SYNTHESIS OF GENERALIZED COHERENT OPTICAL PROCESSOR. (U)
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SYNTHESIS OF GENERALIZED COHERENT OPTICAL PROCESSOR

by

F. Paul Carlson

U of W Technical Report No. 220
ONR Contract No. N00014-76-C-0522
Task No. NR 350-005
FINAL REPORT
1 August 1975 - 30 September 1978
August 1980

Scientific Officer
Mr. Joel Trimble

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Prepared for
Office of Naval Research
Mathematical and Information Sciences Division
Code 437
Arlington, Virginia 22217
UNIVERSITY OF WASHINGTON
COLLEGE OF ENGINEERING
Department of Electrical Engineering
Seattle, Washington 98195

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ABSTRACT

This final report gives a summary of all the work completed under this contract, covering the period from August 1975 to September 1978. The work covers a broad spectrum of activities, including generalized operator theory for coherent optical processors to specific realizations of processor elements and algorithms.

The emphasis is directed towards generating new ideas to solve theoretical as well as practical problems. Success in our effort is evidenced by the list of reports and publications.
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1. **Introduction**

Our effort for the past three years has been centered on the following related subjects:

1. General optical processor theory
2. Adaptive optical processors
3. Application of photodichroic materials
4. Fiber optic and integrated optical switches, multiplexers, and modulators
5. Applications to high data rate ocean surveillance data reduction problems and algorithms.

Our primary effort was to concentrate on generating new ideas and formalisms for which no previous formal work had been done. Secondly, to find practical realizations and application of these ideas and methodology.

A brief description of each research area follows in this report along with a list of publications.

II. **General Optical Processor Theory**

This first effort concentrated on general studies of the n-plane optical processor. This entailed explorations of the 5-, 6-, and n-plane processors in terms of existence and realizability tests, and in terms of realistic information processing measures for the general ocean surveillance problem. The algebraic and algorithmic implications of this n-plane analysis approach showed the basis of a generalized optical computing theory. Our work has shown that the Fourier processor and the correlation/convolution processors are the simplest non-integral processors (2- and 3-plane processors) that arise in this n-plane formalism. The 4-plane system has led to a general description of the ambiguity function
optical processor and to an oblique to rectangular image erecting system. Although these realizations do not represent the most general realizations in a 4-plane system, existence and realization tests have been derived for the test of any 4-plane realization. The details of this work are presented in publications 1-3, 5, 7, 8, 9, 11 and 12 and presentations 1, 2 and 4.

III. Adaptive Optical Processors

Our second focus was on the general extension of the work in adaptive optical processors. Our work has shown that hybrid optical/digital adaptive systems can be synthesized for pattern recognition and detection/counting data processing problems. Details of work accomplished are presented in publications 4 and 6 and in presentation number 3.

IV. Application of Photodichroic Materials

The third area involved the pursuit of the development of real-time, thin-film dichroic photographic film. It now seems possible to develop a reusable and modifiable film for use in optical processor interface applications. Our work with the evaporation of colored photodichroics onto appropriate substrates and with ion-implanted thin-films has shown that writeable photodichroic media can be achieved. The efficiencies are within 35% to 45% of that achievable with bulk materials. In addition the media seems stable with minimal diffusion to the film surface. From our early tests it appears that multiple implanted layers will yield the needed optical density ranges while preserving media integrity. Details of this work are presented in publications 8 and 13.
V. Fiber Optic and Integrated Optical Switches, Multiplexes, and Modulators

A fourth area of work was on integrated optical switches, multiplexers, and modulators. It appeared that the Marcatelli technique of tuned resonator coupling could be used as either an integrated optical switch, multiplexer/demultiplexer, or modulator/demodulator system in hybrid fiber-integrated optical systems. We explored how to overcome the problems encountered by Marcatelli by using an electric field to tune the resonator length. These electric field techniques have been used by NRL and NOSC in the development of simple integrated optical phase controlled switches.

Details of this work are presented in technical reports 2 and 3.

VI. Applications to High Data Rate Ocean Surveillance Data Reduction Problems and Algorithms

We explored the application of the above optical computing theory and device realizations to the high data rate problems associated with the ocean surveillance data reduction problem. This involved specific exploration of how to best realize the ambiguity function algorithm. Several models were explored and discussed in publications 2, 3, 5, 7-12 and technical report 4.

Higher-order algorithms were explored and discussed in detail in publications 3, 5, 7-11, technical report 4, and in presentations 2-4. The higher order algorithms turned out to be particularly important in problems where library spectra or signature were to be compared and correlated simultaneously with the basic processing algorithm. In addition, higher order correlations like the ambiguity function are desirable when multi-dimension signals and tracks are compared and tested, even including multi-dimensional doppler signals.
VII. Personnel

Dr. F. Paul Carlson, Principal Investigator

Dr. John L. Bjorkstam, Co-principal Investigator

Research Assistants

- Mr. R. E. Francois, Jr. (Ph.D. 1978)
- Mr. C. K. Lee (Ph.D. 1980)
- Mr. C. K. Lau (M.S. 1976)
- Mr. A. Richter (Ph.D. expected 1981)
- Mr. M. Mueller (Ph.D. 1975)
- Mr. C. T. Chang (Ph.D. 1976)
LIST OF PUBLICATIONS ACCOMPLISHED
UNDER SUBJECT CONTRACT

Journals


Presentations (unpublished)


Books


Technical Reports


This final report gives a summary of all the work completed under this contract, covering the period from August 1975 to September 1978. The work covers a broad spectrum of activities, including generalized operator theory for coherent optical processors to specific realizations of processor elements and algorithms.

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### KEY WORDS

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