INTERNATIONAL SUMMER SCHOOL
ON COMPUTER SCIENCE, COMPUTER
ENGINEERING AND EDUCATION
TECHNOLOGY 2018

Proceedings of the ISCSET-2018 workshop
(Novosibirsk, Russia, 12-18 of August)
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V. CONCLUSIONS

Based on the analysis of algorithm, a CBIR system based on the SIFT algorithm was designed, and then an experiment proved the availability of the system. Because the system has good robustness to scale changes, translation, rotation and brightness changes, it has broad application prospects in the field of accurate image retrieval, such as pattern recognition, face recognition, video key frame search and medical image retrieval.

ACKNOWLEDGEMENT

This work was financially supported by National Natural Science Foundation of China (Grant No. 61671190).

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The amplitude and phase values can be found from the set of holograms using phase-shifting interferometry.

The stepwise phase shift method is based on recording several interference patterns when the reference wave phase changes by a certain amount. The phase shift between interfering beams can be realized in various ways. The phase shift is most often set using a mirror fixed to a piezoceramic. Depending on the number of phase shifts, there are various decoding algorithms, e.g., (PSI) methods.

In [3], it is shown how to obtain computational procedures which, using combinations of intensity of interference patterns, obtain the distribution of the phase difference \( \phi(x, y) \) of interfering beams for arbitrary angles of displacement. In [4-6], a generalized scheme of the algorithm for a different number of shifts is obtained. Knowing the phase difference \( \phi(x, y) \) and the phase of the reference wave \( \varphi_0(x, y) \), it is possible to determine the initial phase distribution \( \varphi(x, y) \).

\[
\varphi(x, y) = \varphi_0(x, y) - \varphi_0(x, y)
\]

To form a mathematical hologram it is also necessary to determine the amplitude of the wave field \( \rho_0(x, y) \) reflected from the object in the plane of the hologram. The values of the amplitudes of the object and reference beam can be determined by overlapping the corresponding beams in the optical circuit. But if we already have a set of registered holograms with a phase shift used to determine the phase values, then we can obtain the amplitude of the object beam by the stepwise shift method using the same set of holograms [7,8].

If you can find a mathematical hologram \( G(x, y) \), then in the image plane you can restore the complex amplitude of the field scattered from the object. For this, it is necessary to carry out the Fresnel transformation over \( G(x, y) \) [9].

\[
\Gamma(r, s) = \frac{1}{i \lambda d} \exp \left[ i \frac{2 \pi d}{\lambda} \right] \exp \left[ i \frac{\pi}{\lambda d} \left( x^2 + y^2 \right) \right] \times \\
\times \sum_{k, l} b(k, l) \exp \left[ i \frac{\pi}{\lambda d} \left( k \Delta x + l \Delta y \right) \right] \exp \left[ -i \frac{2 \pi}{N} (kr + ls) \right]
\]

In expression (3), \( d \) - the distance to the object. The Fresnel transformation algorithm provides a simple scaling of the reconstructed image, but this imposes a number of limitations on the design of the measuring system, in particular, the upper and lower limits of the permissible recording distance of the hologram become a significant factor.

It is necessary to determine at what distances we can use the discrete Fresnel transform. It was shown in [10] that discrete Fresnel and Fourier transforms can be used when the distance to the object is comparable with the size of the object and hologram, while the object is in the near zone of diffraction. When recording digital holograms, the optical scheme shown in Fig. 1.

![Fig. 1. Scheme of recording a digital hologram](image)

The beam of light from the laser expands (3) and hits the separation cube. Part of the beam hits the mirror fixed to the piezoceramic (5). When reflecting from this mirror, an object beam is formed. Another part of the beam hits the object. When reflecting from the object (2), a reference beam is formed. To equalize the intensities of the reference and object beams, a light filter is used to form the hologram (4). The interference of the reference and object beams and the formation of holograms occurs on the camera array (9).

III. EXPERIMENTS AND RESULTS

The object was a jubilee silver badge with the emblem of the university. In Fig. 2 shows the results of interference between the reference and object beams when the phase angle of the shift is changed. Interference patterns were projected directly onto the digital array of photodetectors.

![Figure 2. Interference patterns with a change in the phase angle of shear](image)

\( \delta_1 = 0^\circ, \delta_2 = 90^\circ, \delta_3 = 180^\circ, \delta_4 = 270^\circ \)
For these pictures, the phase distribution and amplitude were determined. Then a mathematical hologram was formed using the expression (1). In Fig. 3 shows the amplitude and phase of the mathematical hologram.

Figure 3. Amplitude and phase of the mathematical hologram.

The actual image was reconstructed from the mathematical hologram using the Fresnel transform. The size of the object is 7 mm, the distance to the object is 135 mm. The result of the restoration is shown in Fig. 4.

Figure 4. Left source object, right: the result of restoring the actual image from the mathematical hologram.

The noise in Fig. 4 are caused by the deflection of the reference beam from the plane beam. By improving the quality of optical elements, this factor can be eliminated.

This work was supported by the Russian Foundation for Basic Research "Development and research of computer holographic interferometry methods for complex objects" (Grant No. 18-08-00580).

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