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Robust wavefront sensing in harsh turbulence conditions

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The ultimate performance of adaptive optics is limited by the quality of the wavefront sensing. This is particularly the case when the turbulence is faster or stronger than the medium conditions assumed in the design of the system, or in case of low signal to noise ratio (e.g. low flux). In such extreme conditions, some general parameters of the system, like modal gains, can be tuned at minute scale. But the turbulent wavefronts rapidly evolve in time (e.g. turbulence bursts) and space (variations across a large pupil). The algorithms we have developed for such harsh conditions rely on the estimation of the error associated with each wavefront sensor measurement, including the covariance of the errors. This information allows the control loop to promptly optimize itself to fast varying conditions. An overview of the wavefront sensing algorithms in charge of implementing this strategy will be presented, with the constraint to fit in a current multi-core CPU. The method is demonstrated on streams of data obtained on THEMIS solar telescope in the visible, where the images of solar granulation given by the subapertures of the Shack-Hartmann wavefront sensor get randomly blurred, some of them possibly fading away. The structure of the noise shows correlations of the gradients similar to the ones induced by laser guide stars elongationn on an ELT.

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