The Rubin Observatory Simonyi Survey Telescope's Active Optics System

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Abstract

The Vera C. Rubin Observatory's Simonyi Survey Telescope (SST) is an 8.4m telescope now in construction on Cerro Pachon in Chile. In order to achieve the Rubin Observatory scientific goals of conducting a decade-long time domain survey of the optical sky, the telescope requires delivering a consistent good image quality over its 3.5 degrees field of view (FoV).
This is achieved using a combination of an open-loop and a closed-loop active optics system (AOS). The open-loop AOS will correct for gravity induced wavefront errors while the closed-loop AOS will correct semi-realtime (_˜30s) system aberrations introduced by temperature gradients, hysteresis and other non-predictable errors. The closed-loop AOS uses a combination of 4 curvature wavefront sensors (CWSs) integrated into the focal plane of the science detector and located on the edge of the SST's field of view. The information coming from the 4 CWSs are combined using tomography techniques to calculate the appropriate corrections to be sent to the three SST's mirrors, all equipped with actuators.

The AOS software is composed of a Wavefront Estimation Pipeline (WEP) to estimate the error at each of the wavefront sensors and a control system to reconstruct the state of the 3-mirrors system and find the optimal correction. Because of the large field of view and the off-axis position of the wavefront sensor detectors, the design brings interesting problematics to the traditional curvature wavefront sensing used in adaptive optics, such as: overlapping donuts, vignetting, pairing versus stacking donuts to measure the wavefront error and others. In the process, we also focussed on new emergent and promising techniques of wavefront estimation/correction such as machine learning and reinforcement learning.

Finally, in preparation of on-sky performance evaluation planned for next year, the team is working on developing tools to align the telescope within the range of the wavefront sensor, verify the sensitivity matrix on sky, evaluate the overall AOS performance and also calibrate the non-common path aberrations between the wavefront sensors at the edge of the

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3.5 degrees FoV and the detector image PSF. Some of these first steps can be done using PSF moments variations across the entire FoV to understand misalignment but also mirror shape residual errors.

In this paper, we describe the algorithms optimization and trade-offs, including the use of PSF variations for wavefront error estimation and we will discuss the commissioning plan. Finally, we will present some preliminary AOS performance using our Auxiliary Telescope, a 1.2 telescope using identical hardware and software as the SST.

Keywords: Active Optics, Curvature Wavefront Sensing, Machine Learning, PSF moments, Alignment