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Book Reviews

Steven C. Gustafson, Book Reviews Editor

Optical Processing and Computing

H. H. Arsenault, T. Szoplik, and B. Macukow, eds., xii + 493 pp., illus., index, references, list of contributors. ISBN 0-12-064470-3. Academic Press, 1250 Sixth Avenue, San Diego, CA 92101 (1989) $59.50 hardbound.

Reviewed by Mohammad A. Karim, University of Dayton, Center for Electro-Optics and Electrical Engineering Department, 300 College Park Avenue, Dayton, Ohio 45469-0226.

A total of 23 authors from the USA, USSR, Canada, and Poland combined their efforts to produce this book of 15 chapters, presenting selected topics that loosely fall within the rapidly expanding areas of "digital optical computing" and "analog optical processing" (as stated in the preface). However, it will become obvious to readers that the book has not done justice to the area of "digital" optical computing, in particular. Indeed, it is not possible to completely cover a newly explored technology, however, there are too many loopholes in this book, as may be discovered by comparing its content with the latest trends in digital optical computing publications. These trends are reflected in part in special issues of various optics journals (for example, *Applied Optics* of May 10, 1990). The editors realize this apparent problem of their book, and the preface states "a collection of articles from the principals in the field in Europe and Japan would be a useful complement to this book, and we hope that someone will compile such a collection."

Chapter 1 (Goodman) reviews uses, types, and properties of optical interconnections. The discussion leads to a power comparison between optical and electrical interconnects and issues pertaining to optical clock distribution to a VLSI chip. The next chapter (Petrov and Kuzin) introduces optical fibers as a medium for nonlinear optical elements. Operations such as amplification and switching of optical signals and, in particular, the design of a fiber-optic inverter are also discussed. The role of Chap. 3 (Johnson and Tanguay), entitled "Fundamental Physical Limitations of the Photorefractive Grating Recording Sensitivity," is questionable. What is it doing in this book? Its relationship with optical computing or optical processing is not clear, and the chapter does not establish any relationship. Chapter 4 (Bazhenov, Soskin, Taranenko, and Vasnetsov) reviews the impact of biopolymers. In particular, works pertaining to sensitized gelatin and materials based on bacteriorhodopsin as well as their applications in real-time optical processing are discussed.

The application of diode lasers in optical computing are elaborated in Chap. 5 (Morozov). Topics such as recording and reconstruction of holograms with diode lasers, their applications in optical correlators, issues pertaining to integration of holograms with waveguides as well as the design of diode-laser-based optical logic gates, and integration of diode lasers with electronic circuits are addressed. Chapter 6 (Tverdokhleb), entitled "Array Optoelectronic Computers," is interesting. It summarizes the work of Soviet scientists, most of which was done in the 1970s and early 1980s. The next chapter (Abushagur and Caulfield) deals with the related area of optical matrix computations. The authors review some of the basics of linear algebra, including problem complexity, solution algorithms, and matrix operations, and then introduce the concept of the bimodal optical computer. In Chap. 8 (Psaltis, Brady, Gu, and Hsu), the authors discuss how optical methods can be used to implement neural computers. This chapter, like many of the others, is somewhat more fundamental than applied.

Chapter 9 (Koronkevich) is entitled "Computer Synthesis of Diffraction Optical Elements" and, like Chap. 3, is somewhat out of place in this book. Diffraction optical elements are usable in optical processing, but the chapter makes no effort to emphasize that fact. In the following chapter (Arsenault), the author examines distortion-invariant pattern recognition using circular harmonic matched filters. Following a review of shift, rotation, scale, contrast, distortion, and noise invariances, the chapter deals with aspects of both composite and multiple circular harmonic matched filters. Chapter 11 (Morris), entitled "Pattern Recognition Using Photon-Limited Images," concentrates on pattern recognition systems in which low-light-level scenes are correlated with stored references. The effects of additive noise, detector dead time, and distortion-invariant filters are considered. In Chap. 12 (Szoplik), the author considers line detection and directional analysis of images by means of anamorphic Fourier transforms, meso-optical Fourier transforms, and Hough transforms. Chapter 13 (Leith) briefly describes incoherent optical processing and holography, while Chap. 14 (Chalasinska-Macukow) describes both phase-only matched filter and tandem component filter based systems as examples of high light efficiency pattern recognition. Finally, Chap. 15 (Nezhevenko) summarizes the optoelectronic analog processor works carried out at the Institute of Automation and Electrometry of the USSR Academy of Sciences in Novosibirsk.

