DEPARTMENTS

BOOK REVIEWS

Optical Computer Architectures: The Application of Optical Concepts to Next Generation Computers

Alastair D. McAulay, 547 pages, illus., index, references, appendix. ISBN 0-471-63242-2. John Wiley & Sons, Inc., New York, NY 10158-0012 (1991) $59.95 hardbound.

Reviewed by John A. Neff, Optoelectronic Computing Systems Center, University of Colorado, Boulder, CO 80309-0525.

This is a book that fills a void that has persisted far too long. Until publication of this book, book-length coverage of computer architectures as viewed from the perspective of optics technology did not exist. Readers who desire knowledge of what optics has to offer in future generations of computers will enjoy reading this book. The fundamental concepts of optical computer architectures are presented in a concise and smooth-flowing format, unencumbered by detailed technical discussions and mathematical formality. *Optical Computer Architectures* is excellent reading for students contemplating entering the field of optical computing because the book could instill in readers who are not yet knowledgeable in optics an appreciation for the key architectural issues.

The book has the format of a text with the content divided into short chapters easily assignable as individual lessons and with challenging exercises following each chapter. The 18 chapters are divided into three groups titled Background for Optical Computing, Subsystems for Optical Computing, and Architectural Models of Computation. This organization is excellent because it permits readers with various levels of knowledge of optical computing to readily locate the chapters of most interest to them. For example, readers familiar with the basics of Fourier optics, holography, and optoelectronic devices may choose to forego the first five chapters and begin with Sec. 2 on Subsystems for Optical Computing. Readers with extensive knowledge of optical interconnects, optical logic, and optical numerical computation may choose to begin with the final section on system architectures. Such selective reading is possible because the book is well organized and contains sufficient cross references. The many references to preceding material permits the selective reader to easily access text that may have been missed.

Two other strong points worth mentioning are the degree of illustration and referencing. Almost every key point is associated with an illustration that simplifies understanding of that point. This is especially advantageous in Secs. 2 and 3 for describing subsystems and architectures. With respect to referencing, the author did an excellent job of giving "credit where credit was due." A total of 293 references provides the interested reader with access to more detailed coverage of selected topics.

Chapter 1 focuses on a comparison of electronics and optics for achieving various computing functions. The level of this discussion is just right for this book, and the discussion is done in an unbiased fashion. Chapters 2 and 3 present the basic fundamentals of optics and are written so as to be easily understood by readers not previously familiar with optics. The discussion in Chap. 2 on lens design is more detailed than necessary for the purposes of understanding computer architectures and may be omitted by any reader who finds it difficult to understand. One basic concept that was omitted is dispersion, which is the key to understanding coherence length as discussed at the end of Chap. 2. Chapter 2 also needs a discussion of light detection (photon/electron conversion). This is important for an understanding of some of the device discussions in Chap. 4. The discussion in Chap. 3 on Fourier plane filtering could be improved with an illustration of the scaling factor and the resulting position invariance, which is a very important attribute in such optical filtering systems.

Chapters 4 and 5 present a good overview of optoelectronic devices that are, or soon are expected to be, available for constructing optical computers. One inconsistency is on the modulation rate achievable with laser diodes. The 10-GHz figure noted in Chap. 4 differs from the 30-GHz figure cited in Chap. 1. Both figures could be correct if one is careful to differentiate between what has been accomplished with an individual device in the laboratory and what has been realized in a system. This is the first known book to discuss devices and (in later chapters) systems based on electron trapping materials.

Chapter 6 on optical interconnections begins Sec. 2 on Subsystems for Optical Computing. The advantage of free space optics in crossbar switches and multistage interconnection networks (MINs) is only briefly mentioned. This represents a major niche for optics and should have been expanded. MINs are introduced under the topic of Regular Limited Interconnections, and are described in an exceptionally clear and easy to understand manner. Overall, Chap. 6 is highly recommended reading for anyone wanting an introduction to optical interconnection.

