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Contributed Papers

ThE1. Technique of Incoherent Optical Processing. F. T. S. YU AND ANTHONY TAI, *Electrical and Computer Engineering Dept., Wayne State University, 5050 Anthony Wayne Dr., Detroit, Mich. 48202.*—One of the most interesting and important applications of optical information processing is signal detection by complex spatial filtering. However, most of the complex optical processing techniques require a coherent source. But coherent optical processing systems are plagued with the well-known artifact noise, which in practice is unavoidable. Although techniques of optical information processing by incoherent light are available, they generally have a serious shortcoming; namely, the production of error terms due to the bias level in the signal and other transparencies. In this paper, we propose a new technique that permits signal detection by complex spatial filtering to be carried out with a spectrally incoherent light source (i.e., a white light source). Our processing system can be used for signal detection, i.e., matched filtering. Since all the spatial filters, including real and pure phase filters, can be synthesized by means of interferometric technique, this technique can also be applied to some problems in the complex spatial filtering. Although this incoherent processing technique applies to two-dimensional objects, the operation to be performed must be one dimensional. In addition, the application of this techinque to smeared-image restoration, and to image subtraction and addition, will also be provided. (13 min.)

ThE2. Microcomputer-Based Hybrid Processor Applied to New Optical Processing Applications. JAMES R. LEGER, JACK CEDERQUIST, AND SING H. LEE, *Applied Physics and Information Science Dept., University of California, San Diego, La Jolla, Calif. 92093.*—A hybrid optical-electronic processor has been developed for coherent processing. The electronic portion consists of a microcomputer, a television digitizer, and a video disk. The microcomputer controls a laser scanner which provides the capability to make accurate zero-order and holographic spatial filters of high resolution. With the present system, filters which contain 10^7 Raleigh limited points can be generated. The output of the optical portion is detected by a television camera, digitized in real time, and stored in a buffer memory. The digital data is then analyzed by the microcomputer and the result is displayed on a T.V. monitor or stored on the video disk for further processing. A 2% accuracy has been achieved with this television digitizer–microcomputer combination. For the optical portion of the hybrid processor, two variations have been used. The first is a confocal Fabry-Perot interferometer employing optical feedback for solving a wide variety of partial differential equations. The second, a coherent optical correlator using special coding techniques, performs generalized two-dimensional linear transformations, and generates the transform coefficients in parallel. Experimental results for both applications will be presented. (13 min.)

ThE3. New Developments in the Use of Incoherent Optical Systems for Matrix-Vector Multiplication.* J. W. GOODMAN, A. R. DIAS, L. M. WOODY, AND J. ERICKSON, *Electrical Engineering Dept., Stanford University, Stanford, Calif. 94305.*—A ten-channel incoherent matrix-vector multiplier is under construction. Data is entered by means of an array of ten infrared light emitting diodes, each modulated with 10 MHz of bandwidth. Data is extracted by a PIN detector array with ten parallel electronic channels. Various suitable optical systems are described, including one that uses planar waveguides. By use of biased real and imaginary parts, complex arithmetic is carried out, allowing a discrete Fourier transform to be performed. A microcomputer periodically probes the system with known inputs, adjusting input and output electronic gains to maximize accuracy. Various methods for extending operation of the processor to two-dimensional data are described. The most attractive approach uses an array of analog chirp-Z transform devices to perform Fourier transforms in one direction, and the incoherent processor to perform Fourier transforms in the orthogonal direction. In this manner, large space-bandwidth products can be achieved with no reduction of throughput rate. (13 min.)

* Work supported by the Ballistic Missile Defense Advanced Technology Center of the U.S. Army.

ThE4. Input Scanning Technique for Coherent Processing.* E. LEE KRAL, MARION O. HAGLER, AND JOHN F. WALKUP, *Dept. of Electrical Engineering, Texas Tech University, Lubbock, Tex. 79409,* and ROBERT J. MARKS II, *Dept. of Electrical Engineering, FT-10, University of Washington, Seattle, Wash. 98195.*—A common approach in real-time optical processing is to utilize a spatial light modulator as the input to a linear coherent processor. As an alternative, the input may be formed by temporally modulating the amplitude and/or phase of a scanning laser beam. In the input plane of the system a photosensitive medium, ideally erasable, is used to holographically record the interference pattern of a stationary reference beam and the time-varying output of the processor whose input plane is being scanned. The resulting hologram, when played back, yields a diffracted term proportional to the output which would have resulted if instead the input had been encoded spatially. Some potential advantages of this input scanning technique include the possibility of representing complex inputs. The technique is applicable to all linear coherent processors, including those which are space variant. In addition to describing the basic theory of the processor, preliminary experimental results will be presented. (13 min.)

* Research supported by AFOSR Grant No. 75-2855.

ThE5. Real-Time Optical Phase Measurement. LEE M. FRANTZ (introduced by A. A. Sawchuk), W. VON DER OHE, AND A. A. SAWCHUK,* *Systems Group Research Staff, TRW Defense and Space Systems Group, One Space Park, Redondo Beach, Calif. 90278.*—A method for the real-time measurement of optical phase has been developed. The optical wave whose phase is to be measured is interfered with a spatially coherent plane-wave reference on the face of a photodetector array. The irradiance is measured simultaneously at all array elements for each of three specific phase shifts of the reference. The phase (and magnitude) at each array element is then calculated from the three measured irradiances by a very simple algorithm. The method can be utilized for hybrid optical-digital analog computation of two-dimensional Fourier transforms. Information is introduced coherently into the front focal plane of a lens with a spatial light modulator and the phase and magnitude are measured in the back focal plane. Other applications will be discussed, and experimental results of the Fourier transform technique will be presented. (13 min.)

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ThE6. Perception and Estimation of Dot Frequency. E. P. HORNE AND C. E. TURNBULL, *Dept. of Psychology, University of Florida, P.O. Box 14445, Gainesville, Fla. 32604.*—Estimation of numerosity for displayed information was reported in a 1974 paper (OSA). Experimental variables studied were number of dots per display card, dot color, background illuminance, ascending versus descending order of presentation, and sex. Each observer viewed 42 cards each displaying dots of one of three colors randomly dispersed over a background of one of two levels of luminance, at each of seven frequency levels. Each observer viewed the display for 1 s with the