integration of design and manufacture, there is an interesting attempt in the third chapter to treat aspects of product design by a formal representation similar to that used in the systematic methods of production planning. This is at an early stage and seems to be an area pioneered by the author of the book.

There is certainly a great deal of useful material here, both on account of its immediate usefulness and for its pointers to future developments.

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MULTIPLE VIEW GEOMETRY IN COMPUTER VISION, by Richard Hartley and Andrew Zisserman, Cambridge University Press, Cambridge, 2000, xvi + 607 pp., ISBN 0–521–62304–9 (hardback, £60.00).

Recent developments in the more speculative area of robotics, as described by Brooks[1] and by Pfeifer and Scheier[2], with implications for theories of biological processing, have tended to de-emphasise the rigorous geometric analysis of images. An earlier view of biological processing, particularly associated with David Marr, assumed rather complete reconstruction of the visible environment at an early stage of processing. It is not difficult to show that something other than this is needed in an animal or a robot operating in real-time in a non-static environment, and these workers describe schemes having relatively direct coupling between sensory inputs and effector mechanisms.

The new methods have been successful in allowing robots to drive vehicles, deliver mail in offices, collect empty drinks cans, and to perform various other useful tasks. This certainly does not mean that rigorous geometric analysis plays no part in biological processing, nor that it has no value in robotics. There are important

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areas of activity in which it cannot be assumed, to quote Brooks,[1] that "the world is its own best model" for all purposes. The versatility of biological processing is summed up by the quotation from Fischler and Firschein.[3]

> "I suspect that the representational system with which we think, if that's the right way to describe it, is so rich that if you think up any form of symbolism at all, it probably plays some role in thinking."

Given that rigorous geometric analysis is wanted, it is difficult to imagine how it could be treated more comprehensively than in the book being reviewed, which will certainly become a standard work of reference. As the title indicates, it is particularly concerned with interpretation of multiple views. The coverage is indicated by the following two paragraphs on the opening page:

"A basic problem in computer vision is to understand the structure of a real world scene given several images of it. Techniques used in the book for solving this are taken from projective geometry and photogrammetry. The distinctive flavour here, though, is that the approach is uncalibrated – it is not necessary to know or to have to compute the camera's internal parameters before getting an answer to the problem. Recent major developments in the theory and practice of scene reconstruction are described in detail in a unified framework.

"The book covers the geometric principles and their algebraic representation in terms of camera projection matrices, the fundamental matrix and the trifocal tensor. The theory and methods of computation of these entities is discussed with real examples, as is their use in the reconstruction of scenes from multiple images. The authors provide comprehensive background material, so a reader familiar with linear algebra and basic numerical methods will be able to understand the projective geometry and estimation algorithms presented, and implement the algorithms directly from the book."

The treatment is the culmination of studies over the whole history of *AI* and the comment is made in a Foreword that in the nineteen-sixties the difficulty of making a computer see was enormously underestimated. It is acknowledged that even now it is impossible to be sure that this work is a step in the right direction in pursuit of this "holy grail", but it is certainly a major contribution that no one concerned with computer vision can afford to ignore.

The material has been ordered in textbook fashion, starting with projection in two dimensions before extending it to three, and so on. The presentation is supplemented by high-quality figures, some of them line drawings or graphs illustrating the theory, and others showing images as processed. In five appendices, special mathematical aspects are treated, including an introduction to the use of tensors, and a review of necessary statistical theory. Algorithms that can be implemented on computers are also set out in detail here, though not actually in a programming language. There can be no doubt that this is an important and well-prepared book.

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2. Rolf Pfeifer and Christian Scheier, *Understanding Intelligence* (MIT Press, Cambridge, Mass., 1999).
3. M.A. Fischler and O. Firschein, *Intelligence: The Eye, the Brain and the Computer* (Addison Wesley, Reading, Mass, 1987), p. 308.

ROBO SAPIENS: EVOLUTION OF A NEW SPECIES, by Peter Menzel and Faith D'Aluisio, Material World, Napa, California and MIT Press, Cambridge, Mass., 2000, 240 pp., ISBN 0–262–13382–2 (hardback, £19.95).

This is a large-format glossy production, lavishly provided with dramatic colour photographs, that will no doubt be a welcome Christmas present to many budding scientists and a conversation piece on coffee tables and in corporate reception areas. The authors have travelled widely, in Europe, USA and Japan, to obtain the pictures and to interview robotics pioneers. Some of the pictures have little connection with serious robotics, and show gadgets for creating effects on the stage or for publicity. A number show "face robots" devised because of the current interest in having machines show emotion, and lending themselves to striking pictures including the one on the front cover of the book. On the other hand, others of them do show important developments, along with accounts of the visits of the authors to the laboratories and their discussions to obtain the views and motivations of the robot developers.

