Pacific University

CommonKnowledge

College of Optometry

Theses, Dissertations and Capstone Projects

5-1994

A study in pattern recognition: The optical interaction of masks and targets

Jon Converse
Pacific University

Lisa Robinson-Shumway
Pacific University

Cameron Seidel
Pacific University

A study in pattern recognition: The optical interaction of masks and targets

Abstract

This paper explores a new process that may be utilized in pattern recognition. By using masks and targets, we were able to photograph convolutions without the use of lenses. These convolutions were unique and we believe by employing them in pattern recognition devices in the future that pattern recognition will be improved.

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Jurgen R. Meyer-Arendt

Keywords

Mask, target, convolution, pattern recognition

Subject Categories

Optometry

A STUDY IN PATTERN RECOGNITION: THE OPTICAL INTERACTION OF MASKS AND TARGETS

By

JON CONVERSE

LISA ROBINSON-SHUMWAY

CAMERON SEIDEL

A thesis submitted to the faculty of the
College of Optometry
Pacific University
Forest Grove, Oregon
for the degree of
Doctor of Optometry
May 1994

Advisor:

Dr. Jurgen R. Meyer-Arendt

SIGNATURES

Jon Converse

Lisa Robinson-Shumway

Cameron Seidel

Dr. Jurgen R. Meyer-Arendt
Advisor

JON CONVERSE

Jon Converse is currently a third year graduate student at Pacific University's College of Optometry in Forest Grove, Oregon. He did his undergraduate work at the University of Oregon in Eugene, where he received a Bachelor of Science degree in General Science and graduated Phi Beta Kappa in 1990. Upon graduating from the College of Optometry in 1994, Jon plans on working for a eye care clinic and then going into private practice.

CAMERON SEIDEL

Cameron Seidel currently attends Pacific University's College of Optometry in Forest Grove, Oregon where he received his Bachelor of Science degree in Visual Science in 1992. He is a member of Beta Sigma Kappa as an honor student, and has been acknowledged in a nationally circulated honor student publication.

After graduation from the College of Optometry in 1994, Cameron plans to work in an ophthalmologic eye care center and in the future to open his own private practice.

LISA ROBINSON-SHUMWAY

Lisa Robinson-Shumway attended Walla Walla College and Walla Walla Community College School of Nursing. She received a Bachelor of Science degree in Visual Science from Pacific University in 1992. She is currently a graduate student at Pacific University College of Optometry in Forest Grove, Oregon.

After the completion of her Doctorate in Optometry in 1994, Lisa plans to open a private practice specializing in contact lenses.

ABSTRACT

This paper explores a new process that may be utilized in pattern recognition. By using masks and targets, we were able to photograph convolutions without the use of lenses. These convolutions were unique and we believe by employing them in pattern recognition devices in the future that pattern recognition will be improved.

Key words: Mask, target, convolution, pattern recognition

ACKNOWLEDGEMENT

We would like to thank Dr. Jurgen Meyer-Arendt for his valuable advice and thought in helping us prepare this project.

INTRODUCTION

Pattern recognition is a topic of great interest to the scientific community today. What is pattern recognition and what can be done with it? We start first with an object that we want to recognize in some way. Using an optical device which can be connected to a computing device, we produce a recognizable pattern. With this pattern, the computer can match the object and the pattern. There are different ways this can be done. In this experiment we are proposing a new way to produce a recognizable pattern through the use of targets and masks. Using the resulting pattern called a convolution, we believe that character recognition will be easier to achieve.

HISTORY

Applications for pattern recognition devices are numerous. Maurice Françon talks of how it is often necessary to determine the resemblance that may exist between two photographic images, in addition to using it to examine the changes that have taken place with an object through time.[1] The military has spent millions of dollars to improve the accuracy of their weapons systems by exploring the use of pattern recognition.

Early pattern recognition systems used geometric optics as their basis. If, for example, one wants to design a system to be able to read the character A, one would need an entire set of characters (A, B, C, ...,) printed as negatives on a spool of film (Figure 1). These characters would then be moved across the image plane until the negative of the letter A was present. Once this occurs, the system would send a signal to print the character "A". The problem with this type of system is that the negative, relative to the character, has to be perfectly aligned and identical in size. This was a rather unrealistic requirement and resulted in the system's downfall.[2]

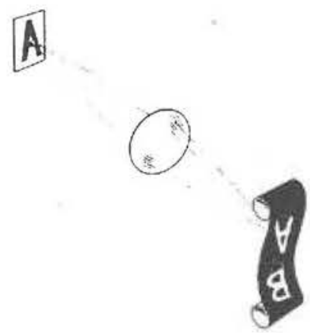

Figure 1

More recent pattern recognition systems are based on holography. Instead of using a real image of the object, a holographic Fourier transform is used. In Figure 2, one can see that the holograph is placed at a point between two lenses of a system.

