Keck Adaptive Optics Note 1369

KAPA Operations Software: Prototype Sequencer Development

Sam Ragland; 8/13/2020

Contents

1. Introduction

The KAPA project aims to provide high Strehl ratios over a substantial fraction of the sky, accompanied by accurate PSF estimates.

One of the sub-systems of the KAPA project, crucial for enabling science operation for the new observing modes, is the operations software system (OSS.) The OSS development for KAPA includes updates to the existing software/tools for the new operational modes, and building new observing tools.

As part of the KAPA operations software design, we explore implementing a Python-based sequencer for target acquisition. Here is the draft plan:

1. Demonstrate a more stable software environment and implement prototype state-machines.
2. Develop a prototype a mini-sequencer to perform a part of or the entire 'setup bench' process of the existing target acquisition IDL tool, 'aoacq'. The proposed mini-sequencer could potentially replace the 'setup bench' tasks of the IDL-based' aoacq.' The effort is partially in support of the observatory's objective to migrate away from the IDL. The next step along this line would be developing a sequencer for the 'acquire' feature of the 'aoacq'.
3. Test running multiple ‘state-machines’ simultaneously.
4. Add new EPICS keywords/channels to connect the 'setup bench' sequencer to the aoacq tool.

5. Add new features such as auto-trigger to run the 'setup bench' task when the telescope slews, auto-trigger ‘acquire’ sequencer once the OA centers the target on ACAM.
6. Develop a prototype a sequencer for the ‘acquire’ task of the ‘aoacq’ tool.

This document is written primarily to introduce the Keck Visiting Scholar (KVS), Emily Rampey, to the project. Emily will be documenting her work as part of her KVS report.

An overview of the 'aoacq' tool is presented in Section 2. The functionality of the 'setup bench' task of the 'aoacq' is presented in Section 3, and the EPICS channels relevant to 'setup_bench' task will be listed in Section 4 if necessary.

The priority is to demonstrate the concept using a part of the 'setup bench tasks' is adequate.' The 'setup bench' IDL routine, including the TRICK sub-system, is ~ 990 lines of code, and we are not committing to delivering a sequencer to replace this through the KVS program.

2. Overview

The 'aoacq' is a relatively complex IDL program consists of ~ 5332 lines of code. A screenshot of the 'aoacq' GUI is shown in Figure 1. The primary functions of the 'aoacq' are

1. reading the star catalog from an ASCII file, and getting the current target name from an EPICS keyword to set the camera parameters,
2. getting the pointing origin information from the user for the next observations,
3. setting the AO bench and the WFS based on the target and the pointing origin information, and
4. acquiring the guide star on the WFS.

The 'aoacq' GUI contains small squares (four red color boxes in Figure 1) to show the status of the acquisition tool and a rectangular graphical window (black in Figure 1) to show the relative position of the chosen pointing origin. These details are not all that relevant to the proposed work.

The main operation of the 'aoacq' include:

1. loading a catalog by clicking the 'load' button on the top row of the GUI (typically done once at the start of an observing program),
2. selecting the observing mode from the pulldown menu (row 3 of 'aoacq'),
3. selecting the instrument pointing origin from the pulldown menu (leftmost column of row 5 of 'aoacq'),
4. clicking the 'setup bench' button (leftmost column of row 11 of 'aoacq'),
5. clicking the 'acquire' button (leftmost column of row 12 of 'aoacq') once the 'setup bench' task is complete and the indicator next to the 'setup bench' turns green,

6. clicking the 'offset to target' button (leftmost column of row 13 of 'aoacq') once the 'acquire' task is complete, and the indicator next to the 'acquire' turns green. This operation is needed only when an off-axis tip/tilt guide star is used.

We do not plan to rewrite the 'aoacq' as part of the KAPA project, a significant undertaking. However, we aim to implement all new developments, specific to the KAPA mode, as stand-alone python sequencers and trigger them from the 'aoacq' indirectly through EPICS channels. A dedicated sequencer may be written for the asterism generator and asterism simulator sub-systems. A high-level sequencer could eventually replace the remaining IDL portion of the 'aoacq' at a later time, outside of the KAPA project, perhaps through a Keck Visiting Scholar or an Akamai student.

