Research progress on adaptive optical image post reconstruction

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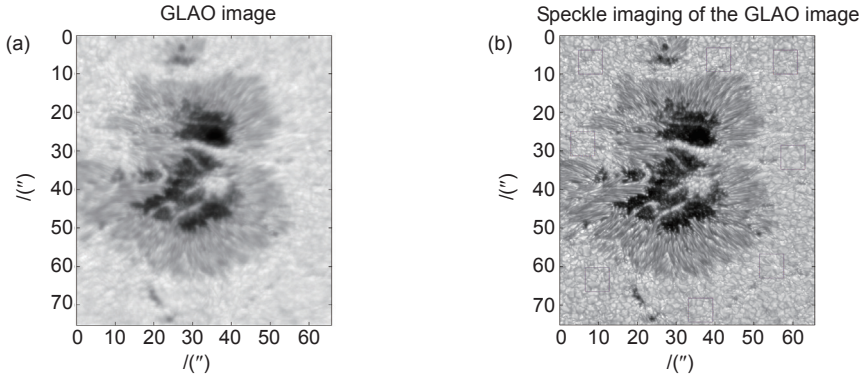

(a) Image after AO correction; (b) Image reconstructed by speckle reconstruction

Overview: The light wave from target is influenced by outside factors such as the atmosphere turbulence, the aberration of telescope and so on. To overcome these problems, the adaptive optical (AO) technique was proposed since 1950s. However, restricted by the accuracy of wave-front sensor, the limited correction of deformable mirror and the limited bandwidth of close-loop, wave-front distortion can only be corrected by AO system partially. Therefore, the AO imaging results are still affected by the residual wave-front aberration. To further improve the quality and resolution of AO images, the image post-processing technique is required.

As we know, the AO technique can effectively reduce the wave-front distortion, so as to effectively reduce the range of solutions of image restoration. Furthermore, the residual wave-front aberration is important prior information to guide the optimal iteration process. In addition, the image post-processing will be more robust as the AO images have higher peak-to-signal ratio (PSNR). However, on the other side, the AO technique will change the model of atmosphere turbulence and the statistical distribution of residual aberrations. Therefore, image reconstruction algorithms must take the characteristics of AO system into consideration.

Currently, the major image processing schemes include blind deconvolution (BD), phase diversity (PD) and speckle imaging technologies (SI). BD is one of the most flexible technologies without special requirements for imaging system and processing object, but BD needs prior knowledge about PSF and support region of real targets to restrict the solving procedure. PD is an aberration detection based on image restorion technology, by using a few groups of images acquired from the same object with different optical channels simultaneously. The main challenge of PD is that this technology requires an extra set of imaging equipment, and the algorithm is sensitive to parameters. SI technology uses the statistical characteristics of atmosphere turbulence to reconstruct the phase and amplitude of the imaging target respectively, which has widely been applied to high resolution solar image reconstruction. However, as SI is based on the statistical information of atmosphere turbulence, it needs hundreds of short-exposure images to reconstruct a single image; therefore the imaged object cannot have obviously changing in the imaging procedure.

In order to get acceptable reconstructed AO images, the major three image processing technologies mentioned above have been deeply discussed in this paper, and relevant improvements are proposed to suit AO system characteristics. The high quality processing results of human retinal images and the large field of view of sunspots images have proved our methods are effective and reliable.

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