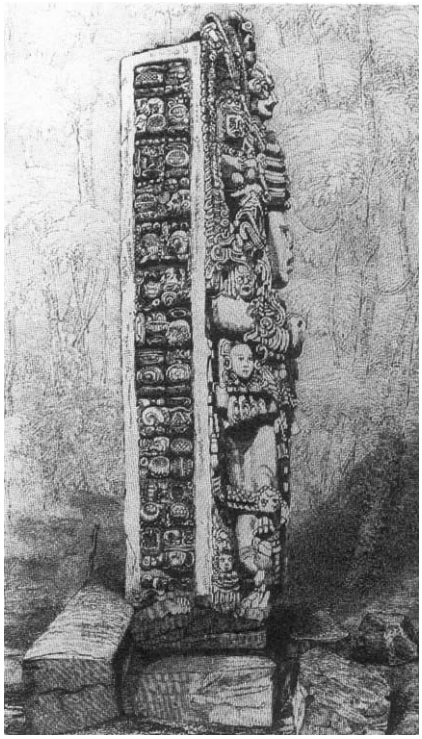
ley and J. Eric S. Thompson were caught in a conceptual straitjacket, believing that Maya society was a peaceful theocracy ruled by a benevolent priesthood. This intellectual élite's apparent lack of interest in recording real or idealized history in favour of esoteric and mythological events made Maya civilization suspiciously unique.

Caught between admiration for Thompson's many scholarly achievements and a dislike of his often pedantic style, Coe nevertheless blames this forceful personality for almost singlehandedly blocking the decipherment for half a century. We see how those who dared to espouse a linguistic interpretation were buried under Thompson's bitingly dismissive rejoinders and vast erudition. Consequently, by 1950 not one named Maya ruler or city was known, and the mass of non-calendrical inscriptions were no better understood than they had been 50 years earlier.

But in 1952, Coe's hero and Thompson's most formidable adversary appeared in the form of the Russian academician Yuri Knorosov. He published convincing evidence that the principles of the Maya script were the same as for the other hieroglyphic systems. Knorosov showed that individual hieroglyphs could at times be phonetic and at other times represent a morpheme (the smallest unit of meaning); that phonetic signs could lessen textual ambiguity; and that glyphs could be inverted for calligraphical reasons. Thompson's uncharitable reaction was to dismiss the breakthrough as nothing less than a Marxist hoax. As Coe perceptively remarks, however, the depth of Thompson's antagonism may well have been due to his suspicion that Knorosov was right.

What Knorosov accomplished for the nature of the Maya script, Tatiana Proskouriakoff achieved for its content. In 1960 she showed that monumental inscriptions recorded history, not astronomy or religion, and that figures graven onto stelae were men and women not gods. By cutting the Gordian knot of Maya epigraphy, Proskouriakoff revealed a decidedly violent world of dynastic rivalry, royal marriages and an astronomically controlled complex of sacrifice and ritual bloodletting.

Not unexpectedly, Thompson's death in 1975 opened the floodgate to new advances. At a series of meetings in the Maya city of Palenque, brainstorming sessions of a new generation of Mayanists resulted in their surmising that if inscriptions reflected Maya language then they should also display the same syntactical structure. Following this line of argument, Linda Schele and Peter Mathews formulated the dynastic history of Palenque by reconstructing the life stories of six successive rulers. There



Cryptic stones — 'Stela A' in Copán, Honduras, as drawn by F. Catherwood, the artist on the expeditions of the American lawyer J. L. Stephens (1805–1852); it was Stephens who first brought the Maya civilization to world attention.

followed an encounter between Schele and a child prodigy named David Stuart, who in eight hours read an inscription that had taken his mentor and others some five years to decipher.

By the mid-1980s, despite disbelieving Mexican scholars and antagonistic North American archaeologists, progress continued apace. The Maya script was finally revealed as being logographic, largely phonetic in content, characterized by the principles of polyvalence (when a single sign has multiple sound values and when a sound is symbolized by more than one sign) and homophony (when multiple signs have the same sound value), and evidently written in a form of the Maya Cholan language family. These breakthroughs also revealed unsuspected details of Maya life, such as the royal status of Maya scribes, a penchant for naming ceramics and temples alike, and the belief in an individual's animal spirit-familiar. The wheel had turned full circle and the Maya were once more speaking for themselves.