3. The Setup Bench Tasks

When the 'setup bench' button on the 'aoacq' GUI, highlighted with a red circle in Figure 1, is pressed, the following setup task is performed:

- Reset the status indicator variables to the default value corresponding to the red color squares.
- Perform quality checks.
    - Check the tip/tilt loop status and ask the user to open the loops if the tip/tilt loop is in the closed state and retry – We may want to skip this step for KAPA.
    - Check the magnitudes settings and ask the user to input a valid magnitude and retry.
    - We will be adding more checks for KAPA and the other existing sub-systems.
- If the quality checks are passed, then the setup bench process starts. The status indicator - the red square box next to the 'setup bench' button on the 'aoacq' GUI (Figure 1) changes the color from red to orange, indicating that the 'setup bench' task is being executed.
- If the observing mode is LGS, then gets the laser sub-mode (i.e. whether the laser is fixed to the science target or slaved to the FSM.)
- Sets the AO bench parameters for the chosen observing modes (0 for the NGS, 1 for the NGS-STRAP, and 2 for the LGS.) The NGS mode uses the beam-splitter, the LGS mode uses the sodium dichroic and the NGS-STRAP could use either the beam-splitter or the sodium dichroic.
- Suppose the observing 'hypermode' is TRICK (i.e., the keyword aohyprmode is greater than or equal to 2). In that case, it sets the instrument pointing origin, TRICK camera, TRICK focus parameters, moves the TRICK focus stage (if not in simulate mode – we may need to revisit this), and sets the TRICK filter.
- Open all AO loops.

- If the observing mode is LGS and the target name is 'LASER ZENITH', it sets the AO rotator to a specific vertical angle.
- Turns on the telemetry recording system (TRS.)
- If the science instrument is NIRC2 then sets the object keyword of the nirc2 EPICS keyword service.
- Reset the LBWFS decount and LBWFS RMS WF error keywords.
- Move the SOD, AFS, and AFM stages.
- Open the WYKO shutter if the shutter is closed and not in 'simulate' mode.
- Configure the focus manager.
- Set the FCS mode (tracking or manual) as per the configuration.
- Copy the FSM origin file appropriate for the observing mode to the default file name. We may want to revisit this for the KAPA mode.
- Set the SOD FCS to offset keyword, 'aofcc0so'. Set this to 'zero' for the case of the 'simulate' mode. We should revisit this.
- Set the WPS mode (tracking or manual) as per the configuration. Also, when the observing mode is NGS, set obwpname keyword to 'ngs.'
- Set the DAR parameters, including the guidestar wavelength.
- Set the TSS gold numbers. We may want to do this only for the LGS mode.
- The status indicator - the red square box next to the 'setup bench' button on the 'aoacq' GUI (Figure 1) changes the color from orange to green, indicating that the 'setup bench' task is complete.

