Defocused Holographic Correlator Array

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Holographic correlator arrays are a powerful tool for many pattern recognition problems because they are capable of computing multiple correlation functions fast and simultaneously. There is a trade-off between the number of templates packed and the amount of shift invariance allowed in the system design, because an error occurs when a correlation peak shifts into neighboring domains when the input is shifted. Shift invariance can be controlled by simply moving the recording material away from the focal plane of the Fourier lens [Ref. 1].

A real time defocused correlator system using 100μm thick DuPont HRF-150 photopolymer with 480 templates has been demonstrated [Fig. 1, 2].

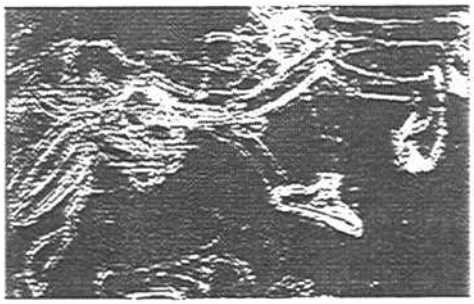

Figure 1: One of the 480 stored templates (edge-enhanced)

Figure 2: Correlation Peak

The correlation peak strength is equalized using the exposure schedule in Ref. 2. The correlation plane is then divided into 24 X 20 domains. A raster scan of the maximum correlation should be obtained as we sequence through the templates [Fig. 4]. Only 10 out of 480 templates are misclassified. This problem can be solved by normalizing the energy of each template.

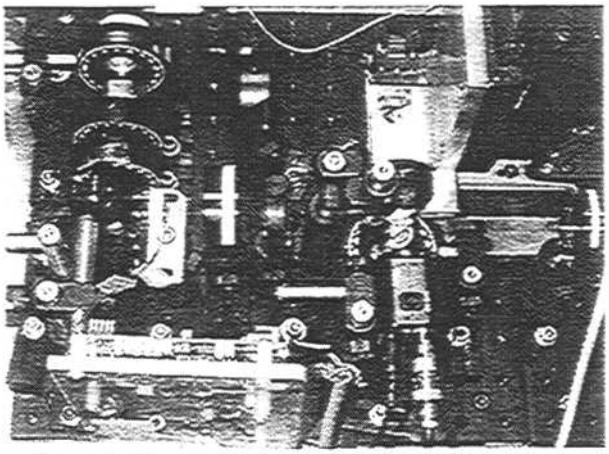

Figure 3: The compact system (25cm X 20cm)

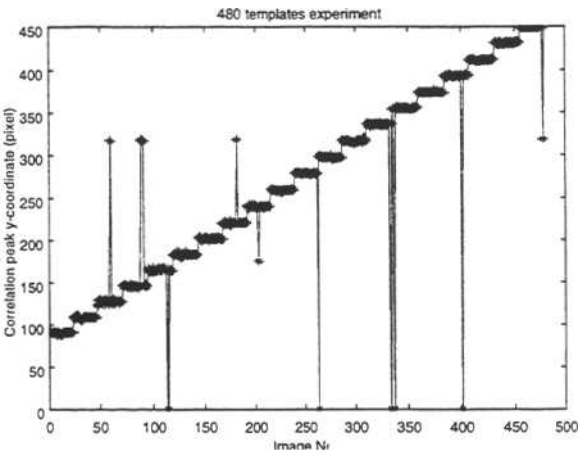

Figure 4: Correlation peak y-coordinate

The template angular selectivity is approximately 0.1 degree and the angular distance between neighboring domains is 0.4 degree. The Bragg selectivity in the in-plane direction is approximately 0.5 degree. Clearly, the defocused correlator system can store more templates. To implement distortion invariance, synthesized templates are used. If each template is synthesized with 10 targets, the system then has about 500 X 10 filters which is very useful in a content searchable database. A compact version of the system has been built [Fig. 3]. The total area is 25 cm by 20 cm.

Our system has been used in real time finger print recognition [Fig.5] and face recognition [Fig. 7]. Fingerprint recognition is particularly interesting because it requires a small degree of shift invariance hence many templates can be stored. Figure 5 shows the cross-section of fingerprint correlation. Figure 7 shows the cross-section of autocorrelation of one face template[Fig 6] and its cross-correlation with other templates. Complete results will be presented in the conference.

