N2ONCPA: a new low order Wavefront Sensor and its first experimental results.

Alessandro Terreri*[2,1], Markus Kasper , Byron Engler[3], Cedric Taissir Heritier[4], Fernando Pedichini[1], and Dario Del Moro[2]

[2]University of Rome ”Tor Vergata” (UToV) – Italy
[1]INAF - Osservatorio Astronomico di Roma – Italy
[3]European Southern Observatory – Germany
[4]ESO – Germany

Abstract

All the aberrations not corrected by Adaptive Optics (AO) systems are important limitations for high contrast imaging on large telescopes. Among them, the most relevant ones are called Non-Common Path Aberrations (NCPA): these are present downstream of the separation of the optical paths to Wavefront Sensor and scientific focal plane and it's a really big issue when working with visible wavelengths. The typical approach to mitigate them is to set an offset on the AO system with the opposite sign of this NCPA. Generally, the amplitude and typology of NCPA is decided after manual and iterative attempts in a so-called trial-and-error approach or in some cases other more sophisticated focal plane wavefront sensing approach have been used. In this talk I will show you my new methodology based on a very simple Neural Network applied to out-of-focus images to measure all the static and quasi-static aberrations. The Network is trained on a dataset of 10000 simulated out-of-focus images with well-known aberrations coefficients in a range of +-50nm for the first 21 Zernike polynomials. A Principal Component Analysis (PCA) on the dataset outputs a series of eigeinimages. Every image is reprojected in this eigenimages basis obtaining a set of PC coefficients representing each of them. The NN is trained to find the relationships between PC coefficients and Zernike polynomials coefficients. The method, which I have already shown working well on simulations, works even better on experimental images. I applied the method on the GHOST bench at ESO laboratories, injecting with a SLM a random set of Zernike polynomials and let the NN measure the aberrations through the analysis of the extrafocal plane image taken by the science camera. The NN not only retrieved the aberrations I injected but also the NCPA already present in the bench. After an iterative process of NN measurement and injection of the corrections through the SLM, I put the camera back in the focal plane obtaining the best image possible for the system and achieving better precision than human trial-and-error approach, both in terms of morphology and intensity peak of the PSF.

*Speaker

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