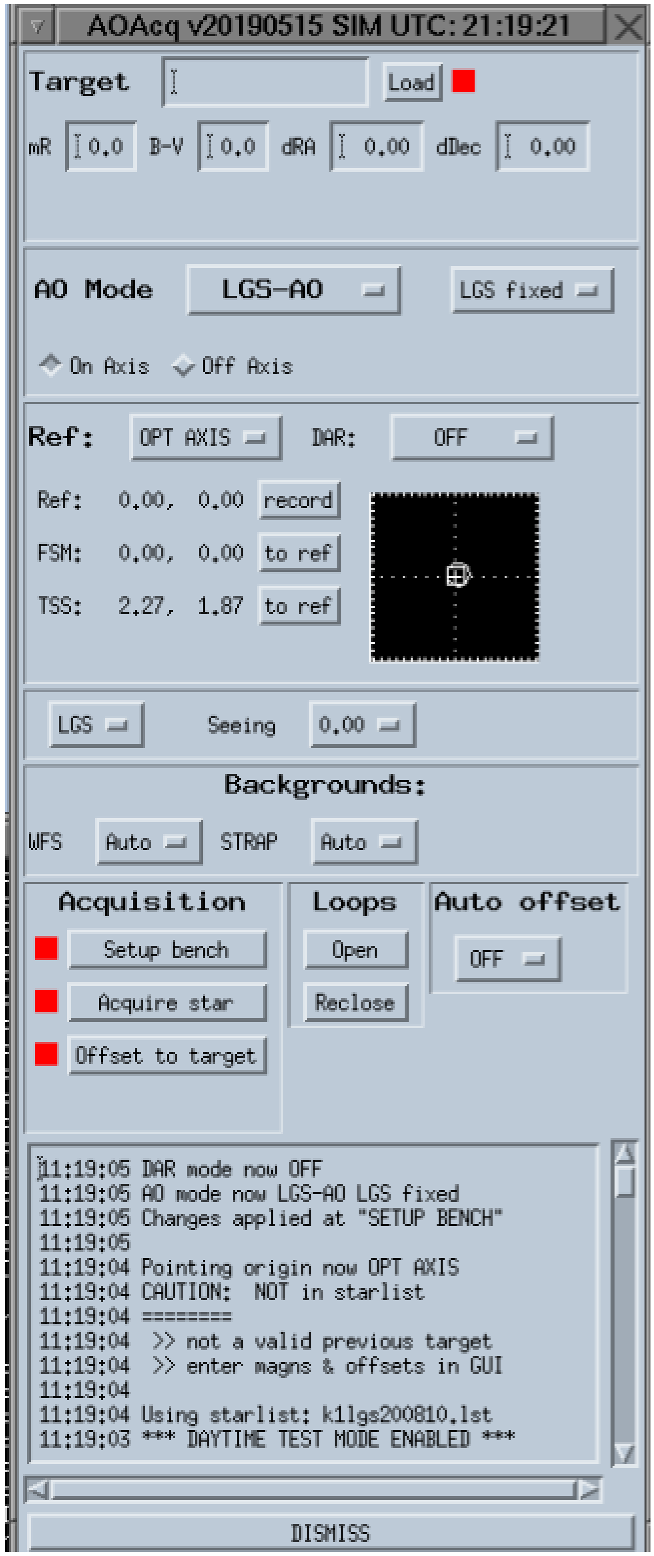

Figure 1: A schematic diagram of the AO acquisition tool, 'aoacq'.

4. State-machines

We will be implementing the Sequencer's standard states such as *START, INIT, REINIT, HALT, STANDBY, SHUTDOWN & FAULT*. The additional states include *SLEW* and *TRACK* for the motion.

We propose developing state-machines specific to the setup bench such as *QC* (quality control), *GET, PREP, SET, MOVE_STAGES*, and *CONFIG_CAMERAS*. The potential 'transitions' are verifying, reading, preparing, setting, moving, and configuring. The tasks for each 'transition' are the following:

- Verifying
  - Check if the TT & DM AO loops open (May want to skip this.)
  - Check if the star magnitude is valid
- Reading
  - Get the observing mode.
    - Gets the laser sub-mode (if LGS mode)
  - Get the hyper mode.
  - Get the BS/Dichroic settings.
  - Get the target name
- Preparing
  - Open all AO loops
  - Turn on TRS
  - Open WYKO shutter
  - Set NIRC2 target name keyword (if NIRC2 is the science instrument)
  - Reset LBWFS decount and LBWFS RMS WF error keywords (if LGS mode)
  - Copy the FSM origin file appropriate for the observing mode to the default file name. We may want to revisit this for the KAPA mode.
- Setting
  - Set the AO rotator to a specific vertical angle (if LGS and the target name is 'LASER ZENITH')
  - Configure the focus manager.
  - Set the FCS mode (tracking or manual) as per the configuration.
  - Set the SOD FCS to offset keyword, 'aofcc0so'. Set this to 'zero' for the case of the 'simulate' mode. We should revisit this. We may want to visit this for the KAPA mode.
  - Set the WPS mode (tracking or manual) as per the configuration. Also, when the observing mode is NGS, set obwpname keyword to 'ngs.'

    - Set the DAR parameters, including the guidestar wavelength.
    - Set the TSS gold numbers. We may want to do this only for the LGS mode.
    - Sets the AO bench parameters for the chosen observing modes (0 for the NGS, 1 for the NGS-STRAP, and 2 for the LGS.)
- Moving
    - Move the SOD, AFS, and AFM stages.
- Configuring
    - Suppose the observing hypermode is TRICK (i.e., the keyword 'aohyprmode' is greater than or equal to 2). In that case, it sets the instrument pointing origin, TRICK camera, TRICK focus parameters, moves the TRICK focus stage (if not in simulate mode – we may need to revisit this), and sets the TRICK filter.

5. EPICS keywords and channels

The EPICS keywords and channels relavent to the state-machines described in Section 4 will be listed in this section.