DEPARTMENTS

BOOK REVIEWS

Spatial Light Modulator Technology: Materials, Devices, and Applications

Uzi Efron, Ed., 680 pages, illustrations, index, references, and no appendices. ISBN 0-8247-9108-8. Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016 (1995) $165 hardbound.

Reviewed by **Abdul A. S. Awwal,** Computer Science and Engineering, Wright State University, Dayton, OH 45435.

The spatial light modulator (SLM) is the single most essential component for optical information processing and visualization. An SLM is for an optical information processing system what an input/output device is for a digital computer, since to harness the enormous processing speed and power of optics, one must be able to encode two-dimensional information into optical form. Improvements in the speed and size of spatial light modulators today may be comparable to the advancement of early day computers in terms of bus size and speed.

SLM performance is directly linked with the performance of the optical information system, and has made possible the transition from film-based processing to real-time optical processing. SLMs may also serve as output devices (user interfaces) for computer visualization of information. In fact, the application of SLM technology to visualization is one of the vigorously pursued areas for possible application in high definition TV.

The population and economy involved in the worldwide consumer electronics market provide a constant impetus to advancing SLM technology. For all these various technological reasons and worldwide application, SLM technology is very lucrative to material scientists, optical engineers, and display engineers. Surprisingly though, there has been no good reference book in this area. The

book *Spatial Light Modulator Technology: Materials, Devices, and Applications,* edited by Uzi Efron, will definitely fill the void in this very important and emerging field. The multidisciplinary scope of the subject of SLM technology is well reflected in both the title and coverage of the book.

Materials required to construct an SLM are those that somehow can be electrically/optically controlled to impress a spatial pattern on an optical signal. The development of appropriate material is of great interest to chemists, physicists, and materials scientists. The book devotes 215 out of 665 pages to materials, namely, nonlinear organic and photorefractive materials and liquid crystals. In an appropriate device structure, materials undergo the necessary stimulus, under specific conditions, to exhibit optical properties, thus making SLM a reality. How the materials are put together in device form is a topic for device engineers and is elaborated in the second part of this book. In the devices area, multiple quantum wells, smart pixels, ferro-electrics, magneto-optics, acousto-optics, and charge transfer plate memories are covered. The optical engineer uses these devices in optical analog/digital computing, display optics, real-time holography, and other applications. The most contemporary applications, mentioned above, are covered nicely and thoroughly in the third section of this book.

For both flat panel display and light modulation applications there is lot of interest in the study of liquid crystal (LC) devices. Nematic LCs are discussed by Wu and novel electro-optic effects used for construction of LC-based (smectic LCs) devices are covered by Patel et al. Fundamentals and integrated optic applications of electro-optic polymer devices are covered by Garito et al., while the fourth chapter by Wood et al. discusses the basics and elaborates on tungsten bronze crystals with notes

on the applications of photorefractive effects.

The devices section starts with a chapter on multiple quantum well (MQW) devices and is authored by Efron himself, with the aid of Livescu from AT&T Bell Laboratories. The authors provide a very comprehensive and authoritative coverage on MQW SLMs (both Hughes and AT&T Bell Laboratories are currently involved heavily in MQW research).

The next important chapter is devoted to the rapidly advancing field of ferroelectric liquid crystal (FLC) SLMs. All three major types of FLC SLMs are covered; namely, optically addressable, electrically addressable, and active backplane SLMs. The chapter is authored by Moddel from the University of Colorado group, belonging to one of the most active groups in the areas of both SLM development and application.

The next chapter on acousto-optic modulators and charge transfer devices adds to the breadth of device coverage. Finally, a chapter on application-specific SLMs, such as smart pixel devices, makes a nice transition between the device and application aspects of the book, and also adds a nice edge to the emerging field of SLMs.

SLMs used for visualization/display and those used for computing/switching are the topics of the last section of this book. Owechko's impressive and broad coverage of both analog and digital optical processing plus Pepper et al.'s coverage of adaptive optics in the last chapter provide a very nicely balanced review of optical signal processing and computing. The section on display applications of SLMs is a very concise but informative section of this book. Other than display applications, telecommunication and switching applications provided one of the earliest motivations for research and development of the SLM technology (e.g., SEED devices at Bell Laboratories). A chapter by

two well-known experts, Dias and Goodman, has focused on this very important switching aspect of SLM applications.

