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Book Reviews

Steven C. Gustafson, Book Reviews Editor

A Digital Design Methodology for Optical Computing

Miles Murdocca. xi + 161 pp., illus., subject index, bibliography. ISBN 0-262-13251-6. MIT Press, 55 Hayward St., Cambridge, MA 02142 (1990) $30.00 hardbound.

Reviewed by Alastair D. McAulay, Wright State University, Department of Computer Science and Engineering, Dayton, OH 45435.

This book is based on the author's Ph.D. thesis and describes a methodology for designing optical combinational logic circuits. The design uses 2-D spatial light modulators (SLMs), acting as parallel AND or OR gates, connected with regular, free-space, two-input, two-output interconnections, using masks to select interconnections. Such combinational circuits should permit demonstration of special-purpose logic and optical computing. However, the author's goals appear to be to show that this optical combinational logic approach is superior to others and is sufficient for constructing computing machines that are efficient and competitive with electronic machines.

Chapter 1 discusses the photon versus electron advantage for interconnects. It suggests that free-space, regular interconnects are superior to guided waves (as in fibers and integrated optics) and to irregular free-space interconnects because free-space regular interconnects are easier to implement and permit pipelining.

Chapter 2 describes briefly three devices: SEED, optical logic etalon, and interference filter. In addition, a brief review of interconnection networks is provided. The remainder of the book concentrates on two-input, two-output, regular interconnection networks. A further constraint allows only crossover or straight through and shift, where the shift between one SLM and the next is the same for every element in the SLM.

Chapter 3 mentions a few approaches to optical computing. There is a six-page description of symbolic substitution. Six other appoaches are described too briefly, in approximately 200 words each: QWES, neural networks, optical VLSI interconnects, bit serial computer, and acousto-optic cell computers. The basic concept for the book, free-space regular interconnects, is described in approximately 300 words.

Chapter 4, over a third of the book, provides the design methodology. The first step reduces combination logic to a parallel set of AND gates, followed by a parallel set of OR gates, as in electronic logic design using programmable logic arrays. The next step for optical design replaces the multiple input gates by a sequence of two-input, two-output gates. This results in a series of 2-D SLMs for ANDing followed by a series of
2-D SLMs for ORing and specified interconnections between SLMs. An unimaginative trial and error algorithm is presented in which input and output locations are selected and interconnections between them are traced along allowable paths. If there are conflicts, the positions of the outputs are moved and the process is repeated. A similar algorithm is proposed when the connections are constrained to straight through and shift. Interconnections between SLMs are implemented with a beamsplitter, surrounded on four sides with the input, a periodic prism for crossover connections, a mirror, and the output. A mask is used at the output to select interconnections. The procedure is illustrated by applications to the design of a serial adder and a random access memory. A micro-optic implementation proposes stacking of arrays of lenslets, prisms, and SLMs. A figure on looping is inadequately described.

Chapter 5 describes three applications: a sorter circuit, an optical design for the DARPA-sponsored experimental Connection Machine, and a content addressable memory (CAM). Reasons are presented why a proposed optical sorting circuit might be better than a VLSI design. A preliminary optical design for the Connection Machine architecture is discussed, including an ALU, router, and hypercube interconnections. I agree with the author that "the resulting design is not immediately practical." Parallel search and tree gathering are performed optically in the CAM, while the remainder of the machine is electronic. A preliminary optical design for a CAM word module is described.

The book does not provide sufficient evidence that the proposed optical combinational logic using free-space, regular interconnects and masks is superior to combinations of other approaches. Analysis and optical experiments comparing this approach with others is required to show superiority. The fixed masks restrict design flexibility. Reconfigurability is generally needed for reasons such as fault tolerance. It would have been useful to see a discussion of how the masks are to be implemented and how the use of reconfigurable masks would affect performance. Further, it seems unlikely that a single optical combinational logic circuit approach is sufficient for constructing all elements of a complete computer that is efficient and competitive with electronic machines. The author tries to use this one approach for everything.

In summary, the book is reasonably clear and makes a good presentation of the free-space, regular interconnection approach to optical combinational logic circuit design. It should be of interest to logic designers in computer engineering. The claims of superiority to other approaches and the ability to use this concept to construct optical computers that are competitive with electronic ones remain to be proven. A minor comment: in such a short book it does not seem necessary to repeat figures such as the architectural concept (pp. 41, 142), the micro-optic design (pp. 28, 64), and the optical interconnection diagram (pp. 24, 77, 101). It is also disconcerting to find blank spaces in the middle of chapters; 21 pages have over 8 lines blank and four pages have a half page or more blank.

BOOKS RECEIVED

C Language Algorithms for Digital Signal Processing, by Paul M. Embree and Bruce Kimble. xvi + 456 pp., illus., list of key symbols, subject index, references, appendixes. ISBN 0-13-133406-9. Prentice-Hall, Inc., Englewood Cliffs, NJ 07632 (1991). Covers filtering, discrete Fourier transform, basic image processing, a DSP data file format and user interface, basic 1-D and 2-D DSP techniques, and basic matrix and vector routines. Floppy disk (included) contains C language source codes for programs contained in the book.

