R.J. Marks II, J.F. Walkup, M.O. Hagler and T.F. Krile,
"General one-dimensional space-variant coherent optical processors",
Journal of the Optical Society of America, vol. 66, p.1130A (1976).

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## Information Processing

### *Contributed Papers*

**FB11. Nonlinearities in Projection Reconstruction.** R. E. ALVAREZ,* J. P. STONESTROM, AND A. MACOVSKI, *Electrical Engineering Dept., Stanford University, Durand Room 111, Stanford, Calif. 94305.*—The basic data required by a projection reconstruction system are the line integrals of the function being reconstructed. These line integrals must be calculated from physical measurements and will inevitably contain errors and nonlinearities. In any practical system the nonlinearities must be small and may be described by a power series with a small number of terms. We describe the artifacts in the final reconstructed image caused by nonlinearities of this type. The power series model may be used to describe an important artifact in medical x-ray projection reconstruction systems due to the use of a broad spectrum x-ray beam to measure the line integrals. We discuss the relationship of the various terms in the model to the physical parameters. We show how the model accurately predicts the artifacts experimentally observed in these systems. (13 min.)

*Also Varian Assoc., Palo Alto, Calif. 94303.

**FB12. Coherent Optical Adaptive Processor.*** F. PAUL CARLSON, *University of Washington, Seattle. Wash. 98195.*—A coherent optical adaptive processor using discrete sampling of the Weiner spectrum is described. The discrete sampling model can be used to realize a system for recognizing and counting biological cells over a range in size of 0.01 to 100 μm. This process is based on the assumption that a family of cells of distinct morphology will have a unique Fourier spectrum and the intensity of the spectrum from individual cells is additive when the population is large, randomly located, and nonoverlapping. Intensity measurements made at discrete spatial frequencies provide information on the number of cells of each type present. Inference of the counts is made through a linear prediction model obtained by a least-squares regression of the intensity measurements against a set of known counts. If applied to the class of spectra for which the system model is designed, the estimation error is equal to or better than equivalent hand counting methods and is of the same order as that inherent in any least-squares regression process. (13 min.)

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**FB13. Frequency-Variant Optical Signal Processing Systems.*** J. M. FLORENCE AND W. T. RHODES, *School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga. 30332.*—In earlier papers,[1,2] we have described an astigmatic coherent optical system for frequency-variant spectral analysis of one-dimensional signals and a signal waveform processing system based on this analyzer. In the processing system, the spectrum of a moving input signal recording produced by the frequency-variant spectrum analyzer was mixed at a photodetector with a reference wave whose optical frequency was position dependent. Potential applications of the resulting frequency-dependent heterodyning operation, such as nonlinear bandwidth compression and expansion, were discussed. We describe here how the astigmatic analyzer allows us to produce both the signal distribution and the reference distribution with a common optical system, thereby reducing the amount of optics involved while retaining most of the generality of system operation. Two system configurations are described, the first using separate recordings for the input signal and a reference signal and the second using a single recording of a frequency-multiplexed combination of the input signal and a reference signal. Experimental results of system operation are shown. (13 min.)

*Work supported by the NSF.

[1]W. T. Rhodes, J. Opt. Soc. Am. **64**, 545A (1974).
[2]W. T. Rhodes and J. M. Florence, J. Opt. Soc. Am. **65**, 1178A (1975)

**FB14. General One-Dimensional Space-Variant Coherent Optical Processors.*** ROBERT J. MARKS II, JOHN F. WALKUP, MARION O. HAGLER, AND THOMAS F. KRILE,† *Dept. of Electrical Engineering, Texas Tech University, P. O. Box 4439, Lubbock, Tex. 79409.*—Conventional coherent optical processors are commonly used to perform linear space-invariant filtering operations. Recent efforts have been concentrated on using coherent processors to produce one-dimensional coordinate distortions. These may be applied to producing frequency-variant spectrum analyzers[1] or spatial coordinate distortions for use in image processors.[2] Some general one-dimensional coherent processors for application to a wide variety of optical signal processing problems are presented. The system uses a mask, possibly holographically recorded, whose transmittance might represent the spread function of the space-variant operation desired. The one-dimensional input function may be placed adjacent to this mask. Application areas include the computation of signal ambiguity functions, space-variant blurring, real-time autocorrelations, and integral transform evaluations. Experimental results will be used to illustrate the theory. (13 min.)

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†Dept. of Electrical Engineering, Rose-Hulman Inst. of Tech., Terre Haute, Ind. 47803.

[1]W. T. Rhodes and J. M. Florence "Frequency Variant Optical Signal Processing," Appl. Opt. (to be published).
[2]J. W. Goodman "Operations Achievable with Coherent Optical Information Processing Systems," Proc. IEEE (to be published).

**FB15. Measurement of Information Capacity by the Use of Optical Processing Systems.** STEPHEN F. SAGAN AND ROBERT R. SHANNON, *Optical Sciences Center, University of Arizona, Tucson, Ariz. 85721.*—The studies described in this paper stem from work initiated by Patrick Cheatham on the signal-to-noise power spectrum (SNPS). His work has shown that the SNPS is a good indication of image content and our results are consistent with his. We have carried the work a step further and have shown, with reasonable consistency, that the SNPS can be used to measure information capacity of aerial photographic images where information capacity is defined as

$$C = 3.14 \int_0^\infty \log_2 [1 + \mathrm{SNPS}(\nu)]\, \nu d\nu \ ,$$

and SNPS is a function of spatial frequency $\nu$. The power spectrum measurements were obtained from a coherent optical transform system and a Recognition Systems EDPSU unit. The tests were executed with four samples, two high-contrast and two low-contrast images, one of each on Kodak 1414- and Kodak 649f-type film. Studies were conducted on the effects of sampling aperture diameter and position, film contrast, and film type on the SNPS and information capacity. The results of the investigation showed that all of the above had an effect, as would be expected. As the diameter or position of the aperture was varied, the spatial frequencies within the aperture were also varied, hence a change in the SNPS curve and information capacity. As the