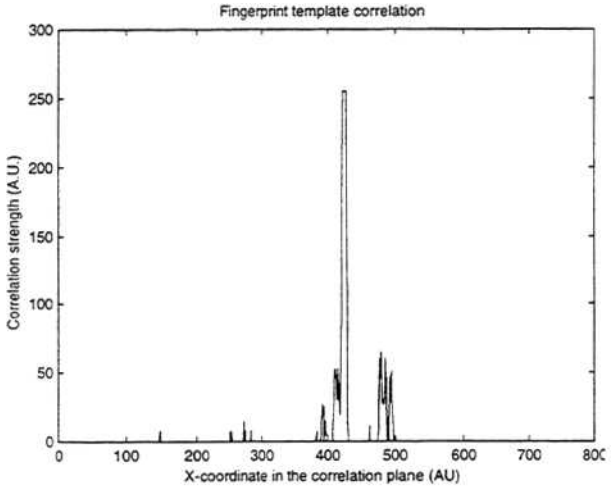

Figure 5a: Correlation of original fingerprint template

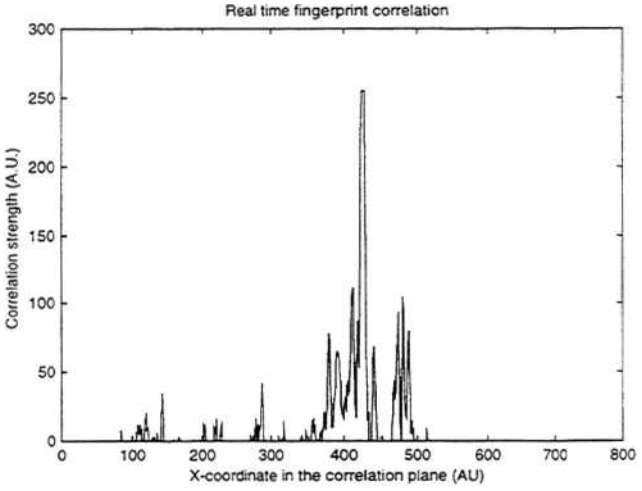

Figure 5b: Real time fingerprint correlation

Figure 6: Edge enhanced face

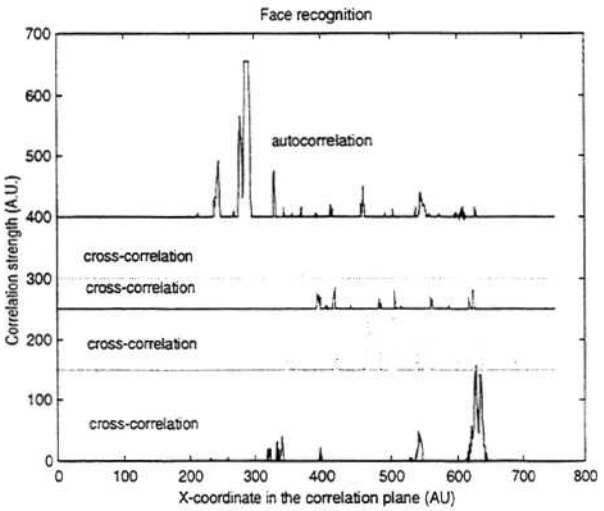

Figure 7: Correlation of the face

In addition, the defocused correlator is investigated in detail. Some of the results are shown below. The angle selectivity is approximately λF/WZc [Fig. 8, 9]. Where λ: wavelength, F: focal length, Zc: distance from the focal plane to the recording material and W: effective image width. Shift invariance is conveniently controlled by simply controlling the defocusing distance Zc. For large enough Zc, the defocusing effect dominates the Bragg selectivity which leads to symmetric correlation domains. This technique is particularly useful for thin photo-polymers.

