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Noise Suppression of the Reconstruction of Infrared Digital Holography based on Pyramid-based bilateral filter

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Abstract: In this paper, we present a new technique of speckle noise suppressing of infrared digital hologram. This technique uses the Laplacian pyramid to separate the original reconstructed hologram into different layers, and conducts the bilateral filter onto each layer to discriminate the noise and the detail information. Because not all noise can be discriminated by the bilateral filter, we design an improved median filter to filter the leftover noise. The detail information of each pyramid layer can then be enhanced without too much noise. We retrieve the separated layer back to a reconstructed image using the reverse Laplacian pyramid method. This technique works effectively on the infrared digital holograms in noise suppressing. No multiple holograms or specific mechanical equipment are needed for doing so, which makes this technique easy to calculate and realize. Figures and numerical results are shown in this paper to demonstrate the performance of this technique.

Keywords: infrared digital holography; Laplacian pyramid; bilateral filter; improved median filter; noise suppression

1 Introduction

The noise situation has been a serious problem during the reconstruction of digital holograms. The noise greatly degrades the image quality of the reconstructed hologram, such as speckle noise arising from the roughness of the object surface when height variations exceed light wavelengths [1]. When a coherent light beam illuminates the rough surfaces of randomly scattering objects, the waves scattered by different surface points fluctuate statistically because of height variations. The superposition of these scattered waves forms a stationary speckle pattern in the recording plane [2]. Thus, the hologram not only includes the grating structure of the light field in object plane, it also incorporates speckles. The presence of speckle noise in reconstructed images degrades the image resolution and measurement accuracy [3].

In the holographic reconstruction, many techniques have been proposed for the speckle reduction. Most of the methods use the temporal integration by multiplexing holograms [4,5,6] or introducing a scanning or rotating element [7,8,9,10,11]. Both approaches are successful to reduce the speckle noise effectually. However, there are some drawbacks within these methods. Such as, the moving element approach has the problem which the disturbance of the system. On the other hand, the temporal approach gives the blur to the reconstructed image instead of the disturbance. This is especially obvious in the infrared digital holographic display because in the infrared digital holography, longer wavelength and bigger pixel size of the infrared microbolometer make the speckle much serious then in the normal visible light
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