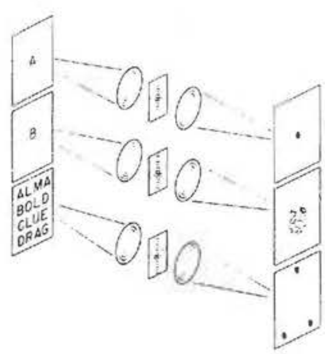

Figure 2

Identification of the object takes place at the image plane of the object. In a perfect system, identification of the object as being the same as the holograph results in a single luminous point on the image screen (Figure 2, top). (However, this does not occur in reality, the character is replaced by a luminous point surrounded by a "faint and irregular halo".[1]) If the character and the holograph do not correlate, the image formed on the screen is scattered (Figure 2, center). In other words, the point of light becomes less and less distinct. This also occurs when the character's (the object's) orientation, size, or dimension is not compatible with the holographic construct. This type of pattern recognition device is also able to search a matrix and determine how many times the pattern has occurred (Figure 2, bottom).[2]

Some of the most current pattern recognition devices use correlation filters as their basis. Several different types are listed in the literature.[3-9]

This paper will explore the possibilities of using a different basis for pattern recognition. The type of system we envision is based on convolutions. A convolution is the interaction of light with two patterns. It has been shown that the formation of a convolution does not depend on a tightly defined (x,y) orientation of the object.[10] In fact, the target can be positioned in what would have been a misalignment in a conventional system, and still form a convolution.

In this project we had two main goals. The first was to try to create a design that would enable us to photograph several different convolutions. The second was to see if a convolution for a given target/mask configuration was unique and usable in character recognition.

EXPERIMENTAL METHODS

In order to obtain convolutions on photographic film, we assembled an experimental apparatus as shown in Figure 3. The light source was a 15 watt fluorescent light which had a diffuser covering the bulb, thus yielding incoherent light. A piece of cardboard was carefully cut and placed over this bulb, with a 1 inch by 1 inch aperture to allow light through. The light source, along with the transparencies and camera, were then mounted on a table.

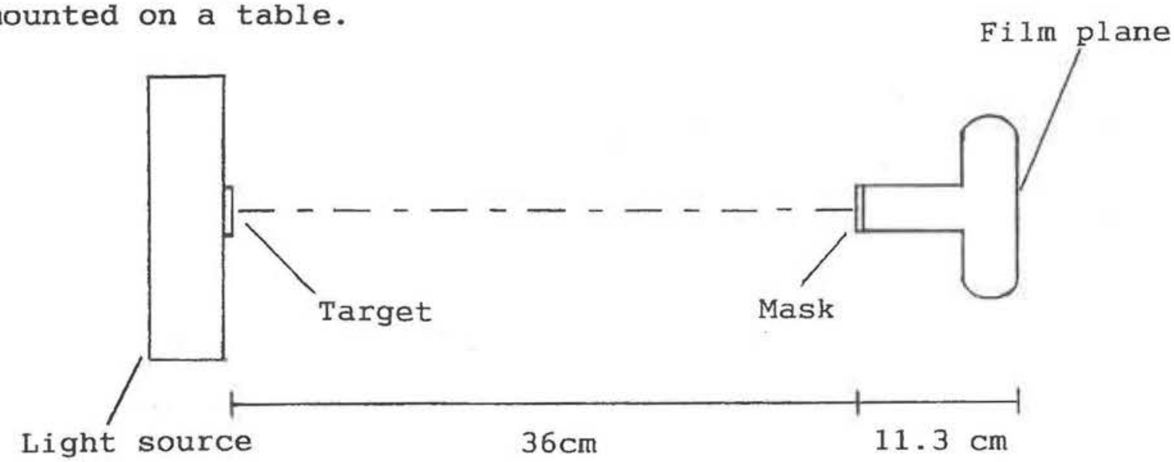

Figure 3 General apparatus arrangement

The transparencies, called masks and targets respectively, were assembled from photographic negatives and steel washers.