In summary, material in this book pertaining to analog optical processing is reasonably balanced. However, topics pertaining to digital optical computing are too few and are not adequately representative of the field. This reviewer doubts the upbeat assertion that the book will benefit "students and researchers who need a broad coverage of the principles of optical computing and of the underlying physics." The book is different in that it contains the work of several East European scientists. The format and style of the book are neat and its price is tolerable.

Introduction to the Optical Transfer Function

Charles S. Williams and Orville A. Becklund, Part of Wiley Series in Pure and Applied Optics. xi + 412 pp., illus., index, references. ISBN 0-471-94770-9. John Wiley & Sons, 605

Third Ave., New York, NY 10158 (1989) $44.95 hardbound.

Reviewed by John S. Loomis, University of Dayton, Dayton, OH 45469-0140.

The optical transfer function (OTF) is the image response of an optical system to periodic patterns in object space as a function of spatial frequency. How the OTF has come to play a central role in modern optical design and evaluation is revealed to us by Charles Williams and Orville Becklund.

The book consists of 10 chapters and three appendixes. There are references at the end of each chapter and a subject index at the end of the book.

Chapter 1 provides a historical background of the OTF, from tests of star images (point spread function), to bar charts, to formal Fourier analysis. The OTF, whose theoretical foundations were established in the 1940s, is a relatively new concept in optics. After testing methods and understanding improved through the 1950s, in recent decades the OTF has become an established part of the optics industry.

Chapter 2 covers the conceptual background for the OTF. Here the reader will find definitions and illustrations of spatial frequency, contrast, spread functions, isoplanatism, linear superposition, and coherence. This chapter contains most of the photographic illustrations in the book, including the traditional picket fence. Mathematical details of Fourier analysis and diffraction theory are contained in appendixes. The majority of the chapter is expositional rather than mathematical.

Chapter 3 deals with notation and coordinate systems for pupils, images, paraxial rays, and wavefronts. Chapter 4 discusses diffraction and wavefront aberrations. Here we find studies of the OTF for each of the primary aberrations. Chapter 5 is a mathematical exposition of many of the concepts introduced in Chap. 2. There is a discussion of the OTF for perfect optical systems, illustrations of spurious resolution, and a section on apodization. The geometrical approximation to the OTF and a brief discussion of polychromatic OTF concepts conclude Chap. 5.

Chapter 6, on optical design and image criteria, and Chap. 7, on merit functions and aberration balancing, are much broader in scope than one might expect from the narrow book title. Chapter 6 gives a good general introduction to the practices of optical design, including the features found in computer programs for optical design. The chapter continues with a section on resolving power versus acutance, addressing the issue of evaluating the quality of a photographic image. The final section discusses the phase component (phase transfer function) of the OTF. Chapter 7 is relatively specialized and discusses the merit functions used by optical design programs to quantitatively assess optical performance. The relationship of ray and wavefront aberrations in merit functions to the OTF is illustrated, and the question of how the merit function selects the balance of aberrations is treated.

Chapter 8 concentrates on the measurement of the OTF. Measurement techniques are divided into direct methods using periodic patterns of various kinds and indirect methods using edge traces or interferometric (wavefront) measurements from which the OTF may be derived.

The final two chapters are on calculating the OTF. Chapter 9 presents analytic methods based on series expansions of Bessel functions, and Chap. 10 gives numerical methods based on Gaussian quadrature of a wavefront expressed as a polynomial series.

