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광굴절매질을 이용한 실시간 공간불변 광상관기에 관한 연구

REAL-TIME DEFORMATION INVARIANT CORRELATOR USING PHOTOREFRACTIVE MEDIUM

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ABSTRACT

The scale and rotation invariant polar-logarithmic coordinate transformation is used to achieve in-plane distortion invariant pattern recognition.

The coordinate transform is produced by a computer generated hologram(CGH) on a laser printer. The mask for the lnr-θ coordinate transformation is made of the CGH whose transmission function is derived by the use of the stationary phase method.

For the real-time processing, the optically produced coordinate transformed input pattern is interfaced to a correlator and a LCTV. BaTiO (BTO) single crystal is used as a real-time matched filter.

1. INTRODUCTION

The advantage of optical processing, a description of various operations possible, and many applications of optical processors have been described elsewhere.

Pattern recognition using a coherent optical system has great advantages of high speed and parallel processing. But the conventional correlator cannot recognize scaled or rotated images of the reference object.

For example the SNR of the resultant correlation peak can be 10dB down from that of the autocorrelation for a 1% scale changes of the reference object, and a 20dB loss can occur for a 1.7% rotation of the input from the reference.

To solve these problems is to develop a space variant optical processor which is realized by applying a coordinate transformation processing operation to the input and reference data.

Coordinate transformations such as the logarithmic transformation which is scale invariant, the polar(r-θ) transformation which is rotation invariant, and the ln r-θ coordinate transformation which is deformation invariant have been reported.

In this paper we consider the optical implementation of deformation invariant real-time optical pattern recognition using CGH, LCTV, and BTO. By the use of CGH with a Fourier transform lens, ln r-θ coordinate transformation is performed.

CGH is consisted of many interferometrically produced holographic optical element (HOES) for coordinate transformations. The design of CGH is presented in Sec.II .

LCTVs are used to connect the coordinate transform processing system to a BTO as a conventional optical matched spatial filter correlator in real time.

Scale and rotation invariant pattern recognition is achieved in real-time by the coordinate transformation and the optical matched fitering based on real-time hololgraphy.

Real-time scale and rotation invariant pattern recognition is verified experimentally in Sec.III. sec experimental resultes are presented.

2. DESIGN OF CGH

The general problem of making a binary synthetic hologram is to find a hologram function h(x,y) that has 0 or 1 as its values and can produce any desired wavefront just by changing its parameters.

Fig 1. is to show the system to realize the ln r-θ coordinate transformation.

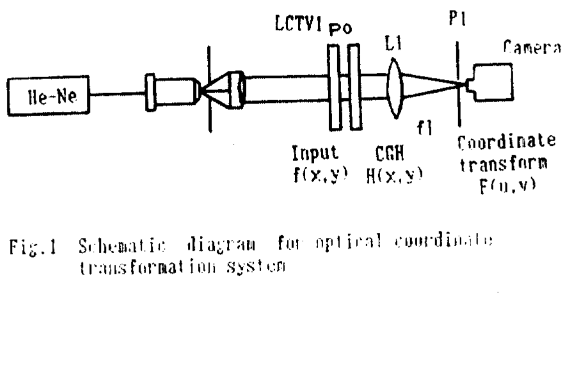

Fig.1 Schematic diagram for optical coordinate transformation system

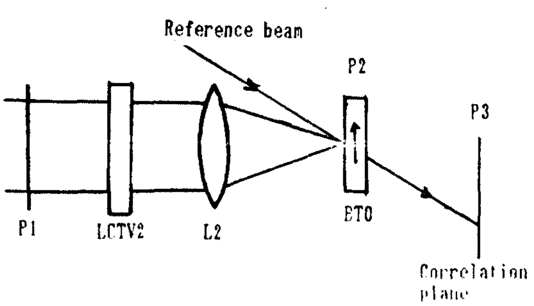

Fig.2 Real time optical correlator

In the input plane Po, the input f(x,y) is placed in contact with CGH with transmittance h(x,y)=exp[j (x,y)], where (x,y) is phase transmission.

The Fourier transform of the product f(x,y)× h(x,y) at plane P1, is formed by lens L1

$$F(u,v) = \iint_{-\infty}^{\infty} f(x,y)\exp[j\phi(x,y)] \times \exp[-j(2\pi/\lambda f_L)(xu + yv)]dxdy, \quad (1)$$

u,v plane is the Fourier transformed plane P1, of Fig.1.

$$u(x,y) = \ln(x^2 + y^2)^{1/2} - \ln v,$$
$$v(x,y) = -\tan^{-1}(y/x), \quad (2)$$

and the desired phase function is

$$\phi(x,y) = (2\pi/\lambda f_L)[x\ln(x^2 + y^2)^{1/2} - y\tan^{-1}(y/x) - x], \quad (3)$$

With a collimated coherent plane wave (plane, the ln r θ coordinate transformation is performed by CGH and the the transformed pattern appears in the focal plane P1 of lens L1.