The negatives were made from taking a picture of a dark object on a white background, and thus yielded a transparent object on a black background in the form of the negative. Then the negatives were glued between 2 steel washers as a mounting medium which could in turn be mounted to either the camera or the light source. In this experiment we employed simple designs, utilizing two rings and two equilateral triangles for transparencies, two larger of each kind and two smaller of each kind. Figure 4 shows both the masks and targets drawn to scale.

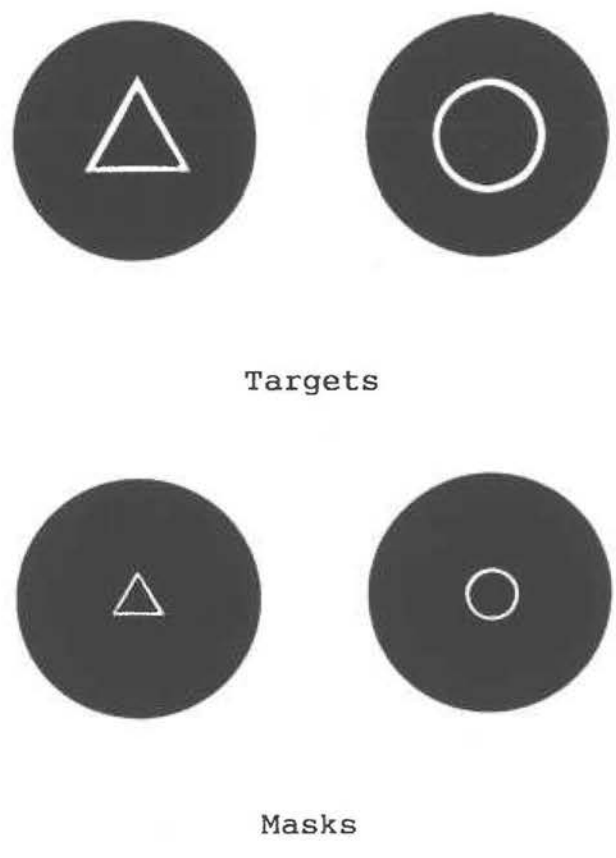

Figure 4 Physical parameters of masks and targets
(Drawn to scale, washers not shown)

The larger negatives were utilized as targets and mounted exactly over the aperture of the light source, thus allowing the light to be emitted only through the negative. The smaller negatives were utilized as masks and mounted on the end of a tube mounted to a Minolta XG-7 camera used in the experiment. But the apparatus did not use a camera lens, only a hollow tube 8.7 cm long, which attached to the camera body. The effective distance from the film surface to the end of this tube was 11.3 cm. On the end of this tube we attached the mask, so that the only light allowed to enter the tube entered through the mask. In the experimental apparatus, the mask was placed 36 cm from the target.

The film chosen in this experiment was Kodak black and white T-max film, rated at 100 ISO. The actual experiment took place in a dark room, and the exposure times were varied from 1 second to 30 seconds. The most favorable exposures were from 1 to 4 seconds. Figure 5 was exposed for 1 second, Figure 7 for 4 seconds, and Figures 6, 8, and 9 each for 2 seconds.

