IAP Symposium
Autumn 2000

21st Century Computing

Friday 20th October 2000

Frontier Technologies

The theme for this year was 21st Century Computing — frontier technologies and where they might take us during the course of the next few decades.

Our international panel of distinguished researchers took delegates on a grand tour of the most intriguing questions in 21st Century Informatics:

1. Given that the conscious mind depends upon the architecture of the brain, could we engineer a machine that has both imagination and emotions, and would such a machine be conscious?
2. Soon after 2010, when the CMOS endpoint repeals Moore's Law, could nanotechnology and coherent quantum devices satisfy our relentless demand for more computational power?
3. Will teleportation (nonlocality) be harnessed to devise new types of quantum logic gate, and might quantum devices be fabricated out of the very stuff of life itself – DNA?
4. Should we redesign the human-computer interface to accommodate the environmentally and biologically impaired eg soldiers, astronauts, the elderly, and disabled people?
5. Are we bobbing around in a flood of data from which we abstract too little useful information and, worse still, are crude data reduction methods misinforming public policy?

PRESENTER BIOGRAPHY: Prof Igor Aleksander FREng

Born in Zagreb, Yugoslavia, educated in Italy and South Africa, Igor Aleksander came to the UK in the late 50s. He first joined STC as a graduate engineer and then entered the academic world as Lecturer (at Queen Mary College, London, 1961), Reader in Electronics (University of Kent, 1968), Professor of Electronics (Brunel University, 1974), Professor of the Management of Information Technology (Imperial College, 1984), Head of Electrical Engineering and Gabor Professor of Neural Systems Engineering (Imperial College, 1988), Pro-Rector (External Relations) (Imperial College, 1997).

He has researched Artificial Intelligence, Neural Networks and IT Management. His recent work lies in the area of Artificial Visual Awareness which arises from a collaboration with the California Institute of Technology. He has published over 200 papers in these fields and 12 books including "Impossible minds: my neurons my consciousness" published by Imperial College Press 1996 and 'Machines with Imagination' Weidenfeld and Nicolson (out May 2000). In the 1980s he was responsible for the design of the world's first neural pattern recognition system (the WISARD, commercialised by CRS, Wokingham), and in 1991 he and his students designed the MAGNUS neurocomputational system (now commercialised by NTS as Neural Representation Modeller). He has consulted for many computer manufacturers and IT providers. In 1988 he was elected to the Fellowship of the Royal Academy of Engineering.

He likes talking to general audiences about his work and sometimes appears in TV and radio programmes, e.g. Horizon, The Late Show, Tomorrow's World, Equinox, Newsnight, Wide World, Eureka, The Big Bang, The Afternoon Shift, Start the Week, Inspiration, Desert Island Discs, In Our Time, The Network, Letter to the Future. He enjoys Jazz and Classical music, used to play the drums, likes cooking and not doing very much in Greek and French villages.

PRESENTATION ABSTRACT: Brain Inspired Computing - the new AI?

The year 2000 marks the 50th year since the publication of Claude Shannon's paper on computer chess. While Deep Blue has now beaten Kasparov, and some pretty smart computer programs grace our screens, Artificial Intelligence, by and large, has failed to achieve one of its own ambitions: to explain how the human brain manages to generate a conscious mind. The fact that a programmer causes

machines to be smart when the brain does it for itself has made life scientists and philosophers alike sceptical of the AI approach.

I shall show that things are changing so that the next 50 years of AI will be about understanding and modelling the intricate architecture of the brain and discovering how a conscious mind depends on the 'engineering' of the awesome machine we call the brain. I shall also suggest reasons as to why this will lead to a new and more competent style of computational products.

EXHIBITION: The Neural Representation Modeller

This is Meccano-like software that can be used to create models of parts of the brain. We shall demonstrate recent work which is currently being pursued on modelling visual awareness: that is, what might be the mechanisms of a human visual system that lead us to perceive and imagine objects? What this virtual 'brain' perceives is decoded so as to be displayed on a screen.

PRESENTER BIOGRAPHY: Prof Susan A Greenfield CBE

Susan Greenfield was an undergraduate at St Hilda's College, Oxford and subsequently took a DPhil in the University Department of Pharmacology. She has held fellowships in the Department of Physiology, Oxford, the College de France in Paris, and NYU Medical Center in New York. In 1985 she was appointed Fellow and Tutor in Medicine, Lincoln College, and, in 1996 gained the title of Professor of Pharmacology at Oxford, where she heads a multi-disciplinary group studying non-classical mechanisms underlying neurodegenerative disorders. In 1998 she became Director of the Royal Institution – the first woman to hold this office in the Royal Institution's 200 year history. She received the Michael Faraday medal from the Royal Society for making the most significant contribution in 1998 to the public understanding of science. Susan has been awarded twelve Honorary Degrees, and received the CBE in this year's New Year's Honours List.