Since we need a continuous phase function to be recorded on the mask, we can use binary recording technique.

The interferogram is the interference pattern of (x,y) and a plane wave reference at an angle * .

The interference fringe pattern is formed by the points satisfying (4)

$$2\pi\alpha x - \phi(x,y) = 2\pi n, \quad (4)$$

where n is an integer which denotes different fringes and where the carrier frequency $\alpha = (\sin\theta)/\lambda$.

If (x,y) is constant, the binary synthetic hologram made by using Eq(4) is a periodic grating with period T.

It is the constant T that determines the angular separation of the differential waves in the reconstruction.

Since the positions of the fringes are obtained by solving Eq(4), the accuracy of the solutions found depends on the sampling periods along the x direction. In practice, the sampling period is selected as T/M, where M is an integer. The accuracy of the fringe position can be set by M.

To solve eq(4) by a digital computer, a sampled version of it is first obtained by substituting T/Mkx for x, 2Tky for y. Residue arithmetic can be used to simplify the computation.

To detect only the first order diffraction pattern at P1 * should satisfy

$$\alpha > (1.5/\pi)\max\left|\frac{\partial\phi(x,y)}{\partial x}\right|. \quad (5)$$

We used parameters T=0.025, M=10, n=400, *=0.0006325, f1=400, *=40 line pairs/mm.

We solved various (x,y) that satisfy eq(4) using Lee type CGH and plotted the associated pattern on an laser printer. High guality CGH mask is made by E beam pattern generator developed for making masks for IC with submicron features.

3. EXPERIMENTS

Fig.3 is the central part of CGH pattern.

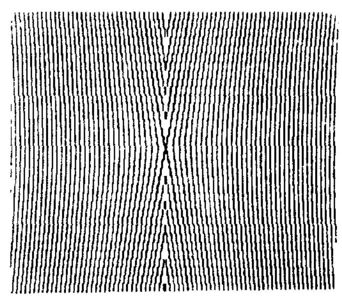

Fig.3 Central portion of fabricated CGH

The CGH is photoreduced to the size 10mm x 10mm.

The carrier frequency is 40 lines/mm in the x direction. The light source is 10/mW He-Le laser. The focal length f1 is 400 mm.

The CGH to perform deformation invariant optical pattern recognition in real-time is tested in the system of Fig.1 with reference patterns which are distorted by rotation and scale changes in the Po input images.

A spatial light modulator such as LCTV is required to record the input Po pattern and often also the coordinate transformed pattern at P1 of Fig.1. LCTV where is placed in the P1 plane contains transformed inputs by feeding the TV detected output of the P1 pattern of Fig.1 to an LCTV at P1 of Fig.2.

Fig.4 shows the experimental set up.

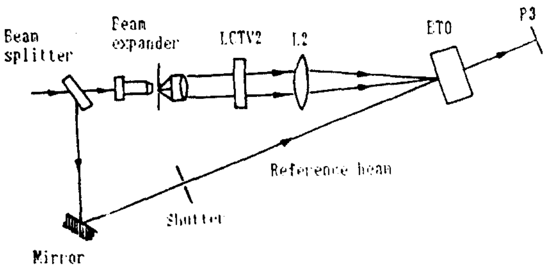

Fig.4 Experimental set up

A BTO of the coordinate transformed object to be recognized is formed at P2 with the beam balance ratio,chosen to yield the optimal correlation SNR. The output correlation of P3 is detected by a camera. The specification of BTO is 7.8x5.5x5.1mm of Sanders Co. and LCTVs are model number 16 156 of Radio Shack Co..

In order to increase the correlation peak, the zero-order terms of the input object is slightly suppressed and the higher-order terms of it are enhanced by the edge enhancement mechanism and degenerated four wave mixing configuration. The original binary image is Fourier transformed by lens and hologram is formed in the BTO crystal with reference beam at angle θ .

4. DISCUSSION

The scale and rotation invariant pattern recognition system is examined in real time processing. the key factor of performance is to make CGH precisely. The current capability of producing CGHs having large space bandwidth product using electron beam lithography,high quality CRT displays imaged onto a translatable photographic plate,or high resolution rotating drum laser film recorders should stimulate futher research.

The detailed results will be represented in the conference.

5. REFERENCE

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