Linear Controller Design: Limits of Performance, by Stephen P. Boyd and Craig H. Barratt; edited by Thomas Kailath. xi + 416 pp., illus., subject index, notes and references following each chapter. ISBN 0-13-538687-X. Prentice-Hall, Inc., Englewood Cliffs, NJ 07632 (1991). Covers design specifications, analytical tools, and numerical methods, using a less formal mathematical approach than some other books. Main focus is on describing how the controller design problem can be solved for a restricted set of systems and design specifications by combining recent theoretical results with numerical convex optimization techniques.

Modern Signals and Systems, by Huibert Kwakernaak and Raphael Sivan; edited by Thomas Kailath. xxiii + 791 pp., illus., index, bibliography, SIGSYS tutorial index and diskette. ISBN 0-13-809252-4. Prentice-Hall, Inc., Englewood Cliffs, NJ 07632 (1991). Covers linear systems, harmonic and periodic inputs, frequency response of various system models, stability of convolution systems, etc. Examines practical applications to various systems, giving numerous examples. Includes application software offering a wide variety of operations, including Fourier transformation, convolution, and integration of differential equations.

Photoconductivity: Art, Science, and Technology, by N.V. Joshi. Volume 25 of the Optical Engineering Series, Brian J. Thompson, series editor. x + 309 pp., illus., subject index, references at end of each chapter, one appendix. ISBN 0-8247-8321-2. Marcel Dekker, Inc., 270 Madison Ave., New York, NY 10016 (1990) $99.75 hardbound. Focuses on modern two-dimensional photodetectors and highlights important facets of photoconductivity and photodetection. Contains over 125 diagrams and tables as well as statistics on creation, annihlation, transport of charge carriers, etc.

Principles of Optical Circuit Engineering, by Mark A. Mentzer. Volume 26 of the Optical Engineering Series, Brian J. Thompson, series editor. x + 313 pp., illus., subject index, references at end of each chapter, four appendixes. ISBN 0-8247-8202-X. Marcel Dekker, Inc., 270 Madison Ave., New York, NY 10016 (1990) $99.75 hardbound. Examines devices, physical phenomena, and component technologies of optical systems functions. Gives detailed design guidelines for optical circuits and discusses high-performance device fabrication. Explains testing and characterization of optical circuits and explains relationships between optics, microwaves, and electronics.

Optical Materials, edited by Solomon Musikant. Volume 1 in A Series of Advances, Brian J. Thompson, consulting editor. xi + 430 pp., illus., subject index, references following each chapter, one appendix. ISBN 0-8247-8131-7. Marcel Dekker, Inc., 270 Madison Ave., New York, NY 10016 (1990) $115.00 hardbound. Covers nematic liquid crystals for active optics; optical fiber materials; and crystalline optical materials for ultraviolet, visible, and infrared applications.

Image Understanding 1989, edited by Shimon Ullman and Whitman Richards. Volume 3 of the Image Understanding Series. xi + 233 pp., illus., subject index, author index, references following each chapter. ISBN 0-89391-547-5. Ablex Publishing Corp., 355 Chestnut St., Norwood, NJ 07648 (1990). Hardbound prices: $55 (institution), $32.50 (personal). Covers constrained smoothness, general architecture, edges and zero crossings, and natural constraints in visual computations.

Basics of Electron Optics, by David A. de Wolf. xvii + 228 pp., illus., subject index, two appendixes, list of symbols, references following each chapter. ISBN 0-471-52457-3. John Wiley & Sons, Inc., 605 Third Ave., New York, NY 10158 (1990) $44.95 hardbound. Covers the relationship between electron optics and light optics, equations of motion, methods of calculating electromagnetic fields, paraxial optics, electron lenses, elements of aberration theory, and electron guns in television and other CRTs.

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.

January 1991—Los Angeles, Calif.

These courses will be offered in conjunction with SPIE's OE/LASE '91, Optics, Electro-Optics and Laser Applications in Science and Engineering, Jan. 20-25, Los Angeles, Calif.

Laser Sources

Infrared Solid State Lasers, Larry G. DeShazer, Solidlite Corp., Sun., 8:00 am-5:30 pm.

Design and Material Considerations for Second Harmonic Generation Laser Devices, Raymond G. Beausoleil and Larry G. DeShazer, Solidlite Corp., Mon., 8:00 am-5:30 pm.

Semiconductor Diode Lasers, Peter S. Zory, Univ. of Florida, Mon., 8:00 am-5:30 pm.

High Power Coherent Semiconductor Laser Arrays, James R. Leger, Massachusetts Inst. of Technology, Tues., 6:00-10:00 pm.

Applications of Laser Diodes, Chandrasekhar Roychoudhuri, United Technologies Research Ctr., Tues., 1:30-5:30 pm.

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

Laser Diagnostics

Diode Laser Testing, Thomas K. Plant, Oregon State Univ., Tues., 8:00 am-noon.

Gaussian Laser Beam Basics: Diameters, Divergence, and Waist Position, Gerald F. Marshall, Optical Design & Engineering, Sun., 1:30-5:30 pm.