Although the book itself is excellent overall, I have a few minor areas of dissatisfaction. The figures are not of uniform quality. Some are high-quality artwork; others are obvious dot-matrix computer output. Next, having references at the end of the chapter, rather than collected at the end of the book, makes it difficult to assess the completeness and age of the bibliographic background. For example, I looked for and could not find a reference to William Wetherell's chapter on the calculation of image quality (in *Applied Optics and Optical Engineering,* Vol. VIII, Academic Press, 1980). The most recent reference in Chap. 10 was 1981. An author index is also very helpful, but not often found. Finally, my favorite books are those that are easily applied to current problems. General discussions of numerical methods whet the appetite, but more detailed presentations including sample software are more satisfying.

The aim of the book is to bring together scattered information about the OFT and its relevance to optical design and evaluation, and this goal is achieved. Especially noteworthy is the way general optical concepts are presented and related to the OTF. This book belongs in the hands of any optical engineer, and I highly recommend it.

BOOKS RECEIVED

Human and Computer Vision: Computing Perceptual Organisation, by James D. McCafferty. iv + 212 pp., illus., subject index, glossary of terms, references, five appendixes. Part of the Ellis Horwood Series in Digital and Signal Processing. ISBN 0-13-445396-4. Prentice Hall, Inc., Englewood Cliffs, NJ 07632 (1990). Considers the incorporation of certain aspects of the human visual system into computer vision systems. Topics covered include machine vision and perceptual organization, computational approaches, measuring and combining grouping energies, performing grouping, parameter space, regularization theory, dynamic programming, linear programming, applications of simulated annealing, stereo matching, and prototype results.

Image Analysis Applications, edited by Rangachar Kasturi and Mohan M. Trivedi. xii + 436 pp., illus., subject index, references following each chapter, author biographies. Part of the Optical Engineering Series. ISBN 0-8247-8198-8. Marcel Dekker, Inc., 270 Madison Ave., New York, NY 10016 (1990) $115.00 hardbound. Topics covered include document-analysis systems and techniques, graphics-recognition systems, automation recognition, image-analysis techniques, digital image processing, three-dimensional reconstruction, visual perception, analysis of high-resolution aerial images, image formation and characterization for three-dimensional vision, the digital Morphological Sampling Theorem, fingerprint analysis, and robot navigation.

Optical Scattering: Measurement and Analysis, by John C. Stover. xi + 238 pp., illus., subject index, bibliography, and three appendixes covering review of electromagnetic wave propagation, Kirchhoff diffraction from sinusoidal gratings, and BSDF data. Part of the Optical and Electro-Optical Engineering Series. ISBN 0-07-061814-3. McGraw-Hill, Inc., 11 West 19th St., New York, NY 10011 (1990) $44.95 hardbound. Topics covered include scatter calculations and diffraction theory, polarizations of scattered light, scatter measurements and instrumentation, scatter specifications, calculation of surface statistics from BRDF, surface roughness, and detection of discrete surface and subsurface defects.

Modern Optical Engineering: The Design of Optical Systems, Second Edition (Revised and Expanded), by Warren J. Smith. xiii + 524 pp., illus., subject index, bibliographies and exercises following each chapter. Part of the Optical and Electro-Optical Engineering Series. ISBN 0-07-059174-1. McGraw-Hill, Inc., 11 West 19th St., New York, NY 10011 (1990) $59.50 hardbound. Topics covered include prisms and mirrors, image formation, radiometry, photometry, optical materials and interference coatings, optical computation, stops and apertures, aberrations, image evaluation, optical specifications and tolerances, and optical laboratory practice, as well as the structure, characteristics, and defects of the eye.