Coe has written that rare book — a masterpiece that transcends the boundaries between academic and popular writing. It is a compulsive account of one of the greatest intellectual adventures of the twentieth century. □

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Network visions

Terrence Sejnowski

Neural Networks for Perception. Vol. 1: Human and Machine Perception. Vol. 2: Computation, Learning and Architectures. Edited by Harry Wechsler. *Academic: 1991. Pp. 520/363. $59.95, £39.50/$49.95, £33.*

ON the morning of 6 October 1991, a neural network drove a van 35 km along Route 28 north of Pittsburgh, setting a distance record for an autonomous land vehicle. The 'eye' of the network was a camera providing a 30×32-pixel view of the road ahead, with the output controlling the steering. The network had previously been trained for 5 minutes by a human driving along the road; then the network took control and proceeded to steer the van along new roadway at 90 km per hour (the maximum speed of the van). Behind all of this was Dean Pomerleau, then a graduate student in the Department of Computer Science at Carnegie-Mellon University, who used a network with only four hidden units between the visual input and the steering output.

Imagine sometime in the future writing a cheque at a supermarket counter; in the time taken to sweep it through an opening, the bank and account codes are read off the cheque. This is accomplished by a single analog VLSI (very large scale integration) chip, about the size of a thumbnail, which consists of a primitive 'retina' that detects the characters flying by, a 'shifter' that aligns the characters, and a 'cortex' that categorizes them. This development is about to become a reality as Synaptics, a small company in San Jose, California, founded by Federico Faggin and Carver Mead, starts to market its first commercial product. Neural networks are under intense investigation as an engineering approach to difficult problems in vision and as a scientific tool for exploring questions about biological vision. *Neural Networks for Perception* is a two-volume sampler with 37 chapters on recent research in this area.

Consider visual textures. B. Julesz, who pioneered the study of texture discrimination 30 years ago, and D. Williams have a chapter on the ability of humans to segregate textured areas on the basis of differences in the texture elements, such as 'T' and 'L'. J. Malik and P. Perona contribute a chapter showing how a network of nonlinear filters similar to the broadly tuned simple and complex cells found in the early stages of processing in the visual cortex

can account for many of these psychophysical observations. Their insight is that visual cues in early vision (brightness, motion, stereo disparity, colour, texture perception) are based on a redundant multi-resolution, multi-orientation representation of the image, rather than on discrete tokens such as textons, brightness edges or zero crossings as suggested by Julesz, D. Marr and others. But, as pointed out by Williams and Julesz, these models do not adequately account for the perceptual asymmetries observed with some texture pairs when figure and ground are reversed. At higher levels of visual processing, such as form recognition, similar principles may apply. A few global features extracted from a large training database, such as those learned by Pomerleau's driving network, outperform much larger systems using hand-crafted local features.

Several chapters consider the problem of how to develop a large-scale perceptual system from special-purpose heterogeneous networks. Oja explores the use of unsupervised, self-organizing maps to extract relevant features from the input stream. The general problem of how to cascade unsupervised learning in a sequence of visual maps remains an open question. Finkel, Reeke and Edelman study occlusion. They show that a distributed, interactive system, designed along the lines of the visual cortex, can segment images such as the Kanizsa triangle, in which the contours are defined subjectively. Ballard and Whitehead examine simple sequential visual behaviours, such as block manipulation. They explore reinforcement learning, a biologically plausible model of learning based on predicted reward rather than external supervision, and come to the surprising conclusion that reconstructing a detailed internal model of the physical world, an explicit goal in computer vision, might not be desirable. Despite our impression that we possess such an internal model, recent psychophysical experiments suggest that it is an illusion.

