Toward on-sky testing of model-based RL for AO

Jalo Nousiainen*†[1], Markus Kasper[2], Byron Engler[2], and Cedric Taissir Heritier[3]

[1]Lappeenranta University of Technology – Finland
[2]European Southern Observatory – Germany
[3]Laboratoire d'Astrophysique de Marseille – Aix Marseille Université, Institut National des Sciences de l'Univers, Centre National d'Études Spatiales [Toulouse], Centre National de la Recherche Scientifique – France

Abstract

One of the main objectives of the next generation of ground-based telescopes is to directly image Earth-like exoplanets. However, identifying these exoplanets can be challenging as they are located very close to their host stars. To overcome the challenge, a careful design of the adaptive optics (AO) system's control algorithm is necessary.

Recently, there has been an emerging interest in improving AO control using data-driven methods such as Reinforcement Learning (RL), a subfield of machine learning where the control of a system is learned through interaction with the environment. In particular model-based RL enables an automated, self-tuning control for AO. It can handle temporal and misregistration errors and adapt to non-linear wavefront sensing while remaining efficient in training and execution.

In this study, we apply and adapt a specific RL method called Policy Optimizations for AO (PO4AO) to the GHOST test bench at ESO headquarters, where we demonstrate strong performance on a simulated cascaded AO system. We explore the predictive and self-calibrating capabilities of the method and show that our current implementation using PyTorch introduces only a latency of 300$\mu$$m.Wealsodiscussandintroducetheoper
$sourceimplementationofthemethod.$

Keywords: Machine learning, reinforcement learning, model predictive control, high contrast imaging

*Speaker
†Corresponding author: jalo.nousiainen@lut.fi