Experiment on pattern recognition for the undergraduate laboratory using overhead transparencies

Ramendra Bahuguna, Panfilo Deguzman

Ramendra Deo Bahuguna, Panfilo C. Deguzman, "Experiment on pattern recognition for the undergraduate laboratory using overhead transparencies," Proc. SPIE 2525, 1995 International Conference on Education in Optics, (13 October 1995); doi: 10.1117/12.224077

Event: SPIE's 1995 International Symposium on Optical Science, Engineering, and Instrumentation, 1995, San Diego, CA, United States

Experiment on pattern recognition for the undergraduate laboratory using overhead transparencies

R. D. Bahuguna
Department of Physics
San Jose state University
and
P. C. DeGuzman
Department of Physics
University of Alabama, Huntsville

ABSTRACT

Character recognition by matched filtering is almost impossible to accomplish without the use of a liquid gate when the object to be recognized is on a transparency. This paper suggests a simple method to overcome this problem. A practical application to fingerprint recognition is discussed.

Keywords: matched filtering, overhead transparencies, phase problem

1. INTRODUCTION

In 1963, Vander Lugt presented a new technique for synthesizing frequency-plane masks for coherent processors [1,2] From patterns of absorption, these masks can control both the amplitude and phase of the transfer function. The flexibility of this technique in synthesizing frequency-plane masks has brought about a promising application, such as character recognition.

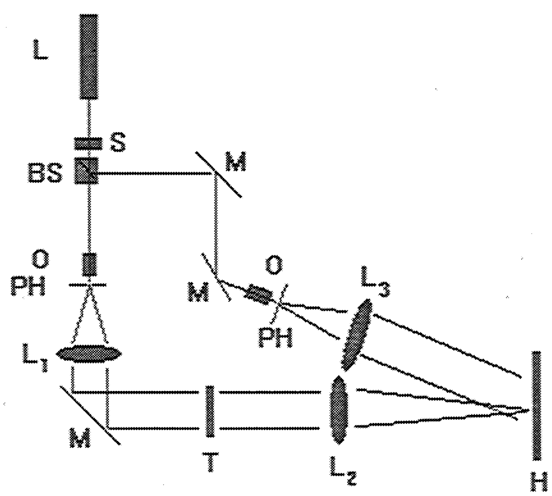

Fig. 1

A typical set-up for recording a matched filter is shown in Fig. 1. A He-Ne laser beam passes though the shutter S and beam splitter BS, dividing the beam into object and reference beams. The object beam is expanded by a microscopic objective O and filtered by the pinhole PH and is then collimated by lens L_1. The plane wave from L_1 passes through the object transparency T and gets Fourier Transformed by Lens L_2 at the back focal plane where a holographic plate is placed. The reference beam is directed by mirrors M,

0-8194-1884-6/95/$6.00

expanded and filtered, and then collimated by lens L_3. This plane wave then illuminates the holographic film. The two beams interfere on the holographic plate to give a complex holographic grating, called the matched filter. The filter is basically a hologram of the Fourier Transform of the object signal and contains all the information about the object amplitude and phase.

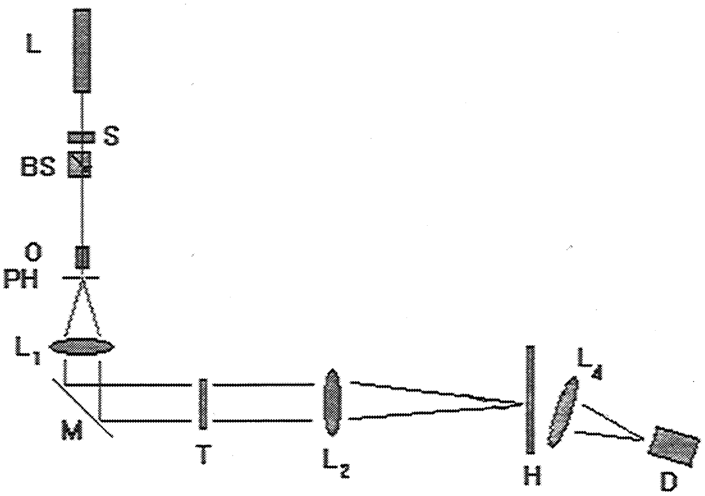

Fig. 2

Fig. 2 shows the recognition set-up using a matched filter. It is obtained by removing the reference beam of figure 1, and adding lens L_4 and detector D. It works as follows. The matched filter of the object transparency to be recognized, made using the set-up of figure 1, is placed at the back focal plane of lens L_2. The transparency T which is to be compared against the object is placed in the same position as during recording and illuminated with the laser light. The Fourier Transform of the transparency T is formed at the back focal plane of lens L_2 and if same as the Fourier Transform recorded in the matched filter, a strong reference signal is generated in the same direction as during recording. On the other hand if the transparency is different than that corresponding to the matched filter a relatively weak signal is generated. The reference signal is focused by the lens L_4 onto the detector D. The strength of the signal depends on how closely the test transparecy matches with the recorded one. A threshold level using a discriminator can be set to obtain a "Yes" or "No" decision on the match.

