Marginalized semi-blind restoration of Adaptive-Optics-corrected images using stochastic sampling

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Abstract

Adaptive optics (AO) corrected image restoration is particularly difficult, as it suffers from the lack of knowledge on the point spread function (PSF) in addition to usual difficulties.
An efficient approach is to marginalize the object out of the problem and to estimate the PSF and (object and noise) hyperparameters only, before deconvolving the object using these estimates.
Recent works have applied this marginal blind deconvolution method, based on the Maximum A Posterior (MAP) estimator, combined to a parametric model of the PSF, to a series of AO corrected astronomical and satellite images.
However, this method does not enable one to infer global uncertainties on the estimated parameters.

In this communication, we propose a new restoration method, which consists in choosing the Minimum Mean Square Error (MMSE) estimator and computing the latter as well as the associated uncertainties thanks to a Markov chain Monte Carlo (MCMC) algorithm.

We validate our method by means of realistic simulations, in two different contexts: an astronomical observation on VLT/SPHERE and a ground-based LEO satellite observation on ONERA's ODISSEE AO system at the 1.52 m telescope of the Observatoire de la Côte d'Azur. We discuss the uncertainties on the estimated parameters as well as on the sought quantities such as the OTF. Additionally, we study and interpret the correlations between the parameters. Finally, we present results on experimental images for both applications.

Additionally, taking into account constraints on the object (such as support constraint) should help distinguishing what comes from the object or the PSF, therefore improve the PSF estimation and image restoration, but is more difficult in the marginalized MAP case and calls for complex computations. We discuss the impact of adding a support constraint on the object in a preliminary study.

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