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Book Review

T. CAELLI. **Visual Perception: Theory and Practice.** Oxford: Pergamon Press, 1981.
pp. x + 197. \$42.00 (h), \$20.00 (p).

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The author is a Senior Lecturer in the Psychology Department, University of Newcastle, New South Wales, Australia. He has spent some time at Bell Laboratories, Murray Hill, New Jersey, where his major research interest was the application of system theoretic ideas to image processing and motion perception. He has written numerous articles in these and related fields, including applications of relativistic ideas to visual processes.

Professor Yellott is with the School of Social Sciences, University of California, Irvine. He coauthored, with W. H. Batchelder and R. A. Bjork, the book *Problems in mathematical learning theory*, Wiley, 1966, and has made significant contributions to the study of choice models; his most recent work has been in vision. Dr. Ahumada is a Research Psychologist at the NASA Ames Research Center. He has written numerous papers in the area of auditory processing, and is also interested in the use of computer graphics.

This book describes itself as "an introduction to the technologies and mathematical techniques used by vision researchers." It offers a guided tour through physical and physiological optics, Fourier transforms and linear systems, neural models, and geometry (Euclidean and otherwise), followed by a survey of their applications in current vision research. It is relatively brief, by current standards inexpensive, and bears the imprimatur of a major scientific publisher. And its author has published papers in leading vision journals, some coauthored with eminent senior scientists. At first glance then, it looks like it might be the perfect text for a course on quantitative methods in visual science—a book that would be especially welcome because there's currently nothing like it on the market.

Unhappily that is not the case: despite good intentions and a sophisticated choice of material this is a dreadful textbook, guaranteed to baffle and misinform. The problem, in a nutshell, is that it contains an astonishing number of errors.

To review the book we each read it independently and compared notes. Both of us were immediately struck by the extremely high error rate—a rate so high that large sections make no technical sense at all and many passages convey information that is completely wrong. Much of the problem evidently was due simply to a massive proofreading failure, but in addition it often appeared that the author was sincerely mistaken on matters of fact or genuinely failed to understand mathematical points he had undertaken to explain. Finally, throughout the book there was a general failure of

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logical progression—an overall tone of incoherence. In an effort to distinguish these three sources of difficulty (and subsequently to quantify them) we divided the statements that bothered us into three classes: Typographical Errors (serious enough to at least slow a student down), Misstatements of Fact (where contextual evidence suggested the author would not have corrected the error even on proofreading), and Incoherent Statements (passages that either made no sense at all, or just enough to convey the wrong impression). Admittedly these classes are quite fuzzy and from a student's point of view our distinctions would often make little difference—he would be just as confused no matter how the error arose. Nevertheless classifying things made our job more interesting: we felt a bit like cognitive archeologists. To illustrate our classification scheme (and the flavor of the book itself) here are some examples chosen more or less at random.

Typographical Errors

p. 11:
$$A \cos(\mathbf{k} \cdot \mathbf{r}) + i \sin(\mathbf{k} \cdot \mathbf{r}) = i \mathbf{k} \cdot \mathbf{r}."$$

[This is the second equation in the book. The first contains an undefined quantity. The right-hand side here should be $Ae^{i\mathbf{k} \cdot \mathbf{r}}$, assuming parentheses had been appropriately placed on the left side. That's the only extrapolation that would make sense.]

p. 18: "The output intensity of the filter is determined by Mault's law

$$I(\theta) = I(O) \cos^2 \theta, \quad I(O) = \frac{c\epsilon_0}{2} E_0^2 \cos^2 \theta."$$

[Confused by the nonsensical " $\cos^2 \theta$ " in the second equation, students might consult the index of an optics text. But they won't find "Mault's law"—they'll have to guess that it's really Malus' law.]

$$f(x) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(k) e^{-ikx} dx$$

p. 40:

$$F(s) = \int_{-\infty}^{a_{\infty}} f(x) e^{isx} dx,"$$

[This is the book's version of Fourier's theorem. It's another double typo, and the " a_{∞} " is a particularly nice touch.]

p. 44: "Secondly, the Fourier transform of the product of two functions is equal to the product of their transforms

$$\mathcal{F}(A \times B) = \mathcal{F}(A) \mathcal{F}(B)$$

where $A \times B$ denotes

$$A \times B = \int_{-\infty}^{\infty} A(x) B(x-t) dx$$

which is called the convolution of A and B . This second property is sometimes called the convolution theorem."

[This is an example of the difficulty one has deciding whether an error—here a double error—is really typographical. At first we thought the author had simply written "product" when he meant to say convolution. But then we noticed that convolution itself is misdefined. The entire treatment of this topic suffers from errors of this sort.]

p. 96:
$$\sin \theta = 1 + \frac{\theta^3}{3!} + \frac{\theta^5}{5!} - \frac{\theta^7}{7!} + \dots$$

[This one occurs three times in the same derivation.]

p. 109: "First, there seems to be different kinds of cells in terms of the frequency response: those that respond particularly to low spatial frequencies (and high temporal frequencies—brisk transient or X -cells), and those that have a preference for high spatial frequencies (and low temporal frequencies—sustained or Y -cells)."