2. THE PHASE PROBLEM

Usually overhead transparencies used in photocopying machines have phase variations that can arise because of thickness variations or inhomogenieties in the material. So when an object transparency is Fourier Transformed, these phase variations give additional undesired intensity variations at the hologram plane and are recorded in the matched filter. During the matching process the same object transparency will show a high correlation but if the same object is written on a different transparency the correlation may fall to a very low value. The strength of the signal depends on how much the phase variations on the new transparency correlate with those of the plastic used during the recording process. The well-known method to eliminate the phase variation is to sandwich the transparency between two optically plane glass plates with an index matching fluid in-between the plates [3]. The technique works but can be messy because of the liquid involved. In this paper we suggest a simple method that does not eliminate the phase variation on the transparency but, however, attempts to avoid it at the filter plane.

3. THE METHOD

The phase variation on an overhead transparency occurs basically during the manufacturing process. Therefore it is not surprising that different brand-names/models yield different types of phase variation.

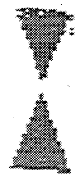

Fig. 3a

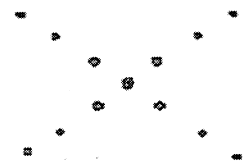

Fig. 3b

Fig. 3 shows the Fourier transform of two transparencies made by 3M and Highland respectively. Let us consider Fig. 3a. The cone like structure can be avoided by masking provided the object signal does not significantly overlap with the cones. One should orient the object, when photocopying it on the transparency, such that the Fourier Transform of the object overlaps by a minimum possible amount. This way a minimum amount of object signal will be cut by masking of the spurious signal.

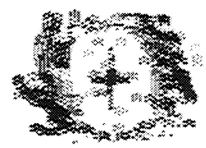

Fig. 4

It should be noted that expanding the Fourier Transform by means of a microscopic objective placed between lens L_2 and H makes the masking more manageable. Further, one can block the central bright spot of the Fourier Transform with black ink; this spot is the D.C component and usually does not have useful information. The magnified Fourier Transform of a fingerprint looks more or less like that shown in Fig. 4.

4. APPLICATION TO FINGERPRINT RECOGNITION

The above method can be successfully applied to fingerprint recognition. This is because the fingerprint Fourier Transform is more or less ring shaped (see Fig. 4) with a bright spot in the center and so the overlap with the Fourier Transform of Fig. 3a or 3b is minimal as shown in Fig. 5a and 5b. It is better to use the transparency corresponding to Fig. 3b since the ring can easily fit in-between the dots with virtually no overlap.

Fig. 5a

Fig. 5b

We suggest that one use the Highland 903 transparency for copying fingerprints. A mask with an annular ring opening, placed in the hologram plane, will block the dots and let the ring structure corresponding to the fingerprint pass through. The matched filter is then recorded on a regular holographic plate. After processing, the holographic plate is registered exactly in the same position in the plate-holder. The object transparency to be tested then replaces the transparency that was recorded and the correlation observed on an oscilloscope.

5. CONCLUSIONS

A simple masking-method has been proposed to overcome the phase problem associated with overhead transparencies. It is a good alternative to index matching without the need for optically parallel plates and an index matching liquid. The experiment is easy to set up and can be done by undergraduates with some guidance.

6. ACKNOWLEDGEMENTS

The authors wish to thank Advanced Precision Technology, Inc. for sponsoring the project and Gareth williams, Allen Tucker and Joseph Becker for their encouragement.

7. REFERENCES

1. A. B. Vander Lugt, "Signal Detection by Complex Spatial Filtering," Radar Lab., Rept. No. 4594-22-T, Institute of Science and Technology, The University of Michigan, Ann Arbor (1963).

2. A. B. Vander Lugt, "Signal Detection by Complex Spatial Filtering," IEEE Transform Information Theory, IT-10:2(1964).

3. W. Thomas Cathey, "Optical Information Processing and Holography" (John Wiley & Sons 1974), p 206.