Velocity filtering using complementary gratings in photorefractive BSO

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Motion detection, velocity filtering and the detection of change in a given scene are all important aspects for optical processing architectures and systems. So far several different techniques have been reported in the literature that use either all optical [1-4], or hybrid (optical plus electronic) [5-6], schemes to implement novelty filter [1] type operations. For essentially all-optical schemes the intrinsic advantages of parallel image subtraction are clear. In this paper we report a different scheme for motion detection and velocity filtering which uses two spatially multiplexed gratings with a relative phase shift of 180 degrees, (known as complementary gratings) in photorefractive BSO.

Here we have recorded complementary gratings by applying a periodic phase modulation to the reference beam. The two gratings recorded in this way produce a photoinduced index modulation Δn_A and Δn_B with a 180^0 phase shift. The resultant superposed index modulations are thus

$$\Delta n_A = N_A \operatorname{Cos} [Kx + \phi_A(x)]$$

$$\Delta n_B = N_B \operatorname{Cos} [Kx + \phi_B(x)]$$

Subtraction is realized when both multiplexed gratings are of identical strength and $\phi_A - \phi_B = 180^0$ so that $\Delta n_A + \Delta n_B = 0$

In the case of a static object these grating profiles are almost identical and the phase conjugate output is ideally reduced to zero. If any movement occurs in the object plane however these multiplexed gratings will undergo dynamic change and any resultant output will indicate motion within the object plane. The complementary gratings build up, decay and differential output can be illustrated via a model as shown in figure 1, which considers the simultaneous presence of two multiplexed gratings. Results showing the phase conjugate output from the complementary gratings (obtained via the experimental arrangement of figure 2) and the corresponding simulation results are shown in figure 3.

Results of optical motion detection and velocity filtering are demonstrated in image plane (figure 4) as well as Fourier plane (figure 5).

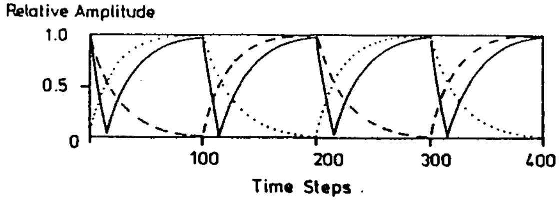

Figure [1]. Result of simulation for the complementary gratings build up, decay and the differential output (....: grating A, - - - : grating B, —: differential output).

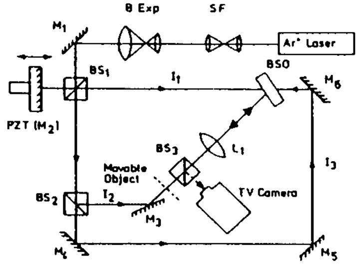

Figure [2] The experimental arrangement for velocity filtering using complementary gratings in photorefractive BSO.

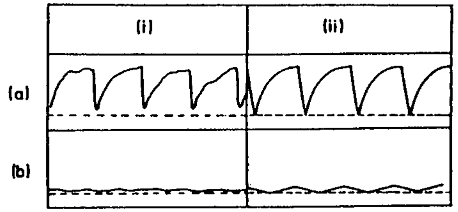

Figure [3] Column (i) oscilloscope traces of the phase conjugate output for piezo-electric pusher frequencies of 1 Hz (a) and 30 Hz (b). Column (ii) shows simulations for corresponding frequencies.

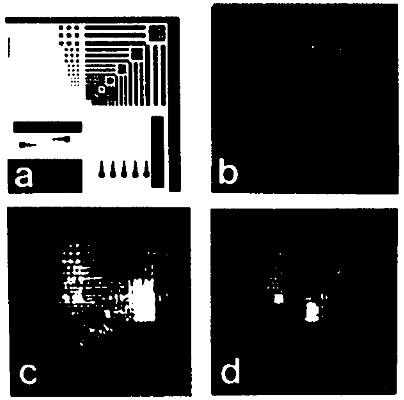

Figure [4]: (a) shows a resolution test chart whose phase replica was placed in the object plane. (b) shows the result of image subtraction when complementary gratings are recorded at a pushing frequency of 30 Hz. (c) and (d) are from a sequence of photographs showing velocity filtering detection of features of particular dimensions, which are only observed at specific speeds.

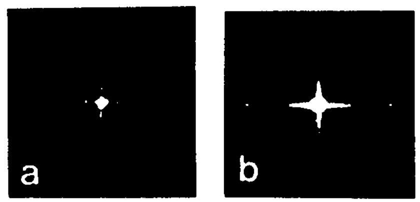

Figure [5] Results of directional motion detection via a Fourier transformation stage. (a) Fourier transform of subtraction of static resolution chart. (b) shows higher horizontal orders which correspond to lower speed.

References

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