Chapters 7 and 8 cover optical memory and optical logic, respectively. Chapters 9 through 12 pull together the concepts of optical interconnection, optical memory, and optical logic to realize optical logic circuits and various numerical computational units. The discussions in these chapters are far more detailed than previous chapters, but such detail is necessary as a preamble to the architecture discussion in Sec. 3. Very little of the content of these chapters can be considered unimportant for what follows in Sec. 3. Chapter 12 will be of special interest to those readers desiring a better understanding of the numerical computation algorithms on which the majority of architectures are based.

Chapter 13 on optical sequential machines begins Sec. 3 on Architectural Models of Computation. This section of the book is devoted to assembling the subsystems introduced in Sec. 2 into complete optical computers. Although the real advantage of optics lies in parallel architectures, the optical sequential architecture introduced in Chap. 13 provides a good lead-in to a discussion of optical computer architecture. This is likely the only published description of a complete optical sequential machine. Because most existing electronic computers are sequential machines, this chapter provides a familiar baseline for discussing the application of optics to computer architectures.

The remaining chapters of the book cover optical parallel architectures, including data flow machines, cellular automata, and neural networks. The author does a good job relating the

vast knowledge base that has developed in the area of computer architectures with the capabilities of optical implementation, and he presents a significant number of original contributions. This is the first book to provide descriptions of massively parallel optical dataflow machines, an optical logic programming machine based on the artificial intelligence language PROLOG, and an optical cellular automata computer. Several of the architecture presentations in Sec. 3 are accompanied by discussions of some new and previously unpublished applications.

Overall, *Optical Computer Architectures* is a very good book. The book would probably qualify as great were it not for the large number of errors and inconsistencies. Many of these are typographical errors that frustrate the reader but do not affect the technical content. There are also many nontypographical errors, some of which could cause considerable confusion for the average reader. For example, on page 250 (paragraph on interconnections and advantages), mask M_4 should be mirror M_1 based on Figure 9.20. On page 329, Schur's algorithm should be said to be more efficient rather than less efficient. The discussion of the Levinson-Durbin algorithm on page 330 uses inconsistent notation. Figure 5.4 on page 105 is mislabeled. Page 228 contains incorrect usage of the conjunction "or" and logic "OR." These, along with numerous other such errors throughout the book, can lead to a significent level of confusion by readers. In addition, the index has numerous deficiencies. For example, the template matching reference lists only page 482, which contains only a minor reference to template matching, whereas an entire chapter subsection (7.3.1) is devoted to this subject but is not listed in the index. Shadow casting was introduced on page 116, but that reference is not in the index. The ultrahigh computational throughput of optical computers is not needed to eliminate such deficiencies from published material.

Electro-Optical Devices and Systems

M. A. Karim, 468 pages, illus., index, references, and four appendixes. ISBN 0-534-91630-9. PWS-Kent Publishing Company, 20 Park Plaza, Boston, MA 02116 (1990) $67.50 hardbound.

Reviewed by Ting-Chung Poon, Optical Image Processing Laboratory, Bradley Department of Electrical Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

This book provides an excellent selection of topics suitable for beginning graduate and advanced undergraduate students. What makes this text unique is the inclusion of some important concepts of atomic physics, quantum mechanics, and solid state physics in the beginning chapters (Chaps. 1 and 3). Also, Chap. 2 discusses radiometry and photometry, which are often neglected by modern optics texts. The coverage of these topics is concise. These chapters are brilliantly written and complement the material presented in subsequent chapters.

Chapter 4 is devoted to a discussion of optoelectronic devices including light-emitting diodes, photoconductors, photodiodes, and photomultipliers. The section on photoconductors is somewhat brief. This chapter also discusses other important devices such as charge-coupled imagers, cathode-ray tubes, and vidicons. Chapter 5 concentrates on the fundamentals of lasers and various laser systems. I particularly like the section on the Gaussian characteristics of the laser beam in which the Gaussian beam is derived directly from the wave equation. Also, this section has a nice touch in that it includes some of the author's research results on the measurement of the Gaussian beam diameter. The inclusion of a discussion on the free electron laser is informative. However, the development of ray matrices could have been done in Chap. 1 instead. Also, some examples on the derivation of these matrices would have been helpful.

