JPEG–Compression of Digital Hologram

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Abstract

We study effects of storing digital particle holograms by a joint photographic experts group (JPEG) compression. Information content of the holograms is statistically evaluated by measuring the degree of similarity between the compressed and its original holograms. We also extract size and position information of the particle from the compressed hologram. The results show that the hologram could be compressed about 30 times smaller without causing the error of measurement to be bigger than 1%.

Keywords: holography, data compression

1. INTRODUTION

Unlike conventional holographic reconstruction technique for measuring a diameter and location of particle [1], digital holography obviates a reconstruction process and can improve an accuracy of measurement. In the digital holography, holographic interference patterns are captured by using a CCD camera. The captured interference pattern is then stored into a memory of computer for further extracting process. However, in real-world applications we may deal with a huge number of hologram images. This may lead to a storage capacity problem. Although the image compression technique offers a practical solution for storage problem, information content of the hologram may be degraded. In this work, we study the effect of lossy JPEG-compression on the digital holograms. The reason of using the lossy compression is that it gives a higher compression ratio compared than the lossless algorithm.

2. METHODOLOGY

In the study, we first evaluate the degree of similarity between original and its compressed holograms by using the correlation technique. The peak-to-correlation energy (PCE) defined as [2]

$$PCE = \frac{|y(0)|^2}{\int_{-\infty}^{\infty} |y(x)|^2 dx} \qquad (1)$$

is used for measuring statistically quality of the information content from the compressed hologram. $y(0)$ and $y(x)$ denotes the correlation peak value and the correlation function, respectively. The PCE measure the energy of the correlation signal and indicates the sharpness of the peak. When the original and the compressed holograms are similar, the correlation signal has a sharp peak. Thus the PCE gives a large value. In an unsimilar case, the correlation signal is broad, thus the PCE is small.

Besides the statistical analysis, we also extract the position and size of the particle from the compressed hologram by using a direct digital analysis which combines a wavelet transform (WT) and a envelope reconstruction technique [3]. This analysis is done as follows: The particle hologram is mathematically constructed by an envelope function that modulates a chirp signal. The envelope function is determined by the particle size, while

frequency of the chirp signal is inversely proportional to its position. Since the WT is useful for analyzing non-stationary signals, the WT analysis of the hologram gives the frequency information of the chirp signal. Therefore, the position of the particle can be obtained. Finally, the envelope function is reconstructed back by locating the maximum and minimum amplitudes of the modulated chirp signal in order to determine the particle size.

3. RESULTS AND DISSCUSION

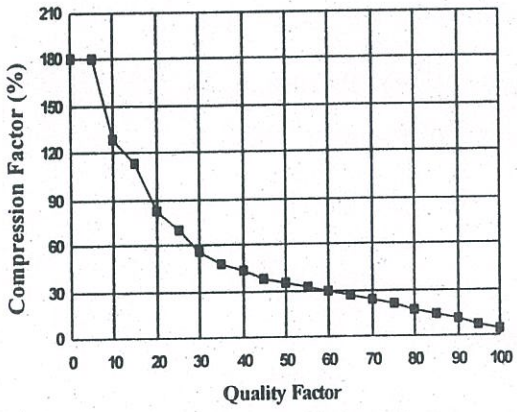
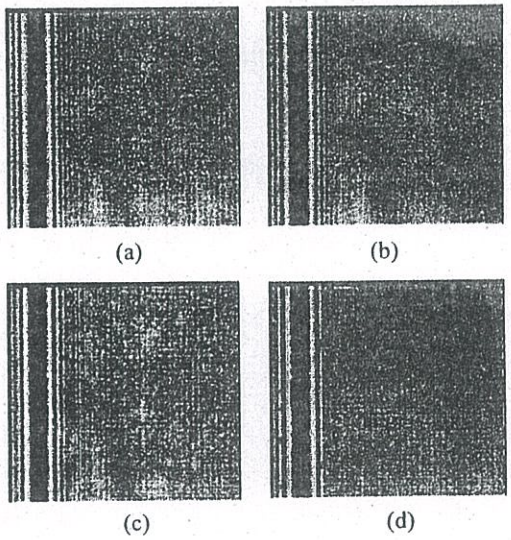


Figure 1. Compression factor as a function of the QF.

In our study, the hologram image of a fiber optic with a diameter 62.48 μm was generated by using a laser light operating at a wavelength of 543.5 nm. The interference pattern was captured by a CCD camera Hamamatsu C5948 with a resolution of 640×480 pixels. The captured hologram was saved in a TIF file format. Its size was about 904 Kbytes. This digital hologram was then compressed into the JPEG file format by using ACDsee software version 3.1. In this software, the compression quality is determined by a parameter called quality factor (QF) whose value can be varied from 100 to 0. Figure 1 shows the compression factor, defined as the ratio of the uncompressed file size to the compressed file size [4], as a function of the QF. The figure describes the characteristic of the QF that a small value of QF gives better compression than of higher one, because more information is discarded during the compression process. In case of our hologram, the lowest QF produced 5 Kbytes compressed file, whereas the highest QF gave about 200 Kbytes. Figure 2 (a), (b), (c), and (d) show the original and compressed holograms with QF of 50, 10, and 0, respectively. It is seen that the higher QF gives the better image quality.



The variation of PCE as a function of the QF is shown in Figure 3. It is obvious that as the QF decreases, the value of the PCE decreases as well. This is caused by the fact that the low QF discards more information than the higher one. As the result, the degree of similarity reduces, and the value of PCE becomes smaller. However, the PCE of the compressed file does not vary significantly.

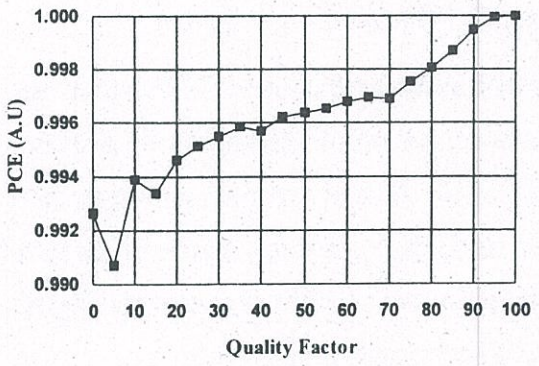


Figure 3. The PCE as a function of the QF.

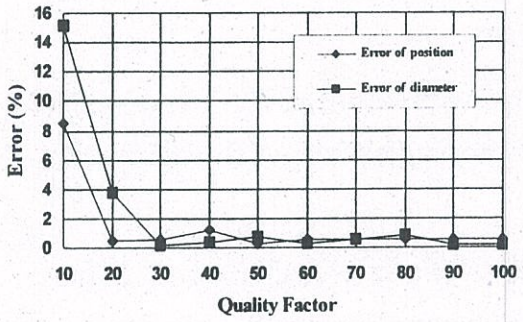


Figure 4. Error of measuring position and diameter as a function of the QF.

In order to further study the effects of image compression, we extract digitally information from the compressed hologram by using a combination of the WT and the envelope reconstruction method. Error of measurements of object size and its location by this method has been verified to be less than 1 %. Figure 4 shows the errors of measuring position and diameter as a function of the QF. The result shows that both errors are less than 1 % when the QF is greater than 50 which corresponds to the compression factor of 30. By considering 1% error as a limiting criterion, we conclude that the digital hologram could be compressed by about 30 times smaller than the original size.

4. CONCLUSION

We have investigated the effects of JPEG-compression on digital hologram by use of the correlation technique and direct digital analysis. The results show that an accurate size and location of particle could still be extracted from the hologram, although it is compressed by about 30 times smaller.

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