COMPUTATIONAL IMAGING THROUGH DYNAMIC TURBULENT MEDIA

Byungjae Hwang, Jung-Hoon Park

Department of Biomedical Engineering

Ulsan National Institute of Science and Technology

50, UNIST gil, Eonyang eup, Ulju gun, Ulsan, Republic of Korea

E-mail: hbj531@gmail.com, jh.park@unist.ac.kr

KEY WORDS turbulent media, computational imaging, bispectrum, shift-invariance

ABSTRACT A challenging problem in optical imaging is to achieve high-resolution imaging through uncontrollable dynamic turbulent media. In conventional adaptive optics (AO), optical instruments such as wavefront sensors and modulators have been employed to compensate for aberrations induced by the randomly varying turbid media. However, techniques based on conventional AO require highly stable and precise alignment among the optical instruments, which limits their widespread applicability. Furthermore, time variant aberrations are especially difficult to compensate using conventional AO. In a different approach, computational wavefront correction exploiting the randomness of time-varying media has proven to be effective. By acquiring multiple short exposure images, each image is able to experience random perturbation while conserving the high-resolution information behind the time-varying media without any blurring effects in long-exposure images. Thus, the acquired multiple short-exposure images can be exploited to reconstruct a single high-resolution image. For example, ensemble averaging of the power spectrum and the bispectrum can be used to estimate the Fourier magnitude and phase of an unknown target. The bispectrum, which is the Fourier transform of the triple-correlation, has the shift-invariant property, which is a key property to extract the Fourier phase of the unknown from the ensemble averaging of the bispectrums [1]. Based on these observations, we demonstrate several fast computational techniques to recover high resolution images through dynamic turbulent media without any aberration measurement or wavefront correction hardware.

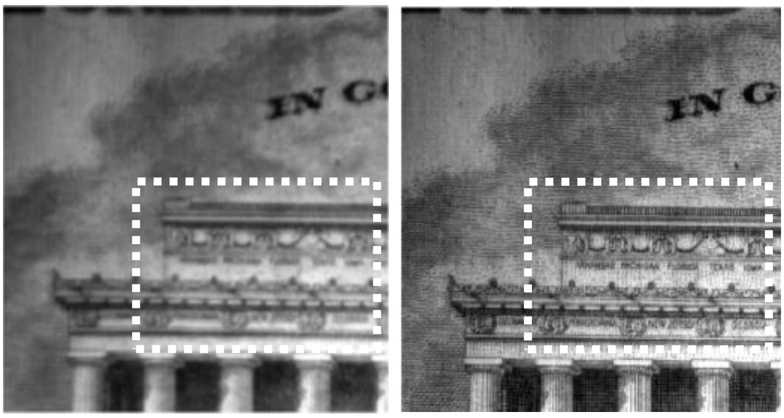

Figure 1. Left. A short-exposure image. Right. reconstructed data using the proposed method

RESULTS

Figure 1. illustrates the typical short-exposure aberrated image (left) and the reconstruction result (right) from the proposed method. White dotted boxes indicate the main difference between the two images. The characters in the reconstructed image are clearly delineated compared to the ones in the acquired image.

REFERENCE

[1] B. Hwang, T. Woo., & J. H. Park. "Fast diffraction-limited image recovery through turbulence via subsampled bispectrum analysis," *Optics Letters*, ***44*****(24)**, 5985-5988, (2019)