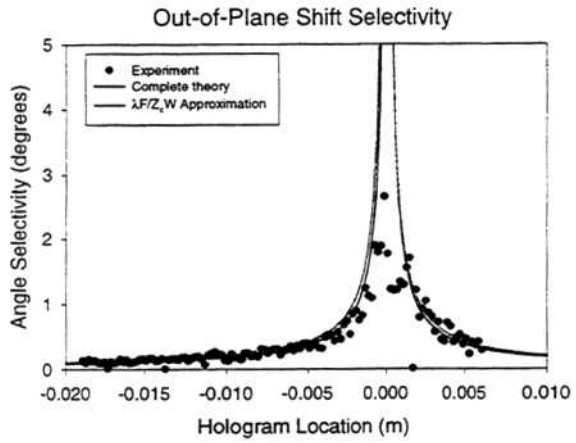

Figure 8: Selectivity at different hologram location

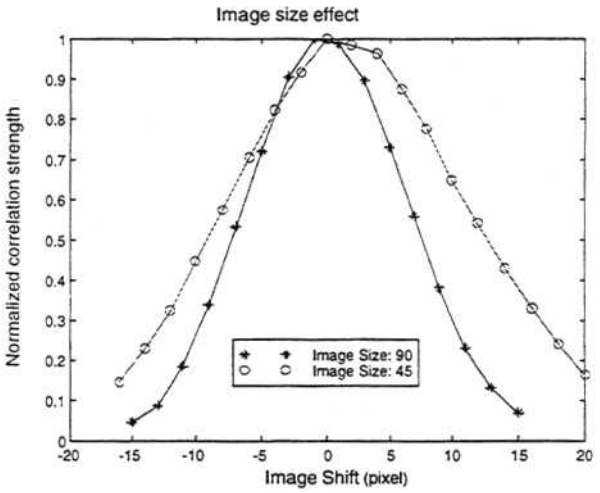

Figure 9: Selectivity with different image size

The defocused correlation function has symmetric forms in both spatial and frequency domains. This implies that the defocused correlator is a mixture of correlator and multiplier. Random binary and Gaussian inputs are analyzed and close form solutions are derived. The theory matches experimental data very well [Fig. 10]

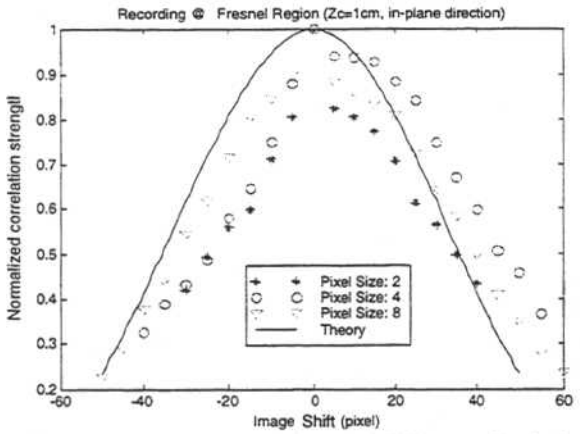

Fig.10a: In-plane selectivity with different pixel size

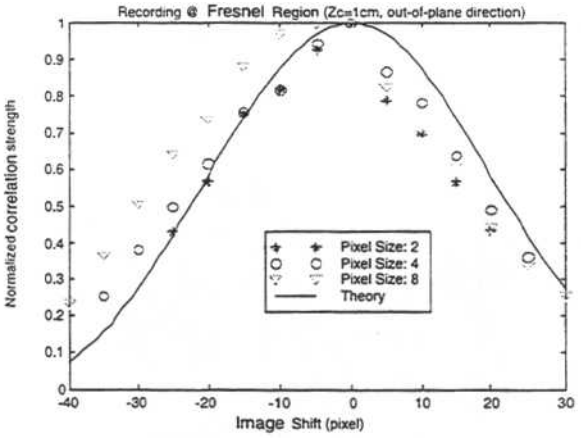

Fig. 10b: Out-of-plane selectivity with different pixel size

[References]

1. Michael Levene, Greg J. Steckman and Demetri Psaltis, "A method to control the shift invariance of optical correlators" , Applied Optics, Jan. 10, 1999
2. Allen Pu, Kevin Curtis and Demetri Psaltis, Opt. Eng. 35 , 2824-2829, 1996
3. J. Goodman, "Statistical Optics", John Wiley & Sons , Inc. 1985