The overall coverage of the book is excellent and well balanced. Efron has done a commendable job in bringing together well-respected expertise in the field and logically organizing the book chapters for a very diverse audience. The book is well illustrated and the subsections in each chapter make it easy to identify topics of interest from the table of contents. Although lack of exercises at the end of chapter does not make it suitable as a textbook, graduate students will definitely benefit from reading this book as a valuable source of reference and background material. The progression within a chapter from basic to advanced helps to familiarize a newcomer to this field with the necessary background and issues in SLM technology.

Different sections of the book will appeal to different audiences with varying expertise and interest. This is a great virtue of the book. If a three-person team were charged with locating appropriate material, and then building an SLM for a specific optical information processing application, then this book would serve as an up-to-date reference for all three. All three experts would want to have this valuable reference book on their desk. Even if a book of this size cannot cover everything (e.g., a chapter on deformable mirror device would have been nice), it has numerous recent references at the end of the chapters, which will quickly put one in contact with the right source.

Elements of Signal Detection and Estimation

Carl W. Helstrom, xvi + 586 pages, illustrations, index, references, problems following each chapter, and ten appendixes. ISBN 0-13-808940-X. PTR Prentice Hall, Englewood Cliffs, NJ 07632 (1995) $63 hardbound.

Reviewed by Timothy P. Grayson, USAF Wright Laboratories, Avionics Directorate, Electro-optic Sensors Branch, WL/AARI-2, Bldg. 622, Wright-Patterson AFB, OH 45433-7700.

In any system that involves the transfer and collection of information, it will at some time be necessary to detect a signal. This is the case in a communication system where a signal is generated and encoded by one user, is transmitted by some means, and then is detected by a distant user so that the information may be decoded. Similarly in radar and other remote sensing applications, a signal is generated and transmitted to an area of interest. Objects in that area of interest effectively "encode" the signal, which the radar receiver then detects to extract information about the remote object. The field of detection and estimation theory addresses the problem of identifying when a signal is present at a receiver and of extracting information from that signal by estimating key signal parameters. *Elements of Signal Detection and Estimation* by Carl W. Helstrom is an in-depth review of this theory.

In many regards, Helstrom's book is similar to the first volume of Harry Van Trees' similarly named book, *Detection, Estimation, and Modulation Theory,* and there are, of course, many similarities between the two. Helstrom, however, brings the material up to date and includes the important addition of numerical techniques. This is indeed one of the strong points of the book. While the concentration is predominantly on the development of the mathematical theory, each chapter includes an outline of numerical and approximation techniques used to solve frequently intractable integrals. While no actual algorithms or codes are given, as this would be outside the scope of the book, these descriptions of practical technique provide an invaluable starting point and a guide to more detailed information. There are even occasional discussions of computational efficiency, as this can be a determining factor in choosing an optimum detector.

The topic matter is appropriate for anyone working with signal detection, primarily radar and communications, but also including other areas such as sonar, seismology, and astronomy. While the material is applicable to all of these areas, the book has a definite bias toward radar. Much of the formalism fits closely with radar scenarios and most of the specific examples involve radar.

This book is quite suitable as a text, appropriate for the master's or doctoral level of study, and problems are included at the end of each chapter. While I confess to not working through the problems, they seem to compliment the content quite reasonably and encourage the reader to perform and verify some of the derivations stated in the body of the chapter. The text and illustrations are clear enough to be instructional for a student new to the subject. The book would likewise be appropriate as a reference for an engineer working in a field involving detection. It would be especially useful for someone involved with detection systems, but with a specialty in some other aspect of the complete system such as the transmitter hardware, who wants to become more familiar with the detection side.