In 1994 she became the first woman to be invited to give a Royal Institution Christmas Lecture and has subsequently made a wide range of TV and radio broadcasts. (She is currently preparing a major six-part series on the brain and mind, to be broadcast on BBC2 in June 2000.) In 1999 she gave a consultative seminar to the Prime Minister, Tony Blair, at Downing Street, and, also in 1999, was invited to give the Dimbleby Lecture. Susan was voted 122nd out of 300 of the most powerful people in the Observer's 'Power List' in October 1999. She has written over 150 scientific publications.

PRESENTATION ABSTRACT: The Uniqueness of the Biological Brain

"You're not thinking, you're just being logical". This admonition by Neils Bohr to one of his students might apply to the big difference between biological brains and computers. Moreover, virtually all brain processes are chemically mediated, bringing an additional qualitative dimension to the digital processing that usually characterises neuron electrical activity. We know that emotions can be influenced differentially by these different chemicals, hence not only must the chemicals themselves be important but, the actual subjective 'feel' of emotions is vital too. But, very little emphasis is placed by computational models on emotions: instead, learning and memory are at a premium. Yet artificial systems already outstrip us in learning and memory skills, hence they cannot be the quintessence of consciousness.

Even if a computer were conscious, it is unlikely to elucidate how the brain generates consciousness. After all, if the critical factor was already known, then one wouldn't need to experiment any further, and if the feature was not known, then the artificial brain would be inviolate since it would have the same ethical claims, as a pain sensing system, as its biological counterpart.

PRESENTER BIOGRAPHY: Prof Anthony J G Hey FIEE FBCS

Tony Hey completed a Doctorate in Theoretical Physics at Oxford and spent time as a post-doc at Caltech in Pasadena and CERN in Geneva. After beginning his academic career in the Physics Department at Southampton, his interests in parallel computing led to a move to the Department of Electronics and Computer Science (ECS) as Professor of Computation in 1985. During his time in ECS he founded the IT Innovation Centre and led the Parallel and Distributed Computing Research Group. He became Head of Department in 1994 and became Dean of Engineering in 1999.

Tony Hey is a member of the EPSRC's Technology Opportunities Panel and is European Editor for the journal 'Concurrency: Practice and Experience'. His research interests in parallel computing now embrace the GRID, with a particular emphasis on the problem of reliable performance prediction. He also has a research interest in quantum computing and in the development of scalable coherent quantum technologies. He is co-author of two popular books on science and a graduate level text on 'Gauge Theories'. He also edited 'The Feynman Lectures on Computation' and a collection of articles and re-prints entitled 'Feynman and Computation'.

PRESENTATION ABSTRACT: The Future of Computing, Moore's Law and Beyond

The talk will begin with a brief survey of both the technology and application drivers for the development of computing in the next decade. Moore's Law will continue to hold for the next ten years, give or take a few, and we will see the development of a pervasive computing environment with billions of intelligent devices connected to a high speed network delivering millions of services. The emergence of data and information GRIDs for global 'e-science' will help direct the evolution of the Internet.

What happens when and if Moore's Law ceases to hold? Nanotechnology and coherent quantum devices based on ion traps, superconducting Josephson Junctions or quantum dots may provide an answer.

PRESENTER BIOGRAPHY: Dr Colin P Williams

Dr. Colin P. Williams is a Principal Scientist and Manager of the Quantum Computing Technologies Group at the NASA Jet Propulsion Laboratory, California Institute of Technology. He is also an Associate Professor in the Computer Science Department, Stanford University. He obtained his Ph.D. in Artificial Intelligence in 1989 from the University of Edinburgh, an M.Sc. in Atmospheric Physics from Imperial College, University of London, and a B.Sc (Hons.) in Mathematical Physics from the University of Nottingham. From 1983-85 Colin was a Research Assistant to Prof. Stephen Hawking, at Cambridge University.

Colin's research has spanned all aspects of the physics/computer science connection. At Edinburgh he developed qualitative physics for commonsense reasoning, at Xerox PARC he invented the theory of computational phase transitions, and at JPL he has made several original contributions to quantum computing, quantum lithography and quantum sensors. His most recent interests have been in teleportation and quantum communication.

PRESENTATION ABSTRACT: Quantum Teleportation, a New Frontier for Computer Science

While teleportation has been the preferred means of moving action heroes around the Universe for the better part of four decades, until recently, most people regarded teleportation as little more than science fiction. However, in this talk I describe how teleportation of quantum information can really be done! I explain the theoretical principles upon which quantum teleportation depends, and describe how it can even be implemented experimentally. I discuss the issues that arise when teleporting larger objects such as molecules, and viruses.

