R.J. Marks II, J.F. Walkup and C.A. Irby "Techniques in one-dimensional space-variant processing",
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if either of these conditions is not satisfied. In order to generate an optimum matched filter for the detection of signals in multiplicative nonwhite random noise (e.g., speckle noise) the input signal is first logarithmically transformed to produce an additive form.[1] The noise characteristics after the logarithmic transformation are generally difficult to evaluate. A statistically averaged whitening filter is utilized to prewhite the noise spectrum to obtain an optimum matched-filtering process. Comparisons with the conventional matched filtering are presented. (13 min.)

[1] Anthony Tai, Thomas Cheng, and F. T. S. Yu, "Logarithmic Transformation Using Inherent Film Non-linearity," Appl. Opt. (to be published).

FB13. White-Light Information Processing. E. LEITH AND J. ROTH, *Electrical and Computer Engineering, University of Michigan, Ann Arbor, Mich. 48109.*—We describe techniques for improved information processing and holography through the development of optical systems that perform coherent operations using white light. These systems are linear in complex amplitude, yet possess the low-noise capabilities of conventional incoherent systems. The theoretical performance and practical limitations of these systems are analyzed, with emphasis on the enhancement of SNR obtainable by broadening the source spectral distribution and modification of the system bandwidth. Experimental results are given. (13 min.)

FB14. Pupil Function Replication in OTF Synthesis.* B. BRAUNECKER,† W. T. RHODES,‡ AND R. HAUCK, *Physikalisches Institut der Universität, D 8520 Erlangen, Federal Republic of Germany.*—Computer-generated pupil transparencies play an important role in diffraction-limited (i.e., non-image-casting) spatial filtering with spatially inchoherent optical systems. By replicating the basic two-dimensional pupil function structure in a regular array, it is possible to increase system light efficiency, to reduce the effects of pupil plane noise sources, and to eliminate virtually all effects of aliasing errors that result from filter design procedures typically employed. A general analysis with experimental confirmation is presented. (13 min.)

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FB15. Incoherent Imaging and Source Size: A Fourier Optics Approach.* W. T. RHODES, *School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga. 30332.*—We present a simple condition for determining whether an optical system for imaging transilluminated objects is spatially incoherent or not. The approach is based on a Fourier optics treatment of an imaging system and is thus particularly useful in the context of optical information processing applications. Only light amplitude and irradiance distributions are involved in the analysis. The approach is conceptually appealing, having a convenient physical interpretation. Critical considerations are the size of the pupil plane aperture and the spatial extent in the pupil plane of the Fourier transform (Fraunhofer pattern) of the object transparency. (13 min.)

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FB16. Methods for Performing Complex-Valued Data Processing Operations with Incoherent Light. J. W. GOODMAN AND L. M. WOODY, *Dept. of Electrical Engineering, Stanford University, Durand Bldg. 127, Stanford, Calif. 94305.*—Incoherent optical systems, being linear in intensity, are limited to performing real and non-negative operations on real and non-negative input data unless some special form of data encoding is used. In this paper we consider the number of real and non-negative operations required to order to perform a single complex-valued operation, such as the discrete Fourier transform. Decomposition of complex quantities into real and imaginary parts, each of which is placed on a bias, in general results in unknown, signal-dependent output bias terms. Decomposition of complex numbers into four real and non-negative parts results in 16 operations being required for a single complex operation. Decomposition of complex numbers into three real and non-negative parts results in nine operations per complex operation. If preprocessing additions and postprocessing subtractions can be performed, six real and non-negative operations can realize a single complex operation. However, a realization requiring only six operations may require an output device with greater space-bandwidth product than a realization requiring nine operations. Six real and non-negative operations appears to be the minimum possible number required for one complex operation. (13 min.)

FB17. Transform Relationships for Optical Heterodyne Signal Processing.* JAMES M. FLORENCE AND W. T. RHODES, *School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga. 30332.*—Coherent optical systems for processing temporal signal waveforms often employ optical heterodyne detection as an important part of the processing operation. Acousto-optical cells can be used to produce the input signal distribution for such systems. The output signal is obtained by mixing the Fourier transform of the (moving) input signal with a local oscillator reference wave at the surface of a large area detector. Systems of this type have been used for modulation and filtering and for the simulation of complex electrical networks.[1] Korpel has noted that the exact plane of detection is unimportant as long as all of the light from the interfering distributions is collected by the detector.[2] This condition is easily proved using conservation of (photon) energy arguments. We present here an alternate proof, based on the Fourier theory, that provides additional insight into the signal processing operations performed. The proof is easily established for planes between which a Fourier transform relationship exists, being a statement of Parseval's theorem. We also extend the analysis to include the more general case where a Fresnel transform relationship exists between planes. (13 min.)

*Work supported by the NSF.

[1] R. Whitman, A. Korpel, and S. Lotsoff, in Proceedings of the Symposium on Modern Optics, Polytechnic Institute of Brooklyn, March 1967.

[2] A. Korpel, in *Optical Information Processing*, edited by Yu. E. Nesterikhin, G. W. Stroke, and W. E. Kock (Plenum, New York, 1976).

FB18. Techniques in One-Dimensional Space-Variant Processing.* ROBERT J. MARKS II, J. F. WALKUP, AND CARL A. IRBY, *Dept. of Electrical Engineering, Texas Tech University, Lubbock, Tex. 79409.*—Conventional coherent optical processors are primarily utilized for performing two-dimensional convolution and Fourier transform operations. Recent efforts [1-3] have been concentrated on using coherent processors to perform a much wider class of *one*-dimensional linear space-variant operations. Such processors require a one-dimensional input and a mask, possibly holographic, on which the kernel of the linear operation is recorded. Spherical and cylindrical lenses are used to perform desired Fourier transform and imaging operations and the corresponding one-dimensional output appears along a line in the processor output plane. For a given linear operation, there may exist a number of corresponding processors.[2] Design concerns include aliasing reduction, linear kernel mask implementability, real-space compactness, and the number of required optical elements. Specific processor designs, including an inverse Abel transform processor, are discussed. We also show that some linear operations can be performed with no aliasing effects, utilizing only a one-dimensional input, a mask, and a few centimeters of free space. Illustrative examples and experimental results will be presented to illustrate the theory. (13 min.)

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