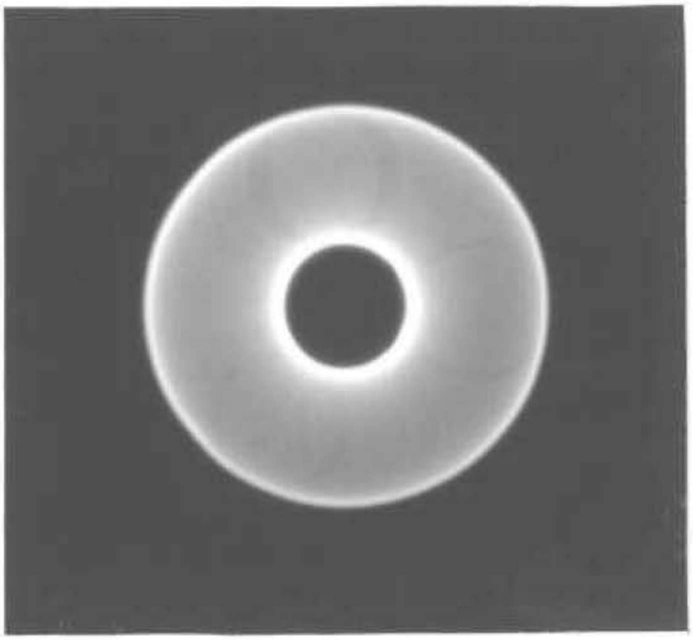

Figure 5

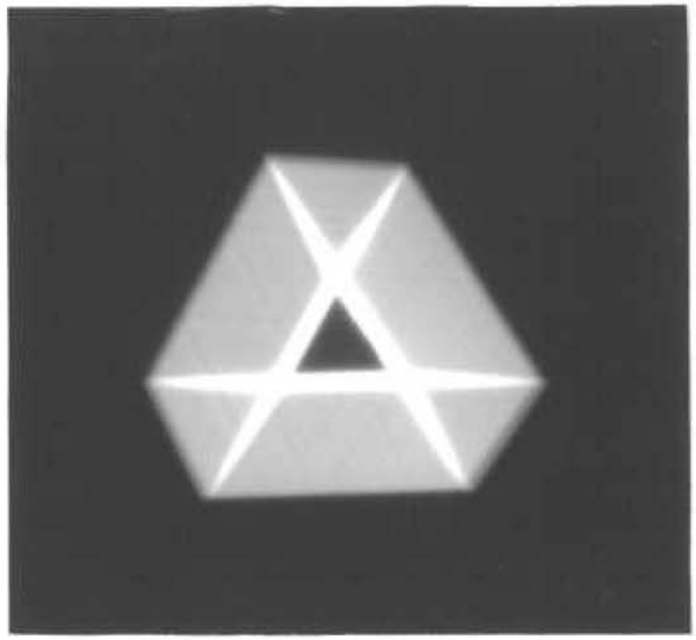

Figure 6

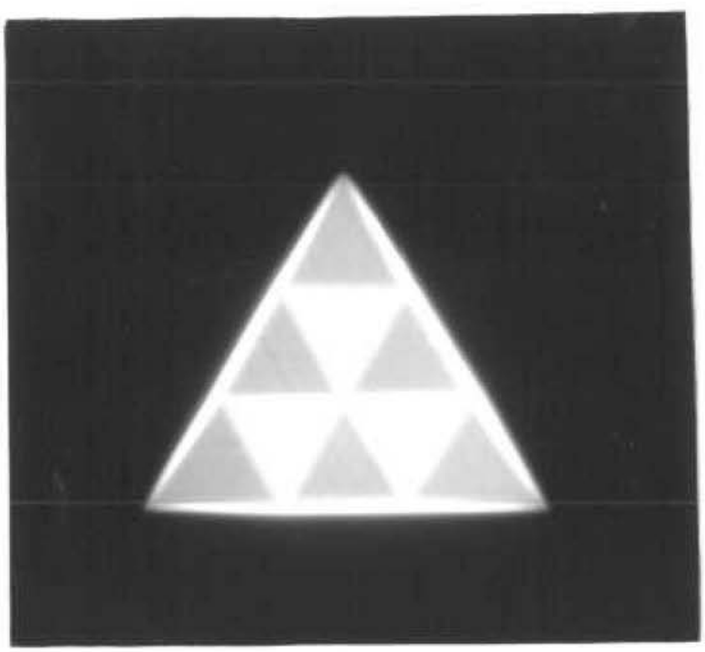

Figure 7

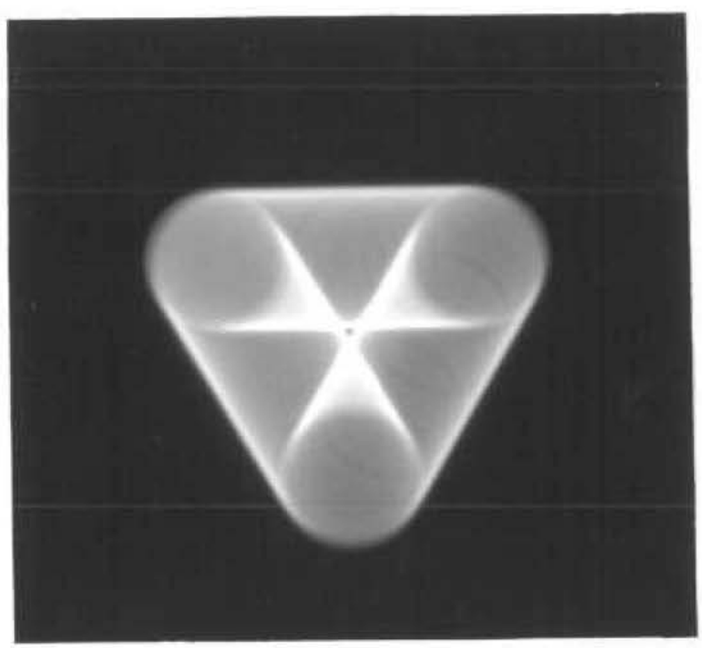

Figure 8

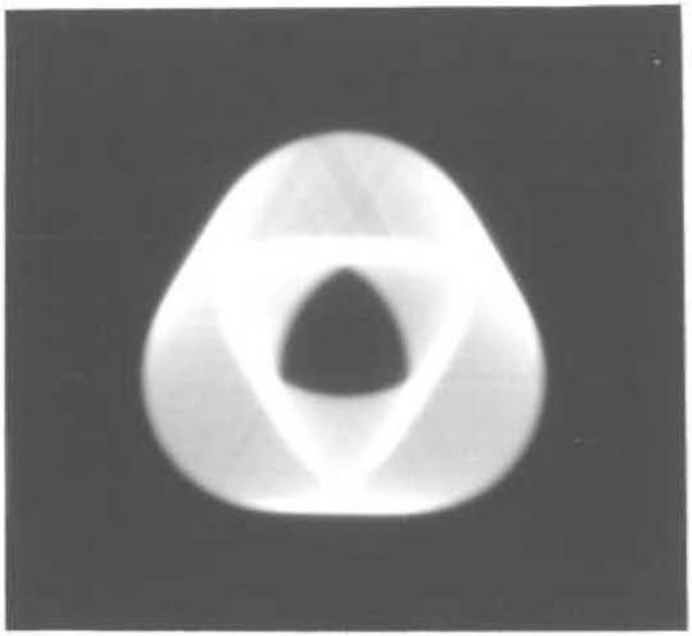

Figure 9

EXPERIMENTAL RESULTS

In performing the experiment, we chose 5 different combinations of transparencies to present. Figure 10 demonstrates the 5 different orientations of masks and targets to obtain the convolutions shown in Figures 5 through 9.