I then describe how the ability to teleport quantum information around the universe can be harnessed to devise new types of quantum logic gates that can be connected together to perform arbitrary quantum computations. Thus quantum teleportation is truly a new, and rather surprising, frontier for computer science.

PRESENTER BIOGRAPHY: Prof Alan F Newell FRSE

Professor Newell has been researching into computer systems to assist elderly and disabled people for thirty years, and in 1995 was awarded the Lloyd of Kilgerran Prize from the Foundation for Science and Technology for this research. He is currently Head of the Applied Computing Department of Dundee University, which was awarded a top grade of 5 in the 1996 Research Assessment Exercise for UK Universities. His Department is one of the major research institutes in the world researching into computer systems for people with disabilities and holds research contracts to the value of 1.7M.

A number of software systems developed by his group have been marketed including the predictive word processors, PAL and Predictability, and conversational systems for non-speaking people such as Talk:About, and Script Talker. Professor Newell is a Fellow of the Royal Society of Edinburgh, the British Computer Society, the Institution of Electrical Engineers, and an Honorary Fellow of the Royal College of Speech and Language Therapists.

PRESENTATION ABSTRACT: Designing the Human-Computer Interface for Everybody

Communications and Information Technology currently offers very little support to older and disabled people in their daily life. There are, however, increasing legal obligations for C & IT systems to be accessible to people with disabilities and, unless the rapidly increasing numbers of older people benefit from advances in C & IT, it may not be economically possible to maintain an appropriate quality of life for them or their carers.

In addition, the concept of Ordinary and Extra-Ordinary HCI draws parallels between extra-ordinary (disabled) people operating in ordinary environments, and able-bodied (ordinary) people operating in extra-ordinary (high work load, environmentally unfriendly) situations. A soldier on a battle-field or an astronaut, or even the user of a mobile telephone, can be seriously handicapped by the environment in which they have to operate. These users may have as little useful functionality as a severely disabled person, and similar techniques can enhance the reliability of human-computer interaction in all these situations.

Raising the profile of research and development of C & IT interfaces for people with disabilities will not only increase market share, but also produce better interface solutions for everyone.

PRESENTER BIOGRAPHY: Dr Mahes Visvalingam

Mahes Visvalingam's use of computers began in 1971 while she was a PhD student at the University of Hull on a Commonwealth Scholarship. While she was a Research Fellow in the Census Research Unit of the University of Durham (1974 -1979), she originated the signed chi-square measure (Xs) for mapping, and co-authored the innovative People in Britain – a census atlas (HMSO, 1980). She continued her research interests in an honorary capacity at the University of Hull (1979 – 1985) where she investigated the utility of Xs as a social indicator, founded the multidisciplinary Cartographic Information Systems Research Group (CISRG) in 1985 and established research collaboration with the Ordnance Survey (GB) on Digital Topographic Mapping.

Mahes became a Lecturer in Computer Science in the University of Hull in 1986, where she is now a Reader in Digital Cartography. Her research interests include spatial reasoning, spatial data modelling, graphic abstraction and visual cognition. She is particularly interested in algorithms for emulating the skilled art of line generalisation and of artistic sketching of terrain. She has played an active part within the International Cartographic Association and the British Cartographic Society (BCS).

PRESENTATION ABSTRACT: Data Rich, Information Poor

The allocation of ear-marked public funds amongst administrative areas is driven by indicators of local conditions, derived from large detailed volumes of government-collected data. This talk will discuss the problems involved in the computation of social indicators, focusing on primitive measures, such as the widely used but potentially misleading ratio indicators.

Despite some 40 years of research on social indicators in data-rich nations, boasting the latest advances in technology, the state-of-the-art of information abstraction remains poor. Yet, public funding is becoming increasingly reliant on a medley of performance indicators. Members of the public could collaborate over the Internet in the evaluation, even if not the design, of indicators.

This is an opportune time since the imminent 2001 population census is likely to instigate the computation of fresh social indicators for use over this decade.

EXHIBITION: Art in Scientific Visualisation of Terrain Data

Now that the challenge of photorealistic rendering has been achieved, researchers have started to focus on the even more difficult problem of non-photorealistic rendering. This has been the quest of Digital Cartography since its very beginnings. The theme of the exhibition focuses on an original thread of research, started in the early 1990s at the University of Hull. The poster exhibition includes the background to the research, samples of recently published computer-drawn sketches, computer demonstrations of algorithms for line generalisation and line segmentation and an animated exploration of terrain in sketch form. The exhibition will also include examples of innovative maps contributed by others and samples of published journal papers and CISRG Discussion Papers.

PRESENTER BIOGRAPHY: Dr Peter Marcer BCS Cybernetic Machine Group

EXHIBITION (ONLY): Quantum Holographic Face Recognition System