Optical Computer Architectures:
The Application of Optical Concepts to
Next Generation Computers
Alastair D. McAulay, 547 pages, illus., index,
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0012 (1991) $59.95 hardcover.

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 technol-
ogy did not exist. Readers who desire knowl-
dge of what optics has to offer in future genera-
tions 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 de-
tailed 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 as-
signable as individual lessons and with chal-
lenging exercises following each chapter. The
18 chapters are divided into three groups titled
Background for Optical Computing, Subsystems
for Optical Computing, and Architectural Mod-
els of Computation. This organization is ex-
cellent 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 opto-
electronic devices may choose to forego the first
five chapters and begin with Sec. 2 on Sub-
systems 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 architec-
tures. 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 elec-
tronics and optics for achieving various comput-
ing 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 architec-
tures 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 understand-
ing 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 invari-
ance, 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 ex-
pected to be, available for constructing optical
computers. One inconsistency is on the modula-
tion 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 be-
 tween what has been accomplished with an indi-
vidual 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 repre-
sents 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 intercon-
nection, optical memory, and optical logic to realize
optical logic circuits and various numerical com-
putational 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 desir-
ing 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 Com-
putation. 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 architec-
tures, the optical sequential architecture intro-
duced 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 sequen-
tial 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 net-
works. 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 $M_0$ should be mirror $M_0$ based on Figure 9.20. On page 329, Schar'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 significant 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**


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, photodetectors, photodiodes, and photomultipliers. The section on photodetectors 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**


