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Several problems in optical signal detection require the fabrication of spatial filters having both amplitude and phase response. In this paper, I show how spatial filters for arbitrary signals can be recorded on ordinary photographic film. [The *SCI*® indicates that this paper has been cited 214 times since 1964.]

Anthony VanderLugt
Harris Corporation
P. O. Box 37
Melbourne, FL 32901

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"When I joined the Willow Run Laboratories of the University of Michigan in 1959, my colleagues were investigating how coherent optical processing systems could be used to obtain maps from synthetic-aperture, side-looking radar systems. This work would eventually lead to the important discovery of off-axis holography. I was interested in solving a different problem—that of using optical processing for pattern recognition.

"Detecting a known pattern or signal in an image requires the fabrication of a complex-valued spatial filter which is matched in both amplitude and phase to the spectrum of that signal. Some successes had been obtained, but only for a limited class of signals—those that were real-valued and symmetrical. Techniques for fabricating a generalized matched filter for an arbitrary signal were yet to be discovered. I repeated many of the previous experiments to gain familiarity with established techniques and then asked, "How can we construct a filter with arbitrary phase amplitude response when the only practical recording material is photographic film—and it cannot record the phase?"

"The answer, in principle, was provided by a colleague. Dr. W. M. Brown, a complex-valued function can be recorded as a real-valued function if it modulates a carrier frequency Fine But how? Some calculations showed me that the spectral bandwidth of the light source would need to be much, much narrower than any source then available Not to be discouraged, I modified my experimental apparatus by acquiring a Mach-Zehnder interferometer which allowed me to establish a spatial career frequency which I modulated with the spectrum Of the signal whose matched filter I wished to construct. The light-source I used was a high pressure mercery arc bulb with a bandpass filter to provide the narrowest spectral bandwidth then possible (≈50Å).

"With this rudimentary apparatus I could indeed see evidence of modulation (fringes) whose spatial frequency I could vary by tilting one of the mirrors in the interferometer. Unfortunately, as the angle of the mirror increased, the amount of overlap of the two beams decreased so (hat, before I was able to obtain a sufficiently small fringe spacing, the beams no longer overlapped. We corrected this problem by using a modified Rayleigh interferometer with which we could obtain both c omplete overlap and small fringe spacing. A much more serious problem was that the fringe contrast was unacceptable; we could only obtain approximately 200 fringes before the fringes disappeared. Clearly we needed a light source with an even narrower spectral bandwidth if we were to be successful.

"Perhaps the most fortuitous aspect of my research work was the timely development ot continuous wave gas lasers Lasers are characterized by having a very narrow spectral bandwidth. I purchased one of the first helium-neon gas lasers delivered by Spectra-Physics and installed it in our experimental system. After we had experimented with new photographic films that were sensitive to the red light produced by helium-neon lasers, we began our experimental work The experiments proceeded rapidly and with unexpected ease All of the experimental results were achieved within a space of two or three weeks in early December of 1962 Since I had already completed the theoretical part of my work, I quickly incorporated the experimental results and finished my paper over the Christmas holidays.

"I believe that my paper, and those that followed, is frequently cited because I gave in it a solution to a long-standing problem of the construction of a generalized spatial filter. Even today, after more than 15 years of research, this techmque is almost always used to construct complex-valued spatial filters If a recording medium were invented that responds directly and independently to both the amplitude and phase of a generalized light distribution, simpler techniques could be used to record filters Since I know ot no physical detector (including photosensitive materials) that is sensitive directly to phase, my technique may prove to be useful for some time to come."