

Introduction to the Special Issue on Optical Computing

IN introducing what some may consider an unusual special issue, it is appropriate to recall that at the 1967 Fall Joint Computer Conference, the name of this journal was changed from IEEE TRANSACTIONS ON ELECTRONIC COMPUTERS to IEEE TRANSACTIONS ON COMPUTERS. This Special Issue on Optical Computing aptly reflects the broad aspects of computing for which this journal was intended.

The field of optical computing encompasses many diverse disciplines, but in all cases is based on the concepts of Fourier optics and holography. For a review of these principles, the reader is referred to [1] and [2]. Researchers in optical computing tend to publish in a multitude of journals, and often only one or two sessions at large conferences contain their research results. This is due to many factors. Data that are processed optically are obtained from a variety of sources: optical, microwave, acoustic, or electronic, and are thus reported in these journals, whereas the elements used in an optical computer are reported on in device or solid-state journals. These facts, coupled with the multitude of diverse disciplines to which optical computing has been applied, make it difficult to keep abreast of this area of computing. To alleviate this problem, the first International Optical Computing Conference was held last April in Zurich [3]. This was the outgrowth of a highly successful one-day 1972 Optical Computing Symposium [4]. Both of these meetings and the forthcoming April 1975 International Optical Computing Conference [5] were fittingly sponsored by the Computer Society of the IEEE.

For these reasons, we welcome this opportunity to present a unified state-of-the-art summary of optical computing in this one special issue. Ten of the fifteen papers in this issue are expanded versions of papers at the 1974 International Optical Computing Conference (IOCC) [3]. Some additional background is provided in each paper to present a more complete description of the many facets of optical computing. Even this one special issue is not a complete description of this field, but it should serve as a stimulant and guide for researchers and applications. There were four sessions at the 1974 IOCC: Optical Computing Systems, Holographic Imaging, Holographic Interferometry, and Coded Aperture. For a brief survey of these four areas, the reader is referred to the 1974 Special Issue on Optical Computing of the *Journal of the Society for Information Display* [6], edited by Prof. Casasent. The May 1974 special issue of *Optical Engineering* [7] is devoted to digital and optical image processing. Additional review papers and texts on optical computing exist [8]–[10]. The digital aspects of image and signal processing have been adequately summarized in two recent special

issues of the PROCEEDINGS OF THE IEEE [11] and IEEE TRANSACTIONS ON COMPUTERS [12].

The evolutionary nature of optical computing was recently pointed out by Prof. G. W. Stroke [3]: "... the leading originators of the field of optical image processing were themselves, in many cases, pioneering creators of digital image processing methods as well. They are thus appropriately familiar with the complementary capabilities of both processing methods." The complementary nature of the disciplines of optical and digital image processing is emphasized in the first three papers in this issue. Prof. H. Stark's paper, "An Optical/Digital Computer for Parallel Processing of Images," emphasizes the use of such a hybrid system in texture analysis. The hybrid system described by Prof. D. Casasent and W. Sterling in their paper, "An Optical/Digital Processor: Hardware and Applications," includes applications in area, image, and text correlation, as well as in radar signal processing. While much of the optical computing work is still in laboratory stages of development, the hybrid system described by Dr. D. McMahon *et al.* is commercially available and described for the first time in their paper, "A Hybrid Optical Computer Processing Technique for Fingerprint Identification." One of the most recent milestones in optical computing has been the emergence of such hybrid optical/digital processors [13]. One of the highlights of the 1975 IOCC [5] will be a panel discussion on optical and digital processing, the results of which will be contained in a July 1975 (tentative) IEEE SPECTRUM article.

The fourth and fifth papers in this present special issue advance other aspects of digital and optical processing. In the paper by Dr. P. Stucki, the use of digital simulation in optical systems is discussed, and the use of solid-state scanning array detectors as optical-to-digital interface devices is noted. The use of optical and numerical reconstruction techniques in microwave imaging of anomalies in optically opaque materials is discussed in the paper by Drs. Yue, Rope, and Tricoles.

In Prof. Preston's paper, "A Comparison of Analog and Digital Techniques for Pattern Recognition," in the October 1972 Special Issue on Digital Pattern Recognition of the PROCEEDINGS OF THE IEEE, he notes several areas in which optical computing techniques are superior. One of these areas is biomedical imaging and processing. The sixth paper in this issue by Dr. H. Weiss describes coded aperture imaging, and presents the recent on-line tomosynthesis results of Philips Laboratories, Germany. Real-time images of the internal structure of metallic and biological objects are included in the Bragg-diffraction acoustic imaging work of Prof. G. Wade, H. Keyani, and S.C. Pei in the seventh paper.

