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InfraRed Adaptive Optics and Machine Learning Optimization for HyperSpectral Imaging

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InfraRed Adaptive Optics and Machine Learning Optimization for HyperSpectral Imaging
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- Diamond Light Source, Harwell Science and innovation Campus, Chilton-Didcot OX11 0DE - U.K. ^ Scientific Machine Learning at STFC, Harwell Science and innovation Campus, Chilton-Didcot OX11 0DE - U.K. ⁰(honorary) Engineering Science at University of Oxford, Oxford OX1 3PJ - U.K. The Multimode InfraRed Imaging And Microspectroscopy (MIRIAM beamline B22) at Diamond Light Source in the UK has been at the forefront of IR micro/nano-spectroscopy research since 15 years. Diamond IR beamline enables a diverse range of applications from life to physical sciences at international level as documented in published literature (B22 publications). IR hyperspectral imaging uses a Focal Plane Array (FPA) (pixellated) detector for large field-of-view, Synchrotron Radiation (SR) as a bright IR source, and high magnification optics for enhanced resolution: but the method is hindered by inhomogeneous and anisotropic illumination at the sample plane [1] by SR IR. The resulting IR maps are marred by lesser pixel-level spectra quality, reducing the molecular sensitivity and microimage resolution. At MIRIAM, a unique Adaptive Optics (AO) system [2] has been developed for FPA imaging via SR IR. This system is composed by two 97-actuators deformable mirrors, a room-temperature microbolometer diagnostic, and a graphics user interface (GUI). These components work together to provide readout, control, and optimization of the microscope's IR illumination [1]. Here, we present a pioneering machine learning (ML) development to solve the longstanding challenge of optimal illumination for FPA imaging. By harnessing a Covariance Matrix Adaptation Evolution Bayesian strategy, seamlessly coupled with ad hoc figures-of-merit, this real-time code implementation is integrated within the GUI to learn how to maximize flux and make IR illumination homogeneous. The IR AO system and software optimization algorithm are shown, with first results obtained and maps discussed based on microspectra quality and image fidelity.

Fig. 1. Left: IR AO scheme at MIRIAM. Right: Optimized illumination (bottom) of the initial MIR source (top) using ML method.
[1] Azizian et al. "Beamshaping for infrared hyperspectral imaging: a sequential optimization for infrared source coupling"Optics Letters 47 (2022) doi:10.1364/OL.456049
[2] Azizian et al. "Characterization of double-deformable-mirror adaptive optics for IR beam shaping in hyperspectral imaging"SPIE Photonics Europe proceedings (2020) doi:10.1117/12.2554162

I plan to submit also conference proceedings

Yes

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