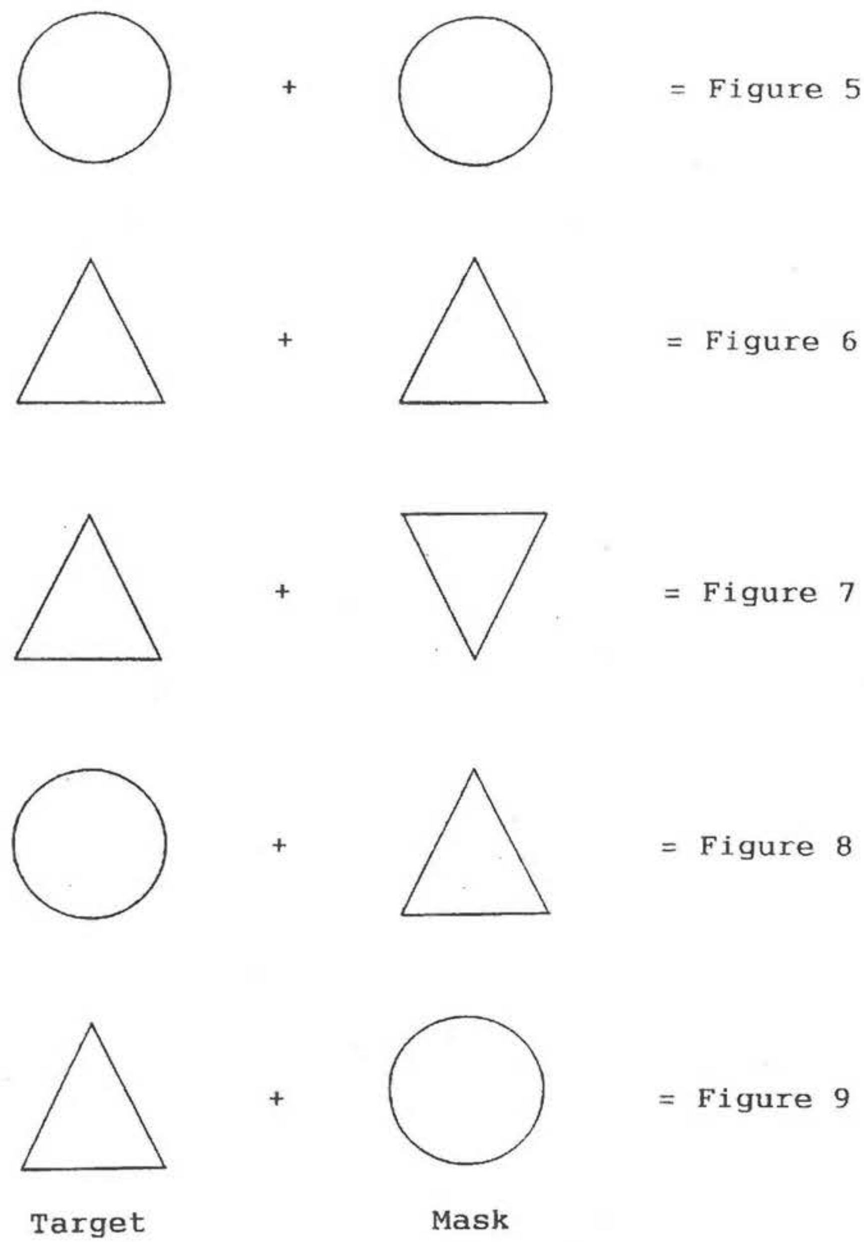

Figure 10 Arrangement of masks and targets and resultant convolutions

Figures 5 and 6 are correlations between two similar objects, aligned equally. Figure 7 shows the triangles aligned unequally, which represents an opposite autocorrelation, whereas Figure 6 represents congruent autocorrelation. The Figures 8 and 9 demonstrate cross-correlation, which shows the interactive nature of a target with a mask of a different shape.

DISCUSSION AND CONCLUSION

Our experiment demonstrates that a simple optical system lacking both lenses and holograms can be used to form a recognizable pattern called a convolution. We have shown that light passing through one transparency, and then through a second, forms a unique resultant convolution. By employing a camera body with no lenses at all, the resultant convolution can be photographed.

In the evaluation of various types of character recognition devices, we want to compare the benefits of our purposed system to those of an electronic origin. What are the advantages of an optical versus an electronic pattern recognition device? Optical systems always process information in parallel, therefore they are very rapid and operate without scanning. Electronic devices also examine information in parallel, one information bit at a time, but the electrons may interfere with one another in the circuit, thus requiring electronic devices to be larger and more inefficient than light devices. In addition, those systems which use holograms are poorer because there must be holograms and lenses present in the system, both of which we have eliminated in this system.[2]

The experimental design we created by utilizing interacting transparencies gave photographs of easily obtainable, unique convolutions. Their shading and shape are very distinctive and we believe that they can be used to enhance the current concept of pattern recognition. The possibilities of devices utilizing convolutions for pattern recognition has widespread application. Thus, we believe our project can be expanded on in the future to create more efficient, more beneficial modes for character recognition.

REFERENCES

1. Françon, Maurice. Optical Image Formation and Processing. New York: Academic Press, Inc., 149-152 (1979).
2. Meyer-Arendt, Jurgen R. Introduction to Classical and Modern Optics. Third ed. Englewood Cliffs, New Jersey: Prentice Hall, 342-343; 353-54 (1989).
3. J.L. Horner and P.D. Gianino, "Phase-Only Matched Filtering," Appl. Opt. 23, 812-816 (1984).
4. H.J. Caulfield and M.H. Weinberg, "Computer Recognition of 2-D Patterns Using Generalized Matched Filters," Appl. Opt. 21, 1699-1704 (1982).
5. D. Casasent, "Unified Synthetic Discriminant Function Comp-putational Formulation," Appl. Opt. 23, 1620-1627 (1984).
6. D. Casasent and W.-T. Chang, "Correlation Synthetic Discriminant Functions," Appl. Opt. 25, 2343-2350 (1986).
7. Y.-N. Hsu and H.H. Arsenault, "Optical Pattern Recognition Using the Circular Harmonic Expansion," Appl. Opt. 21, 4016-4019 (1982).
8. B.V.K. Vijaya Kumar, "Minimum-Variance Synthetic Discriminant Functions," J. Opt. Soc. Am. A 3, 1579-1584 (1986).
9. A. Mahalanobis, B.V.K. Vijaya Kumar, and D. Casasent, "Minimum Average Correlation Energy Filters," Appl. Opt. 26, 3633-3640 (1987).

10. D. McLachlan, Jr., "The Role of Optics in Applying Correlation Functions to Pattern Recognition," J. Opt. Soc. Am., Vol. 52, No. 4, 454-459 (1962).