One of the major research efforts in optical computing is holographic and optical storage for computer memories. The paper by Drs. C. Butter and T.C. Lee, "Thermoplastic Holographic Recording of Binary Patterns in PLZT Line Composer," presents several new advances in this field. A recent special issue of *Applied Optics* [14] contains a complete summary of research in this area. One of the major impediments to the realization of many optical computing devices and systems that exhibit the full throughput and computing power possible in a parallel optical processor has been the realization of real-time input and matched spatial filter recording devices. This paper notes recent advances on two materials for such an on-line spatial light modulator.

In the papers by Casasent, Weiss, and Kock, a KD_2PO_4 light valve is used as a real-time input and reconstruction device in an optical computer. Prof. W. Kock's paper, "A Real-Time Parallel Optical Processing Technique," also contains examples, a summary, and references to the excellent results obtained by optical computing in synthetic aperture radar. The area of ultrasonic holographic Fourier spectroscopy is discussed by Profs. P. Greguss and W. Waidelech in which use is made of a new liquid crystal cell as an acoustical-to-optical converter for real-time display. In the eleventh paper, "Character Recognition with a Coherent Optical Multichannel Correlator" by Dr. G. Winzer, the use of optical computing in character recognition is presented, and yet another real-time electrical-to-optical transducer, the acoustooptic cell, is discussed.

In "Parallel Image Processing" by Prof. C.D. Stamopoulos, the parallel processing advantages of an optical computer are emphasized, and examples of processing results obtained on a digital cellular array processor are presented.

The final three papers present yet other aspects of optical computing. The Fourier transform property of a lens is used by Profs. F. Lanzl and H. Heitman in "Direct Coherent Optical Fourier Transform of Curves." While most optical data processing operations are linear transformations, the possibility of performing nonlinear processing exists, and it is discussed in the paper by Prof. N. Farhat with several examples of applications of such operations.

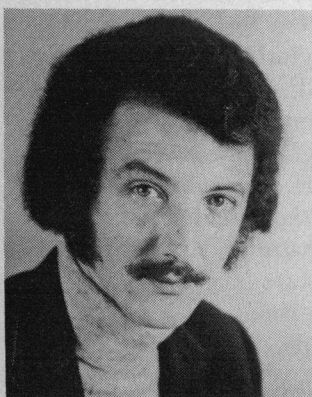
Holographic interferometry and its use in nondestructive testing has been another major application area for optical computing. A unified approach to interferometry, holography, and the seeing problem is presented in the final paper by Drs. R. Bates and P. Gough.

Optical computing is still in its infancy. It is hoped that the real-time devices and hybrid optical/digital systems, together with the application areas covered in these fifteen papers, present a unified treatment of this aspect of computing. We thank Prof. Short and the staff of this journal for this opportunity, and the Computer Society of the IEEE for their continued support of the International Optical Computing Conferences. We hope that this will aid in bringing the disciplines of and researchers in optical and digital processing closer together so that the complementary aspects of these technologies can be better combined to produce more powerful data and information processing systems.

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SAMUEL HORVITZ
Guest Editors

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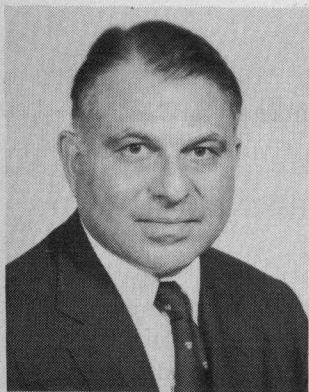


David Casasent (S'68-M'69-SM'74) received the Ph.D. degree in electrical engineering from the University of Illinois, Urbana, in 1969, where he was a Research Assistant in the Digital Computer Laboratory and performed research in optical data processing.

In 1969 he joined the faculty at Carnegie-Mellon University, Pittsburgh, Pa., where he is currently an Associate Professor of Electrical Engineering. He is also presently a Consultant to the Digital Equipment Corporation, Battelle Research Laboratories, Los Alamos Scientific Laboratories, and others. His areas of research include digital and optical data processing and radar. He is the author of two textbooks and over forty technical journal papers.

Dr. Casasent has served on the Organizing and Review Committees of several conferences, and most recently, he was Program Chairman of the 1974 International Optical Computing Conference, Zurich, Switzerland. He is President-Elect of the Pittsburgh Section of the Optical Society of America, Faculty Advisor to Eta Kappa Nu, and Past

Chairman of the Pittsburgh Section of the IEEE Electron Devices Group. He was Guest Editor of the August 1974 special issue of the *Journal of the Society for Information Display*. He is a member of the Optical Society of America, the American Society of Photogrammetry, the Society of Photo-Optical and Instrumentation Engineers, the Society for Information Display, the New York Academy of Science, and Eta Kappa Nu.



Samuel Horvitz (A'58-M'68) was born in Fall River, Mass., on February 10, 1916. He received the B.A. degree from Williams College, Williamstown, Mass., in 1936. Since then he has done graduate work in residence at Harvard University, Cambridge, Mass., and the Massachusetts Institute of Technology, Cambridge.

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23-25.