Chapter 6 concisely covers noise in optical detection. Chapter 7 deals with the modulation of light via the acousto-optic, electro-optic, and magneto-optic effects. Considering the importance of acousto-optic devices in modern optical signal processing systems, I think the coverage of acousto-optics is too brief. The discussion on the principles of electro-optics and its applications is good and well developed. The discussion on liquid crystal light valves is an important inclusion for current modern optics texts. The section on image binarization (where the concept of the Fourier plane is used) could have been postponed to the next chapter in which Fourier optics is first introduced.

Chapter 8 covers the essence of Fourier optics and provides a nice example on spatial filtering. The section on holography is somewhat brief. This chapter also includes other selected topics such as nonlinear signal processing, pattern recognition, and optical computing. The definition of the spatial Fourier transform is different from that of the temporal transform, and to avoid confusion, the author should have made this difference clear. Finally in Chap. 9, the author discusses fiber optics based devices and systems. The principles of fiber optics as well as some integrated optics are covered.

In summary, the book is excellent overall. The selection of topics is quite good, and the coverage of these topics is reasonably balanced. I highly recommend the book to professors as well as optical engineers in the area of applied optics.

BOOKS RECEIVED

Digital Signal Processing, Theory, Applications, and Hardware, edited by Richard A. Haddad, Thomas W. Parson. 636 pp., illus., subject index, appendixes, references. ISBN 0-7167-8206-5. W. H. Freeman and Company Publishers, 41 Madison Avenue, New York, NY 10010 (1991). $54.95 hardbound. Covers numerical operations and system representation, digital representation of signals, two- dimensional signals and transforms, FFT and other fast transforms, design of DSP algorithms, least-squares optimal and adaptive filters, imaging processing applications, hardware realizations.

Laser Handbook, edited by W. B. Colson, C. Pellegrini, and A. Renieri. 528 pp., illus. ISBN 0-444-86953-0. Elsevier Science Publishers, P. O. Box 882, Madison Square Station, New York, NY 10159 (1990). $161.50 hardbound. Covers physics of the free electron laser and concepts in free electron lasers, laser undulators, electron trajectories and spontaneous emission, coherent harmonics generation in free electron lasers, quantum-mechanical analysis of the free electron laser, collective effects in the free electron laser, and single-pass free electron laser amplifiers.

Restoration of Images, edited by Reginald L. Lagendijk, Jan Biemond. 208 pp., illus., bibliography. ISBN 0-7923-9097-0. Kluwer Academic Publishers Group, P. O. Box 989, 3300 AZ Dordrecht, The Netherlands (1991). $67.50 hardbound. Covers image identification and restoration problem, image formation models, regularized image restoration, iterative image restoration, maximum likelihood image identification, methods for improved image identification, and image identification using the EM-Algorithm.

Development of the Visual System, edited by Dominic Mann-Kit Lam and Carla J. Shatz. 299 pp., illus. ISBN 0-262-12154-9. The MIT Press, 55 Hayward Street, Cambridge, MA 02143 (1991). $65.00 hardbound. Contains the 1990 Helmerich Lecture, cell lineage and cell fate in visual system development, specificity and targeting of retinal ganglion cell axons, specifications of visual cortical connections, and correlates of the critical period: experience-dependent development.

Artificial Vision for Mobile Robots, edited by, Nicholas Ayache. 344 pp., illus., subject index, references. ISBN 0-262-01124-7. The MIT Press, 55 Hayward Street, Cambridge, MA 02142. (1991). $45.00 hardbound. Eight chapters on stereo vision and eight chapters on multisensory perception.