The structure of the book progresses roughly from maximum *a priori* knowledge of the signal to minimum. The first chapter is a very general introduction to some of the statistical methods used throughout the book and to the two basic decision strategies. Each subsequent chapter follows a format based on deriving solutions to a particular detection problem under both of these decision criteria. While this chapter does a commendable job of covering all the necessary background subject matter and making the book self-contained, it is recommended that the reader have a fairly comfortable prior knowledge of statistics.

Chapters 2 through 4 deal with problems relating to the detection of a known signal in noise. Chapter 2 is the general detection problem. Chapter 3 deals with the specific but common case of detecting narrowband signals. This condition certainly applies to optical systems, as "narrowband" is defined to be any signal with a modulation bandwidth significantly less than the carrier frequency. Chapter 4 expands detection to the case of many sensors or multiple observations with a single sensor, and even includes an introduction to phased arrays.

Chapter 5 is a digression to discuss in detail evaluation techniques for various intractable integrals that become part of detection problems. Both outlines of numerical techniques as well as analytic approximations are discussed. While this is an extremely worthwhile chapter, useful even as a stand-alone reference, its placement is questionable. It tends to disrupt the flow of the book and is forward referenced by preceding chapters. However, this may be as reasonable a location as any. If placed earlier, the integrals discussed would be out of context, while later placement would require the reader who is only interested with the detection portion of the book to search further for evaluation techniques.

Chapters 6 and 7 address the problem of signal estimation, detecting a signal when one or more parameters are unknown, and determining a value for the parameters. Chapter 6 covers the problem of estimating parameter values when a signal is known to be present, and Chap. 7 extends the theory to the full problem of detection and estimation. The pattern of development is similar to that of Chaps. 2 through 4.

Chapter 8 addresses the problem of least *a priori* knowledge. One section looks at the problem of detecting a signal when no *a priori* knowledge is available about the noise strength, while the second section addresses nonparametric detection. In this scenario, the user does not even know what kinds of parameters the signal possesses, if any.

The remaining chapters cover a few special topics. Chapter 9 covers sequential detection. In a sequential system the decision process is ternary. A decision is made that a signal is present, that it is not present, or that not enough information is available and another measurement should be taken. Chapter 10 addresses signal resolution, including temporal resolution and detection of signals in clutter. Some techniques are described for

enhancement of resolution through the detection process. Chapter 11 repeats much of the earlier formalism of the book for the case of stochastic signals. These are to be distinguished from unknown signals by the fact that there is a random pulse-to-pulse variation in one or more signal parameters. Finally, Chap. 12 describes a few examples of the detection of optical signals. The appendixes provide solutions to some of the more complicated calculations, discussion of integral equation solution techniques, and more detail on certain statistical methods, including details about some special probability density functions.

From the perspective of an optical engineer, the coverage of optical systems is very limited. Helstrom does address some important issues such as photon counting statistics, common noise sources in optical systems, and some specific types of photodetectors. But the coverage is brief for the amount of material, and is therefore somewhat incomplete. A fairly strong prior knowledge of optical detectors is necessary. Nonetheless, the first eleven chapters are still general enough to be relevant to optical systems, and many useful, more detailed references are provided for the optics-specific topics.

In conclusion, Helstrom's book provides a very nice review of detection and estimation theory. The writing is very clear and easy to understand. I would highly recommend it for advanced students and engineers who want to learn about general detection theory. I do not recommend it from the perspective of optical systems. For someone with a strong prior background in optical detection, working for example in laser radar or optical communications, this book would be an excellent resource to learn about processing and interpreting the electrical signal that comes after their photodetector.

BOOKS RECEIVED

Frequency Stabilization of Semiconductor Laser Diodes, by Tetsuhiko Ikegami, Shoichi Sudo,and Yoshihisa Sakai. Subject index, references following each chapter, list of acronyms. ISBN 0-89006-648-5. Artech House, Inc., 685 Canton Street, Norwood, MA 02062 (1995) $88 hardbound. The object of this book is to explain in detail the performance characteristics of semiconductor laser diodes, how the operation frequency of semiconductor lasers can be stabilized, the frequency references for the laser stabilization, and how frequency-stabilized lasers are employed in a wide variety of applications.

