Steinmetz in his "office" at Camp Mohawk, about 1920. [From *Steinmetz: Engineer and Socialist*, Hall of History Foundation, Schenectady, NY]

"synchronous reactance," and "primary admittance." His solution will not please everyone. By reducing his explanations of Steinmetz's work to the most general descriptions, relegating all equations and functions to the endnotes, and defining most concepts in only the briefest terms, Kline will leave many readers (including, at times, this one) frustrated. Arguably, however, the only alternatives were either a book that could be understood only by specialists or a miniature course in alternating current theory and methods. As historians come more and more to grapple with interpreting modern technology, they will confront Kline's dilemma and will probably have to resign themselves to not satisfying everyone.

Kline's task in interpreting Steinmetz's socialism is only marginally easier, for here too it is important to approach the subject with an understanding of its context, both in terms of American political thought and practice and in terms of the engineer's place in the corporation. Almost half of this carefully researched and well-written book is devoted to exploring the sources of Steinmetz's socialism, the paths that it took in America, and how it was consistent both with intellectual currents of the early 20th century and with Steinmetz's perception of the place of engineers and corporations in society. Seen in these terms, there was nothing paradoxical in the man's promotion of "corporate socialism." The apparent contradictions, Kline makes clear, were more the product of the various uses that such disparate interests as General Electric,

the Socialist party, and the electrical engineering profession made of Steinmetz and his reputation.

That the peculiar-looking genius, with his occasional forays into spectacular experiments with high-voltage lightning generators and his unconventional (but essentially non-threatening) politics, should be the object of publicists and myth-makers should come as no surprise. Well informed by recent studies of similar mythologizing, Kline explains both the rise and the decline of Steinmetz's popular reputation. In the end we are left with a figure distinctive, complex, and sometimes puzzling, but, thanks to this biography, fundamentally human.

Robert Friedel
Department of History,
University of Maryland,
College Park, MD 20742

■

Models of Vision

Computational Models of Visual Processing. MICHAEL S. LANDY and J. ANTHONY MOVSHON, Eds. MIT Press, Cambridge, MA, 1991. xii, 394 pp., illus. $55. A Bradford Book. From a workshop, Cold Spring Harbor, NY, June 1989.

This volume arose from an unusual meeting that brought together visual psychophysicists, physiologists, and engineers. The participants demonstrated their computational

models of visual processing on the spot with computer programs that they brought with them in addition to the usual slides. In a sense, the computational models presented in this collection of essays were at the meeting too, contributing to the discussion. This volume presents an accessible view of visual processing from a computational viewpoint that successfully updates David Marr's *Vision* (Freeman, 1981).

The focus of the book is on the early stages of visual processing, starting with a bundle of light rays entering the eye and projecting onto the array of photoreceptors in the retina. In the opening chapter, Adelson and Bergen coin the term "plenoptic" to describe the geometric structure of this bundle throughout space, a concept first introduced by Leonardo da Vinci. The plenoptic function elegantly unifies many traditional spatiotemporal filter models of early visual processing, the goal of which is to concentrate information regarding the shape, motion, texture, color, and depth of objects in an image. Each of these characteristics is discussed separately in later chapters.

Models simulated on digital computers run the risk of being too accurate. For example, the array of pixels in a digital image is perfectly ordered, but in the retina individual photoreceptors form an irregular lattice. How is this irregularity compensated so that humans can judge alignment with an acuity that is 5% of the width of a photoreceptor? Ahumada shows how learning can be used to calibrate the positions of the photoreceptors by taking advantage of correlations that are inherent in projections from the retina. This solution is consistent with evidence for correlational mechanisms that act during the development of visual maps in the brain. This is an exciting area of research, since unsupervised learning algorithms may also prove useful in extracting properties of objects that might be difficult to describe analytically. In a related chapter on noise as a limiting factor in visual detection, Pelli argues that the rate-limiting step may occur as early as the photoreceptors.

The pioneering studies of David Hubel and Torsten Wiesel in primary visual cortex laid the groundwork for models of the spatial (Hawken and Parker) and spatiotemporal (Shapley, Reid, and Soodak) properties of cortical cells. Rectifying nonlinearities are found already in simple cells, and complex cells are even more nonlinear (Heeger). Bergen and Landy show how the nonlinear responses of neurons may be used to perform texture segregation, and Graham points out that nonlinear cortical gain-control mechanisms are also important for understanding visual processing that takes place well above thresholds of detection. In the visual perception of occlusion, a distant feature can profoundly influence the inter-

pretation of local properties, which suggests additional global nonlinearities. The message from these chapters is that cortical processing is essentially nonlinear within its normal operating range and that the field of computational vision is gearing up to meet the challenge.

Under natural conditions, the shape of an object can be sensed by using several cues. Bültoff demonstrates trade-offs between cues such as stereo, texture, and shading, using realistic images of objects generated by computer graphics. These experiments on cue integration are beginning to probe the heart of vision, which lies in building up a unified view of the world from fragmentary, noisy, and often competing sources of evidence. Mathematical models from statistics and neural networks are providing a framework for exploring these interactions. Another area of perception that has benefited from computer graphics is transparency, which Kersten explores in psychophysical experiments.