What new have we learned about visual perception? Some of the chapters in this collection were driven by traditional problems in computer vision, perhaps with a new twist; others, such as the chapter by Ballard and Whitehead, have considerably altered fundamental assumptions. Vision is more than computational optics because actions affect sensations — Ballard calls this 'animate' vision. In the simplest feedforward models, such as Pomerleau's driving network, the link between action and vision is reflexive, but in more complex systems with feedback loops the link is dynamic, with motor control and short- and long-term memory representations becoming central issues.

Brains live in the real world and perform in real time; neural networks as computational models based on principles from biological systems face the same challenges. For neural networks to survive they need to evolve in two ways. First, most of the research has relied on simulations, which are flexible but inefficient. A hardware infrastructure must develop that is cheaper and more powerful than that based on conventional computational models. Several chapters on VLSI chips for neural networks and optical methods for interconnecting them present promising new technology, but none of these devices is close to industrial strength. Second, new network architectures must be found that scale well with increasing problem complexity. A single network can drive a van along divided highways, but many different networks are required for the range of road conditions encountered every day; the problem of how to coordinate these networks for reliable, efficient control is unsolved. Here we have much to learn from nature, which has produced a diversity of brain structures and adaptive behaviours that we are just beginning to understand. Read *Neural Networks for Perception* for a glimpse of a field in transition, not for a coherent new approach to visual perception. □

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Visual computation

Computational modelling of vision is also the subject of several other books published in recent months. A few are listed below:

- *Computational Models of Visual Processing* edited by M. S. Landy and J. A. Movshon. MIT Press, $66.
- *Neural Networks and Image Processing* edited by G. A. Carpenter and S. Grossberg. MIT Press, $55 (pbk).
- *Computer Vision: A Unified, Biologically-Inspired Approach* by Ian Overington. Elsevier, DFL 185, $105.50.
- *Understanding Vision: An Interdisciplinary Perspective* edited by Glyn W. Humphreys. Blackwell, £40 (hbk), £16.95 (pbk).

Network overviews

Two introductory books to neural networks and their applications that have recently been published are:

- *Neural Networks: Current Applications* edited by P. G. Lisboa. Chapman and Hall, £29.95 (pbk).
- *An Introduction to the Modeling of Neural Networks* by P. Peretto. Cambridge University Press, £60 (hbk), £24.95 (pbk).

Web of intrigue

Frances Balkwill

The Cytokine Handbook. Edited by Angus Thomson. *Academic: 1991. Pp. 425. $115, £59.*

THOSE of us enmeshed in the complex web of the cytokine network may find it difficult to appreciate the problems that this rapidly expanding area must present to the novice. A good guide book is certainly necessary. *The Cytokine Handbook* provides a comprehensive introduction to these cell-modulating proteins, with contents that are of interest not only to the uninitiated but also to those already hooked. If the book was a straight catalogue of the characteristics and actions of individual cytokines it would be of limited use, and would date even more quickly. But here such descriptions have much greater relevance, sandwiched as they are between chapters that place cytokines in the context of the immune system and its evolution, that review the molecular biology of most known cytokines, and that describe some of the therapeutic potential of both cytokines and their receptors.

Any new book on cytokines will quickly date. Important areas such as the soluble cytokine receptors and the cytokine receptor families, and the newer cytokines such as interleukins 8–12, would each merit a chapter had the book been written in 1992 instead of 1990. Curiously, the review copy claims to be a second 1992 printing of a 1991 publication, although it is not clear whether the reprinting is due to great demand or to the publisher's being overly cautious about the initial size of the print run. An update of the text would certainly be warranted before a third printing.

Over the past two years, several new cytokine books have been published, all of them excellent general guides, but shorter than *The Cytokine Handbook*. There is a tendency for these guides to contain a few key references at the end of each chapter rather than to reference individual points. This can be frustrating for those who want to delve into the original literature. By contrast, each chapter of *The Cytokine Handbook* refers to well over a hundred original papers, making the book as a whole an important reference source. It provides a useful guide to cytokines and their receptors, and, provided the contents are regularly updated, could well become the definitive introductory text. □

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