Experiment name: MGSU tomography data acquisition, February 9-11, 2006
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Brief description of problem or theory this experiment is addressing:
Goal is to assess the accuracy with which tomographic estimation of three-dimensional atmospheric turbulence can be done, using measurements on multiple natural guide stars with Shack-Hartmann wavefront sensors. Two types of 4-star asterisms will be observed, testing the theories of tomographic turbulence estimation in the MCAO and MOAO scenarios respectively.

Any previous analysis/experiments that has been done:
This is the second observation run in the MGSU tomography experiment effort, the first run (on Jan 11-12) being compromised by technical difficulties. Most of the post-observation analysis and simulation tools have been developed in advance.

Experimental section (there may be multiple experimental sections):

Experiment #1:
Estimated Time: 5 hrs
Perform in the AO lab/On telescope during the day/On telescope at night: Telescope, first half of night 2/9/06
Weather/Seeing/AO Performance Requirements:
Other Special Needs:

Description:
Primary mode: synchronous MGSU+HOWFS data acquisition on 4-star asterisms, with closed FSM loop, varying frame rates (32-256 fps). Secondary mode: closed DM loop.

Step by step instructions for conducting the experiment:
Any time during the night: take HOWFS dark frames, and measure response from DM/FSM calibration modes, e.g. tilt/focus, recording the telemetry (just need a few fixed points on transfer curve to calibrate computer models to the linear range). Also take poked (3-actuator config) MGSU+HOWFS frames once to establish optical clocking.

Primary mode:
1. Point telescope to asterism.
2. Make DM flat map, put on DM.
3. Take ~10s synced MGSU and HOWFS flat frames on white light (pointing off target).
4. Check that MGSU gain/black levels are ok.
5. Acquire first star of asterism in HOWFS, close FSM loop (optimize FSM gain/frame rate).
6. Acquire stars in MGSU2-4
7. Start synchronous MGSU+HOWFS recording with HOWFS in LGS mode, and default MGSU frame rate at 32 fps (program 4)
   a. Take ~30 second exposure
   b. Inspect results - if SNR looks ok, proceed with ~5 min exposure
   c. If SNR good, proceed with recording at 64 and 128 fps.
8. Take PHARO image for seeing measurement simultaneously with 7b.
9. Take ~30 s of sky frames - repeat frequently during the night.

Secondary mode (lower priority):
1. Close DM loop (offload focus to M2 first if necessary)
2. Record ~5 min in 128 or 256 fps
3. Take PHARO exposure sequence of asterism for anisoplanatism measurement

Go to next asterism: repeat 2-3 for every asterism (flexure may be shifting around the pupils slightly). Repeat 5-9 of primary mode for every asterism, go to secondary mode as time allows.

Note: it may be too time consuming to repeat 3 for every asterism, unless we can trust the absolute motor counts for MGSU2-4 which puts them on the white light source. Alternatively it may be easier to steer the white light source onto the MGSU pick-offs using the FSM.

Experiment #2, #3:
Estimated Time: 5+5 hrs
Perform in the AO lab/On telescope during the day/On telescope at night: Telescope, first half of nights 2/10/06, 2/11/06

Description:
Same as experiment #1. If weathered out, either give night back to LGS or do additional engineering/calibrations (e.g. measure transfer curves).

Analysis and conclusions from this experiment:
1. Use MGSU and HOWFS synchronous data to reconstruct the wavefront in the HOWFS direction. Compare the MGSU tomography prediction with the “truth” measurement from the HOWFS, compute performance metric.
2. Apply various types of reconstruction algorithms (MAP, analytical/statistical MVE) and compare their performance for tomographic wavefront estimation. Investigate performance as function of FoV (anisoplanatism) and noise.
3. Use MASS/DIMM data and/or PHARO seeing measurements to reproduce observing conditions in simulation, and rerun the tomography estimation algorithm on simulated data for cross-validation of the results from real data.