Fast and robust single-shot speckle correlation imaging by correlation of speckle patterns

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ABSTRACT: Computational approaches exploiting the optical memory effect have recently proven to be effective in imaging through scattering media. The optical (angular) memory effect refers to a phenomenon where identical and shifted speckle patterns are generated when a point source within a certain range propagates through the scattering media. The speckle pattern plays an important role as the impulse response of the speckle correlation imaging system exploiting the angular memory effect. When light from an unknown target within the angular memory effect range passes through the scattering media, the acquired scattering pattern can be expressed as the target convolved with the speckle pattern. A conventional method to retrieve the unknown target behind the scattering media is to independently recover the Fourier magnitude and phase of the target from the acquired scattering pattern. A key concept in the recovery of the Fourier magnitude is that the autocorrelation of the acquired data is equal to the autocorrelation of the unknown target [1]. To retrieve the Fourier phase of the unknown target, iterative projection-based phase retrieval algorithms have been previously employed using the acquired data and the recovered Fourier magnitude. However, the performance of phase retrieval is not consistent since it depends on the initial value and heuristic parameters to control its convergence behavior. In this work, we propose a newly developed reconstruction method by employing the ergodicity of the speckle patterns. To employ the ergodicity of the speckle patterns, the acquired patterns are divided into multiple subimages. By performing the correlation analysis among the multiple data, the Fourier magnitude and phase can be fully recovered. The proposed method does not rely on the initial value or any parameters and shows robust performance with fast global convergence rate.

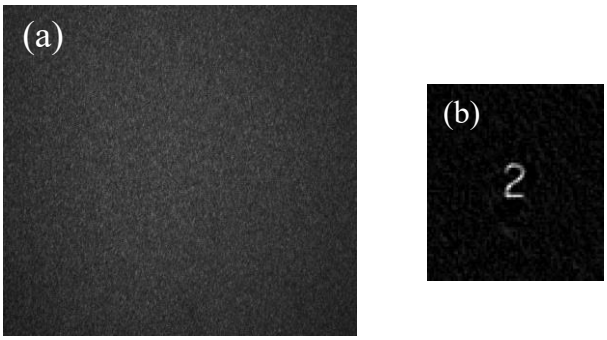

Figure 1. (a)the acquired image, (b) the reconstruction result

RESULTS: Figure1 shows the acquired speckle patterns (a) and the reconstruction results (b). The reconstruction only requires a few seconds on a desktop PC equipped with i7-8550U CPU.

REFERENCE

[1] O. Katz, P. Heidmann, M. Fink, & S. Gigan. “Non-invasive single-shot imaging through scattering layers and around corners via speckle correlations,” *Nature photonics*, *8(10)*, 784, (2014)