Silicon vision

Igor Aleksander and Helen Morton

Analog VLSI and Neural Systems. By Carver Mead. Addison-Wesley: 1989. Pp.371. \$39.95, £21.95.

THE title, *Analog VLSI and Neural Systems*, coupled with the name of the author, Carver Mead, suggests that here is an unmissable educational opportunity for the reader. And education it will be, as the combination of Very Large Scale Integration (VLSI, or simply, the making of silicon chips) and neural systems is a topic which, as yet, has no experts.

Mead is an acknowledged innovator in silicon chip design methods, and neural systems (the study of brain-like computers) is reportedly the hottest area of research among a broad community which stretches from computer scientists and electronic engineers to neurobiologists, including physicists and statisticians along the way. Although the drawing on the cover of the book hints at the possibility that a silicon brain is now ripe for manufacture, the notion is soon tempered by Mead in the preface: "Integrated circuit fabrication has evolved to the point where systems of the scale of small, but identifiable, parts of the nervous system can be emulated on a single piece of silicon. . . . We are not limited by the constraints inherent in our fabrication technology; we are limited by the paucity of our understanding".

The book is clearly intended first to substantiate the assertion that silicon technology has developed to the right level for making devices which function like small corners of the nervous system, and second to make a dent in the "paucity of understanding". The strategy underlying the choice of material in the earlier parts becomes apparent from a glance at the last four chapters. They describe four silicon chips which Mead and his colleagues have developed, all of which are actual emulations of parts of the nervous system.

The first is a device (called SEEHEAR) which transforms a visual image into a stereo sound "tapestry" aimed at helping the blind. So, rather than emulating those nervous functions that exist in a brain, this device might be of help to those who have lost part of their perceptive capacity (sight) by providing a neural system which enhances the part that remains. Although the text does not reveal how unsighted subjects fare with this prosthesis, the idea is fascinating and draws attention to the fact that the benefit that could be obtained from using silicon in aids of this kind is truly enormous.

The second silicon system is a neural motion detector. It is known that an important function of early stages of vision in the brain is to respond to the

Looking up — Buckminster Fuller's "tool for individuals to observe Earth and the relationships between human beings and our planet". Taken from *Buckminster Fuller's Universe: An Appreciation*, by Lloyd Sieden, published by Plenum.

motion of images. Artificial systems of this kind may be essential to the development of sighted robots capable not only of reacting appropriately to moving objects, but also of controlling their own motion on the basis of visual input. The third application is simply called "a silicon retina". This not only reproduces an image received through sensors as neural firing patterns, but produces an output which is largely independent of illumination level and enhances the edges of objects in the visual image. Both of these properties are crucial in the process of 'seeing', and Mead's model is, again, a step towards sighted machines.

Having dealt with vision and the generation of sounds, the last chip, as one might expect, is an electronic cochlea, that organ of hearing that separates the frequencies of a sound into spatially distinct activity in a brain. Again the potential for helping the deaf is apparent, as is the possibility of applying the chip as a 'front end' for a voice-sensitive computing machine. Crude approximations have existed for some time but Mead's chip must be appreciated for its compactness and sophistication.

The earlier parts of the book explain the details, neural and electronic, of the ingredients of the devices featured in the last four chapters. It is an excellent survey of electronics, analogue VLSI operation, neural functions and chip fabrication techniques. Mead calls it "electronics" that is, "the common framework of electrical properties used for information processing in both brains and silicon". The combination is enticing as a subject for new curricula in both technology and neurophysiology.

One thing that the book is *not* is an

explanation of what is currently known as 'neural nets', 'connectionism' or 'parallel distributed processing'. This is the subject alluded to earlier which is being given feverish attention by so many scientists and technologists. The distinction between this and Mead's work centres on the key factor possessed by neural tissue: the ability to build up experience or acquire knowledge. Mead has not expressed a central interest in 'learning' and mentions it only in passing. To this extent he does not address the central concern of those whom one might call the neural systems engineers.

This is not a criticism: in fact, neural systems engineers well versed in connectionism would benefit from reading the book and discovering the sophisticated ways in which fixed (as opposed to 'learning') neural systems can turn sensory data of a vaguely defined nature into well-defined data which facilitate the task for neural nets which learn. The main thrust of Mead's approach is that designers intending to produce the ultimate silicon brain can hardly afford to miss any technological tricks found in the natural counterpart. As he observes, knowing about both brains and silicon need not be like attempting to build flying machines that have feathers and flap their wings. It is more a case of seeing the organizing principles of brains as a basis for silicon systems in the same spirit as a man-made glider is a sign of human appreciation of the elegance of a soaring bird. □

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