High Sensitive Multiresolution Analysis of Low-Contrast Radiologic Images Based on the Digital Pseudocoherent Holographic Interferometry Method

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THE SERIOUS PROBLEM of low-contrast radiologic images analysis is connected with visual identification impossibility of 1% (or less) in brightness variations, whereas for tasks of medical diagnosis, much higher sensitivity is needed. To solve this problem, a new method, called the pseudocoherent holographic interferometry method (PHIM), was developed.

The idea of PHIM is related to the presentation of a low-contrast image as a topologic surface (the third coordinate is brightness) with further illumination by means of a virtual pseudocoherent optical wave. Interaction of the reflected "subject" wave with the "support" one forms a new complex interferometric image.

There is some analogy to the well-known method of optical holographic interferometry, but the PHIM has three very important differences:

1. The PHIM is completely digital method and can be applied to analysis of any radiologic image (x-ray computed tomography [CT], magnetic resonance imaging [MRI], positron emission tomography [PET], and others).
2. A virtual optical wave is mathematical one and has controlled frequency of the pseudocoherent illumination. It makes it possible to

provide the effect of a multiresolution analysis by means of a set synthesis of new images for various frequencies of the pseudocoherent wave field.

3. Image analysis based on the PHIM allows the use of two informational characteristics: amplitude space (as in the ordinary optical method) and phase space. The last characteristics can be visualized only via PHIM. It significantly increases the common sensitivity and space-resolving power of the PHIM.

Very good results were obtained when applied to analysis of numerous radiologic images. Figure 1 the results of the PHIM digital simulation. Figure 2 shows the result of a MRI brain tumor analysis. The results in Fig 3 show the importance of the phase-space information for visualization of very-low-contrast regions (eye nerve on x-ray CT image).

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Fig 1. Demonstration of the PHIM sensitivity of a digital model. (A) Original with 0.4% brightness, invisible discontinuities; (B) result of the PHIM.

Fig 2. MRI brain tumor analysis. (A) Original; (b) tumor; (c) result of the PHIM (a lot of particularities are seen on the brain tumor envelope).

Fig 3. X-ray CT eye nerve tumor analysis. (a) Original; (b) amplitude characteristic of the PHIM; (c) phase characteristic of the PHIM; (d-f) the same characteristics for right healthy eye (the last result demonstrates high sensitivity of the phase information).