[Here X and Y are reversed. This occurs again several sentences later, and that's the last time the X - Y distinction is mentioned. That's a common problem here: Because the book races briskly through many topics the errors made on each one leave a permanent impression.]

p. 32: Figure 2.22. This figure, like many throughout the book, contains graphic errors. Specifically, the diagram that is supposed to illustrate astigmatism actually shows no astigmatism at all, and the diagram illustrating the near point of a hyperopic eye (where rays from the point should be focused on the retina) actually shows the rays converging behind the retina. Here and in many other places it appears that the figures were redrawn from accurate original sources (in this case Hecht and Zajac's *Optics*—an excellent book) but nobody checked the accuracy of the new drawings.

Misstatements of Fact

p. 30: "*Interference* refers to how two light sources interact to produce various interference patterns. Of course, when both sources are polarized no interference effects would occur."

p. 40:
$$f(x) = \frac{1}{\pi} \left[\int_0^\infty A(k) \cos kx \, dk + iB(k) \sin kx \, dk \right]$$

given that

$$A(k) = \int_{-\infty}^{\infty} f(x) \cos kx \, dx \quad \text{and} \quad B(k) = \int_{-\infty}^{\infty} f(x) \sin kx \, dx."$$

[The excess “ i ” in the first equation might be a typo, but we don’t think so: it occurs in the same place three pages earlier in the author’s parallel treatment of Fourier series. A student would probably conclude he means it and try in vain to work things out accordingly.]

- p. 107: “We saw in Chapter 3 that any reasonably smooth image can be decomposed into spatial frequency and phase components. It was also pointed out that in all optical systems these frequency components are not transferred with equal fidelity. The MTF (Fig. 6.6) is typically damped at the low- and high-frequency ranges of the image.”

[This is an interesting error. The fact is that for any *optical* system the MTF (modulation transfer function: the modulus of the Fourier transform of the system’s impulse response) can *never* be damped at the origin—its value there must always be at least as great as its value elsewhere. (This is a general property of linear systems with nonnegative impulse responses.) However, the so-called “MTF” of the human visual system (the psychophysically determined spatial contrast sensitivity function) does show a pronounced decline near the origin—as Fig. 6.6 correctly shows. Precisely for this reason we know that the low frequency damping of the human “MTF” cannot be due to optical defects of the eye, and must instead reflect neural properties of the visual system. The passage just quoted leaves a very different impression. We include this somewhat esoteric example to show that the book does not entirely confine itself to blatant errors—like the following.]

- p. 172: “The molecule known to be responsible for encoding light quanta in the retinal rod and cone systems is rhodopsin (visual purple).”

Incoherent Statements

- p. 31: “The rods are not colour sensitive like the cones are; however the rods are more sensitive to light than the cones, being related to peripheral vision (scotopic vision). Many rods drive the retinal ganglion cells, which, in turn, convey information to the visual cortex. The cones are less sensitive to light and are directly related to foveal or central vision (photopic vision) where down to one cone may drive one ganglion cell.”

[We cannot resist adding that this passage continues “However, the purpose of this book is not to deal with these details, which are assumed to be known to the reader.”]

- p. 46: “The Fourier transform pair does not only provide an approximation to a function, but also introduces us to the concept of a linear system. In this system we have an input-output relationship governed by a transformation $\mathcal{F}$ where for input functions f_1, f_2

$$\mathcal{F}(\alpha f_1 + \beta f_2) = \alpha \mathcal{F}(f_1) + \beta \mathcal{F}(f_2).$$

Here the input functions are carried through the system (represented by $\mathcal{F}$)

such that the linearity is preserved between them. In this sense the Fourier transform pair constitute a linear system. This concept is illustrated in Fig. 3.7. The system is termed stationary if the input-output relationship is unaffected by charges in image position.

One way of determining the output of a system to arbitrary inputs is through the system's responses to impulses or δ -functions. This is called the *impulse response* of the system, and the *point-spread function* corresponds to this output function. With the Fourier transform this happens to be the sine or Bessel function (Mexican hat function)."

[And to cap things off, Fig. 3.7 contains three typographical errors.]

With these three classes in hand, our final step was to comb the first substantive section of the book (Section 2.1: "on the nature of light"), counting and classifying all the errors we could find. In those eight pages we found twelve typographical errors, four misstatements, and nine incoherent statements—an overall average of slightly more than three errors per page. This rate seemed to be typical of the entire book.

After all this, of course, our recommendation is obvious: this book should be treated with great caution—it simply is not a trustworthy guide to the territory it covers. However, in its own way it does describe a great range of important mathematical ideas in contemporary vision research, and in this sense it is a unique contribution to the literature. So if the prospect of taking this guided tour still appeals to you, despite its uncertainties, by all means do so—you'll certainly find the scenery interesting. But take our advice: don't drink the water!