Optical Disks vs. Magnetic Storage, by William Saffady. 122 pp., illus., subject index, and bibliography. ISBN 0-88736-703-8. Meckler Corp., 11 Ferry Lane West, Westport,

Continued on Page SR-188

CT 06880 (1990) $42.50 softbound. Provides a detailed comparison of optical and magnetic devices and media as computer storage technologies, emphasizing similarities and differences in recording technology, storage capacity, performance characteristics, and costs. Topics covered include optical disks vs magnetic disks, optical disks vs magnetic tape, and the role of optical and magnetic media in storage hierarchies.

Fiber Optics and CATV Business Strategy, by Robert K. Yates, Nolwen Mahe, and Jerome Masson. x + 159 pp., illus., subject index, and references following each chapter. Part of the Artech House Telecommunications Library. ISBN 0-89006-413-X. Artech House, 685 Canton St., Norwood, MA 02062 (1990). Topics covered include cable television business strategy, channel capacity, signal quality, system reliability, long term architectures for CATV, trunking and distribution considerations, strategic issues in optical systems, components of optical transmission systems, optical fiber and cable design characteristics, building a fiber optic cable system, operations training, and project management.

Three-Dimensional Neuroimaging, by Arthur W. Toga. xii + 317 pp., illus. (some in color), subject index, list of contributors, references following each chapter. ISBN 0-88167-578-4. Raven Press, 1185 Avenue of the Americas, New York, NY 10036 (1990) $98.00 hardbound. Topics covered include image acquisition; frame processing; image data presentation; quantitative imaging; high-resolution, large-area image recording and analysis; neuronal arbor recording and analysis; receptor binding; digital brain atlas; three-dimensional image of brain function; morphometrics; semi-automated nerve tracing; distortion correction; surface rendering; and databases of brain information.

Digital Design Methodology for Optical Computing, by Miles Murdocca. xi + 161 pp., illus., subject index, and bibliography. ISBN 0-262-13251-6. MIT Press, 55 Hayward St., Cambridge, MA 02142 (1990) $30.00 hardbound. Topics covered include optical logic devices and interconnects, architectural approaches for general-purpose optical computing, programmable logic arrays, random access memory, gate-level reconfigurability, and optical designs of a parallel sorting network and of a content addressable memory.

Short Courses

SPIE EDUCATIONAL PROGRAMS

SPIE short courses are organized to provide fundamental, practical instruction to scientists, engineers, and technical managers whose work focuses on, or is expanding into, optics, electro-optics, and integrated optoelectronics. Course lengths range from a half day (3 1/2 hours) to a full day (6 1/2 hours) to two days (12 hours) of instruction. For more information on SPIE short courses, contact SPIE's Educational Programs Department, P.O. Box 10, Bellingham, WA 98227-0010. 206/676-3290. Fax 206/647-1445. Telex 46-7053.

November 1990—Boston, Mass.

These courses will be offered in conjunction with SPIE's OE/Boston'90, a part of Optcon'90, Nov. 4-9, Hynes Convention Center, Boston, Mass.

Optoelectronics

Laser Noise: A Practical Introduction, Rajarshi Roy, Georgia Inst. of Technology, Tues., 6:00-10:00 pm.

Packaging and Interconnects, Davis H. Hartman, Bellcore, Sun., 1:30-5:30 pm.

Adhesion and Adhesives for Optical and Electronic Applications, Lieng-Huang Lee, Webster Research Ctr. of Xerox Corp., Fri., 8:30 am-5:30 pm.

Numerical Methods in Guided Wave Optics, David Yevick, Queen's Univ./Kingston, Thurs., 8:00 am-noon.

Intelligent Systems

Automated Visual Inspection, Rolf-Juergen Ahlers, Fraunhofer Inst. fuer Produktionstechnik und Automatisierung (FRG); Bruce G. Batchelor, Univ. of Wales, College of Cardiff (UK); Michael A. Snyder and Frederick M. Waltz, 3M Co., Sun.-Mon., 9:00 am-5:30 pm.

Optical Pattern Recognition, David P. Casasent, Carnegie Mellon Univ., Sun., 8:30 am-5:30 pm.