Coherent Lightwave Communication Systems, by Shiro Ryu. Subject index, references and summary following each chapter, list of acronyms. ISBN 0-89006-612-4. Artech House, Inc., 685 Canton Street, Norwood, MA 02062 (1995) $79 hardbound. Discussions of some of the topics in this book stress comparisons between coherent and IM-DD systems to give readers a better understanding of the features of coherent systems. New trends toward future lightwave communication systems, such as all-optical signal processing technology, are also covered.

Optical Fiber Amplifiers: Design and System Applications, by Anders Bjarklev. Subject index, references, and summary following each chapter; list of acronyms; list of symbols. ISBN 0-89006-659-0. Artech House, Inc., 685 Canton Street, Norwood, MA 02062 (1995) $88 hardbound. This book presents a review of the properties of optical fiber amplifiers, with a specific focus on the telecommunication engineering aspects.

Fiber Optic Smart Structures, edited by Eric Udd. xii + 671 pages, illustrations, subject index, references, and summary following each chapter. From the Wiley Series in Pure and Applied Optics. ISBN 0-471-55448-0. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012 (1995) $74.95 hardbound. Covers important aspects of fiber optics smart structure technology, including its history and evolution, background technologies, structural and assembly issues, sensing devices, and numerous applications.

Optical Computing, edited by Brian S. Wherrett. xxii + 660 pages, illustrations, references following each paper. Number 139 in the Institute of Physics Conference Series. Proceedings of the International Conference on Optical Computing, Heriot-Watt University, Edinburgh, UK, 22–25 August 1994. ISBN 0-7503-0126-0. Institute of Physics Publishing, The Public Ledger Building, Suite 1035, Independence Square, Philadelphia, PA 19106 (1995). Coverage of this meeting includes: fundamental information theory in photonics; optical phenomena and devices; architectures and processor implementations; integration and packaging issues.

Laser Experiments for Beginners, by Richard N. Zare, Bertrand H. Spencer, Dwight S. Springer, and Matthew P. Jacobson. xvi + 232 pages, illustrations, subject index, references following each experiment. ISBN 0-935702-36-9. University Science Books, 55 D Gate Five Road, Sausalito, CA 94965 (1995) $26.50 softbound. This book presents a series of experiments for in-class demonstrations or student activities. Quick reference instructions identify needed equipment, recommended safety practices, and help select desired experiments. The book is designed to enhance existing courses in chemistry, physics, and biology.

Lasers: Theory and Practice, by John Hawkes and Ian Latimer. xiv + 520 pages, illustrations, subject index, problems and references following each chapter, list of symbols, nine appendixes. From the Prentice Hall International Series in Optoelectronics. ISBN 0-13-521493-9. Prentice Hall, Inc., Old Tappan, NJ 07675 (1994) $39 softbound. This book on lasers covers both the theoretical and practical sides of the subject. The material is organized in such a way that students with little or no prior knowledge of quantum mechanics can avoid the more theoretical sections and still gain a good appreciation of the physics of lasers.

Newton to Einstein: the Trail of Light, by Ralph Baierlein. xvi + 329 pages, illustrations, subject index, questions following each chapter, three appendixes, glossary. ISBN 0-521-41171-8. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211 (1992) $34.95 hardbound. This undergraduate text takes the reader along the trail of light from Newton's particles to Einstein's relativity. The first seven chapters describe how light behaves, develop Newton's particle theory, introduce waves and an electromagnetic wave theory of light, discover the photon, and culminate in the wave-particle duality. The book then goes on to develop the special theory of relativity, showing how time dilation and length contraction are consequences of the two simple principles on which the theory is funded.

Wavelets and Operators, by Yves Meyer. xv + 223 pages, subject index, references. Volume 37 in the Cambridge Studies in Advanced Mathematics. ISBN 0 521 458692. Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211 (1992) $27.95 softbound. Covers: Fourier series and integrals, filtering and sampling; multiresolution approximation of $L^2(R^n)$; orthonormal wavelet bases; nonorthogonal wavelets; wavelets, the Hardy space H^1 and its dual BMO; and wavelets and spaces of functions and distributions.