The number of sites that were visited is over one hundred, chosen on account of references in the literature, recommendations of other workers, and personal impressions. There is no claim to exhaustive coverage, but a survey on this scale cannot fail to be valuable. Despite the glossy production and its suggestion of sensationalism, the descriptions of what was demonstrated at the sites are sound and informative. In a final section on "Methodology" the second-named author explains how they went about collecting the material and there are also technical details of cameras and lighting used to obtain the magnificent pictures.

The accounts are grouped under six headings. The first section, called "Electric dreams" is particularly stimulating and controversial and introduces the enigmatic title of the book. More will be said about it below. The second section has the title "Robo sapiens" and contains descriptions of robots with some claim to be humanoid, of which the most impressive by far is the Honda P3 walking robot, developed in secret over ten years and at enormous expense by the Honda company. The advantages of having a robot look like a human are discussed, with particular reference to the "Cog" device of Rodney Brooks at MIT. Among the projects of the leg laboratory of MIT there is one on prosthetic devices for amputees, conducted by a researcher who lost parts of his limbs due to frostbite suffered on nearby Mount Washington.

A third section has the title "Biological" with accounts of a remarkable number of robots imitating creatures including snakes, lizards, crabs and cockroaches. These have various motivations, including that of gaining understanding of the biological prototype (an aim that is also mentioned in connection with work on legged locomotion and on social interactions). In one project an artificial cockroach has been built that models the original in great detail. A crab-like robot is useful for walking underwater, like the real crab, and clearing mines. Then a fourth section is on "Remote possibilites" with descriptions of planetary rovers, and also robots to assist astronauts with external repairs to their crafts. In an emergency, a robot can be ready much more quickly than the human to go out into space. A rough-terrain device of the planetary-rover type is shown that has been developed to search in rubble for earthquake victims.

The fifth and sixth sections are on "Work mates" and "Serious fun". The former includes robots used in surgery, as well as helpers for disabled people, and other domestic robots, and an automatic vacuum cleaner that continuously collects hair from the floor of a barber's shop. One of the items in the latter section refers to the "Robot Wars" type of entertainment.

The controversial part of the book is the section on "Electric dreams" where various speculations about the future of robotics are compared. The predictions are mostly remarkably gloomy. There is a reminder that in the play by Karel Čapek that introduced the word "robot" the robots finally rose in revolt, and a number of more recent writers have visualised robotic take-over. These include Marvin Minsky as well as Professor Kevin Warwick of Reading University. Warwick seems to have somewhat modified

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his original stand, and now visualises the demise of humans as we know them and their replacement by hybrids that are part human and part robot, resulting from intimate coupling of the biological nervous systems to the electronics.

A more benign view is attributed to Hans Moravec of Carnegie Mellon, who sees robots as the saviours of mankind when the planet becomes uninhabitable Robots are not visualised as rescuing people bodily, but as preserving genetic information that makes humans effectively immortal and able to re-emerge where conditions may be favourable.

These suggestions of hybrids are the basis of the enigmatic title of the book, and in a Glossary there is a definition:

> **Robo sapiens**. A hybrid species of human and robot with intelligence vastly superior to that of purely biological mankind; will begin to emerge in the twenty-first century.

All this is, of course, controversial, to put it mildly. A more immediate and believable threat is attributed to the inappropriately-named Bill Joy of Sun Microsystems, who sees the ready availability of robots as offering devastating opportunities to terrorists and other mischiefmakers.

A few of the applications featured in the book have military connections. There is the crablike mineclearing robot, and a model plane suitable for surveillance (or spying, depending on the point of view), and a remotely controlled gun with associated remote surveillance for law enforcement. There is no mention of smart weapons of the cruise missile kind, which represent a development, at a government level, of the kind of danger referred to by Bill Joy, and a total rejection of the First Law of Robotic Behaviour proposed by Isaac Asimov, to the effect that no robot should harm a human being.

My own feeling is that the main threat from robots is the enormous scope they offer for the indulgence of man's inhumanity to man, a threat that is tangible and immediate and irrespective of esoteric questions like the possibility (and the meaning) of machine consciousness. In any case, this book gives a stimulating review of the issues as well as of the current state of the art in advanced robotics and is an attractive art work in itself.