Fundamentals of Electro-Optics

Basic Optical Engineering for Electrical Engineers, Glenn D. Boreman, Univ. of Central Florida, Mon., 8:30 am-5:30 pm.

Modulation Transfer Function in Optical and Electro-Optic Systems, Glenn D. Boreman, Univ. of Central Florida, Tues., 8:00 am-noon.

Radiometry from Point A to Point B, James M. Palmer, Optical Sciences Ctr./Univ. of Arizona, Tues., 2:00-6:00 pm.

Infrared Photodetectors, Eustace L. Dereniak, Optical Sciences Ctr./Univ. of Arizona, Wed., 8:00 am-5:30 pm.

Infrared System Design, William L. Wolfe, Optical Sciences Ctr./Univ. of Arizona, Thurs., 8:00 am-5:30 pm.

Sensor Systems Engineering, Richard J. Becherer, Science Applications International Corp., Wed.-Thurs., 9:00 am-6:00 pm.

Optical Design for the Infrared, Robert E. Fischer, Ernst Leitz Canada Ltd. and Optics 1, Inc., Fri., 8:30 am-12:30 pm.

Laser System Design, Hugo Weichel, Nichols Research Corp., Wed., 8:00 am-5:30 pm.

Introduction to Optical Fiber Components and Systems, Michael Corke, Aster Corp., Tues.-Wed., 9:00 am-6:00 pm.

Optical Fabrication

A Primer in Optical Coating Technology, Michael Ray Jacobson, Optical Sciences Ctr./Univ. of Arizona, Mon., 8:30 am-5:00 pm.

Optical Component Fabrication, Specifications, and Tolerances, Warren J. Smith, Kaiser Electro-Optics Inc., Tues., 8:00 am-5:30 pm.

Contemporary Optical Fabrication, Hank H. Karow, Coherent Optics Division, Thurs., 8:00 am-noon.

Precision Optical Fabrication, Norman J. Brown, Lawrence Livermore National Lab., Thurs., 2:00-6:00 pm and Fri., 9:00 am-5:00 pm.

Optical Design

Holographic Optical Elements, B. Jin Chang, Kaiser Optical Systems, Inc., Wed., 8:00 am-5:30 pm.

Principles of Polarized Light, Robert A. Fisher, RA Fisher Associates, Wed., 8:00 am-5:30 pm.

Introduction to Polarimetry, Russell A. Chipman, Univ. of Alabama in Huntsville, Thurs., 8:00 am-noon.

Introduction to Polarized Ray Tracing, Russell A. Chipman, Univ. of Alabama in Huntsville, Thurs., 2:00-6:00 pm.

Introduction to Aberration Theory and Lens Design, Michael J. Kidger, Kidger Optics, Ltd. (UK), Thurs., 9:00 am-6:00 pm and Fri., 9:00 am-5:30 pm.

Optomechanical Design

Optics for Optomechanical Design, Jonathan Maxwell, Imperial College London (UK), Sun., 8:30 am-5:00 pm.

Introduction to Optomechanical Design for Mechanical Engineers, Daniel Vukobratovich, Optical Sciences Ctr./Univ. of Arizona, Mon., 9:00 am-5:30 pm and Tues., 9:00 am-6:00 pm.

Semiconductor Processing

Diffraction Limited Optics, Robert E. Fischer, Ernst Leitz Canada Ltd., and Optics 1, Inc., Mon., 1:30-5:30 pm.

Microlithography Introduction: Resist Materials and Their Processing, C. Grant Willson, IBM Almaden Research Ctr., Tues., 8:00 am-5:30 pm.

Excimer Laser Beam Delivery Systems, Kenneth J. Harte, Image Micro Systems, Inc., Wed., 8:00 am-noon.

Excimer Laser Interaction with Materials, Bodil Braren, IBM T.J. Watson Research Ctr., Wed., 2:00-6:00 pm.

November 1990—Santa Clara, Calif.

These courses will be offered in conjunction with the 2nd Annual Regional Technical Meeting of the

Continued on Page SR-190