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PROPOSITION DE SUJET DE THESE

Intitulé : Image restoration and adaptive optics system co-design for Space observation from the ground (co-conception restauration d'image et système d'optique adaptative pour l'observation de l'Espace depuis le sol)

Référence : **PHY-DOTA-2023-16**
(à rappeler dans toute correspondance)

Début de la thèse : 01/10/2023	**Date limite de candidature :** 31/04/2023

Mots clés :

Optique adaptative, reconstruction d'images, co-conception, problèmes inverses, astronomie, satellites

Profil et compétences recherchées :

Ecoles d'ingénieurs généralistes (physique, optique) ; Master 2 signal/image, astronomie, optique, physique

Présentation du projet doctoral, contexte et objectif :

High resolution imaging in the visible range is the major challenge of today's ground-based instrumentation, whether in the field of astronomy (MUSE instrument, MAVIS project) or defense (imaging of satellites in low Earth orbit [LEO]).

Adaptive Optics [AO] is the leading technique to achieve the desired resolutions, of the order of hundreds or even tens of milli arc-second, and ONERA is a world leader of this technique. Indeed, ONERA has been in charge of quite a few world-class AO systems, from the world's first astronomical AO system (Come-On) to SPHERE, the European planet finder on the Very Large Telescope in Chile. Onera has also developed a prototype of Adaptive Optics (AO) assisted imaging system of LEO satellites, with which we recorded Europe's first AO-corrected images of LEO satellites. This AO bench is located on the MeO telescope of the Observatoire de la Cote d'Azur (OCA).

Yet the correction of AO remains partial, and all the more so as the imaging wavelength is short, so the observation systems must include a key component of image processing. This processing is a challenge both because of the turbulent residuals, which are important in the visible and generally unknown, and because of the short exposure times sometimes required, in particular for satellite imaging. ONERA has developed diverse image processing methods for the a posteriori correction of turbulence-degraded images, with applications for both retinal imaging, astronomical imaging and satellite observation, and these methods have all been successfully used on various experimental data. In particular, a recent PhD work has developed a parsimonious (i.e. few parameters) and accurate AO-corrected instrument response model. A current thesis has incorporated this model into a new Bayesian deconvolution method, based on the sampling of the a posteriori distribution of the unknown parameters (instrument response in particular). This method solves a large part of the problems usually associated with blind or myopic deconvolution (i.e. with unknown instrument response), and allows to obtain uncertainties or "error bars" on the estimated parameters, at least in cases of good AO correction and high flux.

Conventionally, the image processing methods are designed after the AO and the imaging system have been designed and built, but this is clearly suboptimal. In particular, the availability of both fast visible detectors with no electronic noise and fast high performance computing capabilities suggests that one could revisit trade-offs between hardware and software for a given performance.

Thus, in view of the upgrade of the ODISSEE satellite imaging system, and in preparation of ONERA's future satellite imaging system named Providence, the proposed thesis aims at revisiting the imaging system design and the image restoration jointly.

Indeed, this thesis will study the overall performance of an AO-corrected ground-based imaging system that includes the a posteriori image processing. In particular, this thesis will jointly optimize the image restoration method(s) and some key elements of the AO-corrected imaging system, such as the exposure time of the scientific channel and the spectral bandwidth(s). This co-design will significantly improve the performance of the overall system.

It will also allow the motivated candidate to acquire expertise in adaptive optics, data processing and system design.

Collaborations envisagées : Université de Bordeaux, Laboratoire d'Astrophysique de Marseille.	
Laboratoire d'accueil à l'ONERA : Département : Optique et Techniques Associées Lieu (centre ONERA) : Châtillon **Contact** : Laurent Mugnier Tél. : +33-146734747. Email: laurent.mugnier@onera.fr	**Directeur de thèse :** Nom : Laurent Mugnier Laboratoire : ONERA/DOTA/CC Tél. : +33-146734747 Email : : laurent.mugnier@onera.fr

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