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WORLD ROBOTICS 1999 – STATISTICS, MARKET ANALYSIS, CASE STUDIES AND PROFITABILITY OF ROBOT INVESTMENT, co-authored by the International Federation of Robotics (IFR) with the United Nations Economics Commission for Europe (UN/ECE) United Nations, 1999, ix + 298 pp., ISBN 92–1–101007–1; ISSN 1020–1076, UN/ECE, Geneva, Switzerland.

One of the problems about compiling and publishing statistics concerning robotics and automation is that they will always appear dated, even, as in this case, in an annual publication produced jointly by the United Nations and the International Federation of Robotics (IFR). The data follow the pattern of presentation of previous years and for comparison purposes it would be useful to refer to the review given in this journal of the 1998 publication (see *Robotica* **18**, Part 1, 90–1 (2000).

It is claimed, and with some justification, that this is "the world's only publication which presents comprehensive global statistics on industrial robots as well as on service robots, in uniform tables allowing consistent country comparisons". This may, of course, be true but the tables of data are necessarily based on statistics that end in 1998. Anyone wanting immediate information about individual countries and current trends has to look elsewhere. The most likely sources are those that are quarterly-based and record market movements of this sector.

With this proviso it is extremely useful to have detailed statistical data for some 20 countries broken down by experts into application areas, industrial branches, types of robots and by other techno-variables.

For the researcher having data about robot densities and other statistical information is important and saves a great deal of extra analysis of the raw data provided by many countries. Market-watchers will be delighted, in being provided with data on production, exports and imports of not all, but certainly the main global leaders.

The only way of getting an immediate analysis is to have the whole database online so that it is available in an updated form to reflect the current situation across the world. Even so, a yearly based analysis is still invaluable for comparison purposes.

Readers should note, however, that although the actual data is available to 1998, developments in 1999 are analyzed in some detail and forecast up to 2002 are included. The publication also devotes space for Case Histories which is a section concerning actual robot installations and the scenario of their Case Histories which is a section concerning actual robot installations and the scenario of their costings, production and employment structures as well as their overall profitability. It was encouraging to read the paragraph in the Foreword, written by the compilers which tells us that:

> "Total accumulated yearly sales of robots since the beginning of the 1970s amounted at the end of 1998 to over one million units of which about 720,000 are estimated to be in operational use. Driven by advances in semiconductor and computer technologies and the vast potential for new applications, not only in industry but also in construction and in services (hotel, health care, laboratories, surgery etc.), there was every reason to believe that robotics will continue to expand rapidly and play an increasingly important role in production rationalization".

This is a fitting prologue to the five sections which are comprehensively covered. Introduction to the detailed coverage, which includes the all-important definitions and classifications robots, types, industrial branches and application areas: World-wide Diffusion; Structure of the Diffusion; Forecasts (1999–2002); Profitability-Analysis of Case Studies: Annex A and B provide data about industrial robots-sales, stock-shipments etc.

A revealing short Editorial by General Marvin Runyon (US Postal Service) provides a short account of "robotics as the future of the US Postal Service", highlights the introduction of a "Robot Compatible Environment" into their operations. This brings a sense of reality to the statistics provided later because it actually involves humans, in particular, the impact of the widespread introduction of robots on a workforce.

We have been told so many times over the last decade that "we will all inevitably be affected by the 'Robotics Revolution' when machines will perform the work and human employees will service the machines". This annual global statement of the continued advance of robot technology and its implementation worldwide merely confirms with supporting data that it is continuing at a great pace.

It is also useful for readers to know the sources of the data provided and where it concerns individual robotic systems, the basis for both classification and device definitions. So many countries have in the past 'sanitised' their data on robots that it became almost impossible to give credence to the resulting statistical tables. This 'yearbook', we are told unequivocally, is based on data collected and transmitted by more than 20 national industrial robot association. Compiled by the UNO and the IFR it should give us a reliable insight into what is happening in world robotics.

It is obviously an essential text for anyone working in the field, whether scientists or business entrepreneur. Although as has been suggested, it contains mainly statistical tables, the

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comment and explanatory texts are readable and informative. There is no doubt that the presentation improves yearly. It measures up to the compilers claim that it is a 'unique yearbook' and is 'almost encyclopaedic in its scope'.

This publication is an authoritative and important reference work in its own right, particularly for those of us who need to know about, not only the comparatively recent statistics in this field, but who also wish to build-up a year-by-year reference database.

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