Many of the computational models in the book were developed originally for computer vision, and those readers approaching this book from a more naturalistic or ethological view may find this engineering approach limiting. Vision is, after all, in the service of behavior, and visual systems may have evolved in ways we may not have anticipated. For example, David Field at Cornell University, who was present at the meeting but does not to contribute to the book, has found that images of the natural world have a self-similar structure. Thus the world is not arbitrary, and this regularity is probably exploited by the brain in its representation of visual information. It is well established by physiological recordings that many cues, such as disparity, are represented in the visual cortex by populations of neurons that have broad, overlapping selectivities. Recent evidence also points toward a sparse population code for complex objects such as faces. In contrast, local codes for disparity are entrenched in computer vision, which has influenced Frisby's chapter on stereoscopy. We need to develop a better understanding of the types of distributed representations found in the cerebral cortex.

Parker ends the volume with a look toward the future of computational vision. One increasingly important direction is sensorimotor integration. The visual system does not passively sample the incoming stream of visual input. In fact, visual signals derived from the earliest stages of visual processing in the visual cortex are used to direct eye movements. Once the head and eyes are allowed to move under central guidance, the visual system can be used to actively seek out information about the world. Dana Ballard (*Artificial Intelligence*

Journal 48, 57–86 [1991]) has demonstrated that the coupling between sensory and action systems often simplifies the analysis of visual scenes and provides new insights into the biological problems faced by itinerant creatures such as ourselves. The future of vision is shifting from optics to robotics.

There is need for a comprehensive book on vision that presents a unified view of late as well as early vision. It may no longer be possible for a single person to encompass the subject. A 17-volume encyclopedia of vision, *Vision and Visual Dysfunction*, edited by J. R. Cronly-Dillon (Macmillan Press, London, and CRC Press, Boca Raton, Florida) has recently been completed but is difficult to digest. Landy and Movshon's book is admirable in presenting a coherent view of early vision, an achievement that is rare in a compilation. It is beautifully produced and nicely complements traditional texts for vision courses.

Terrence J. Sejnowski
Salk Institute,
University of California at San Diego,
and Howard Hughes Medical Institute,
San Diego, CA 92186

■

Perspectives on the Sun

Solar Interior and Atmosphere. A. N. COX, W. C. LIVINGSTON, and M. S. MATTHEWS, Eds. University of Arizona Press, Tucson, 1992. xvi, 1416 pp., illus. $60.

The sun is a star; a reasonably large number of modern societies take this as a fact. The sun also just happens to be closer to us than any other star, and for this reason it is in a class by itself. The sun, then, is *our* star. We can resolve its surface and observe its small-scale changes over years, days, and seconds. This line of argument defines "solar physics" as a science that studies the physical properties and activities behind the complexity of the detailed phenomena we observe on the sun—a unique endeavor.

We can also argue, however, that the sun is a very common type of star, one among billions of similar stars that rarely do anything of significance (such as blow up in a hurry, astronomically speaking). When viewed from this perspective, "solar physics" is a science whose primary objective is to acquire information that can then be used to better understand more interesting stars.

In the "olden days" (that is, prior to the explosion of astronomical technology and, consequently, data collection), the enterprises of studying the sun as "our star" and studying it as a random example of stars in general were interwoven. My mentor, Al-

brecht Unsöld, was not ashamed to describe our sun in quite some detail in his standard work *Physik der Sternatmosphären* (Springer-Verlag, 1955). Now, however, in consideration of funding sources and other overriding factors, solar scientists must decide beforehand whether to stress "the sun as our star" or "the sun as a stellar example" as the focus of their research.

The editors of *Solar Interior and Atmosphere* have decided to do it all. They define the volume as a text for graduate students as well as a resource for solar and stellar physicists who study the sun, and they rightly claim that the 1400-page volume, with 101 contributors, is the most comprehensive of recent books on this subject. A. N. Cox et al. also include a brief history of the project and comments on their philosophy regarding commonly omitted issues such as "flavor and focusing of controversies."

J.-C. Pecker's introduction (appropriately titled "The global sun") to part 1 of the volume lays the groundwork for appreciating later discussions of how detailed, ground- and space-based observations, from the x-ray to the radio range, verify or reject the idea of the sun as a model star. Pecker places particular emphasis on what he calls coupling among physical processes, such as convection, rotation, and magnetism, for the simple reason that they provide evidence for determining properties of the solar interior and, by implication, stellar interiors. Subsequent contributions detail the observational and theoretical bases of the various processes.

The contributions in part 2 discuss in depth the various types of surface oscillations and what they reveal about the sun and its interior. These data are especially important because a multinational project (GONG, for Global Oscillations Network Group), aimed at setting up dedicated observing stations around the globe, is currently nearing completion. The relatively short part 3 singles out the use of surface observations of radiation as a method of determining a consistent picture of the solar interior. The image quality of ground-based observation is obviously one crucial item of importance, and this section provides a good summary of the early work on adaptive optics, by now one of the most promising avenues of improvements.

Part 4 deals with the bewildering array of observations of the so-called "11-year cycle" of solar activity, its most popularly known effect being the semiperiodic appearance of sunspots (lower surface temperature in the presence of localized strong magnetic fields). The reasons behind such highly localized variations in the physical parameters of solar gas, together with sudden bursts of particles and radiation, pose some of the most exciting and potentially