

Auto-guider Project

1. Overview:

In the nine months from October 1987 to June 1988 the CFHT auto-guider technology has been reviewed as a part time project due to evidence that it was intermittently causing out-of-round CCD images. During that time, run-time data and design theory have both been examined. Baseline and a variety of program perturbations have been compared. The results are that a set of modifications have been released that measurably improve auto-guider performance. Note that the basic technology and algorithms have not been changed.

2. Process:

It was decided at the beginning that a good formal approach would be useful. First, find out what the auto-guider is doing. Secondly, perform a sensitivity analysis by perturbing selected variables. Then thirdly, target some variable(s) for improvement

To find out what the auto-guider SHOULD be doing we performed a technology and code review. In order to find out what the auto-guider WAS doing we gathered run time data on both the state of the auto-guider and the state of the telescope. Twenty-two values were captured four times a second. Values included encoders, motor currents, measured errors on the sky, software requested rates and positions. We also took CCD images, as this is the bottom line on how WELL we're doing.

3. First Results:

No major flaw could be found. Some minor problems were found and fixed but they did not seem to be the cause of our main problem. The basic algorithm and implementation appeared sound. There were no incorrect calculations, critical timing sections, race conditions or hardware faults. Some things examined were:

- writing to the hardware during ripple or clear
- auto-guider program
- TCS control program
- interprocess communication
- image centroiding
- calculated error and correction values

However, it was very clear that when the auto-guider oscillated, all variables were involved. No particular cause and effect could be found. This sounded very much like a basic control loop phase and/or gain problem.

4. Declination Gain:

From the code review it was discovered that a single value was used as both α and δ gain multiplier. It was also known that oscillations happened more frequently in δ and that the δ control hardware was of a different type than the α hardware. It was decided to use two separate gain values.

The results of this change are striking. When the δ gain is tuned back to a little less than one half its previous level the δ response becomes identical to the α response. The oscillations appear to go away and CCD images become round. One image taken with the original gain values is shown in Figure 7. The second image in Figure 8 is with a reduced δ gain. The radial plots clearly show a hotter narrower image with the new gain. The contour plots show the roundness that can be achieved. Further analytical results were acquired through the use of the 'Image Quality Evaluator' (IQE) developed as part of the new summit computer project (Table 4).

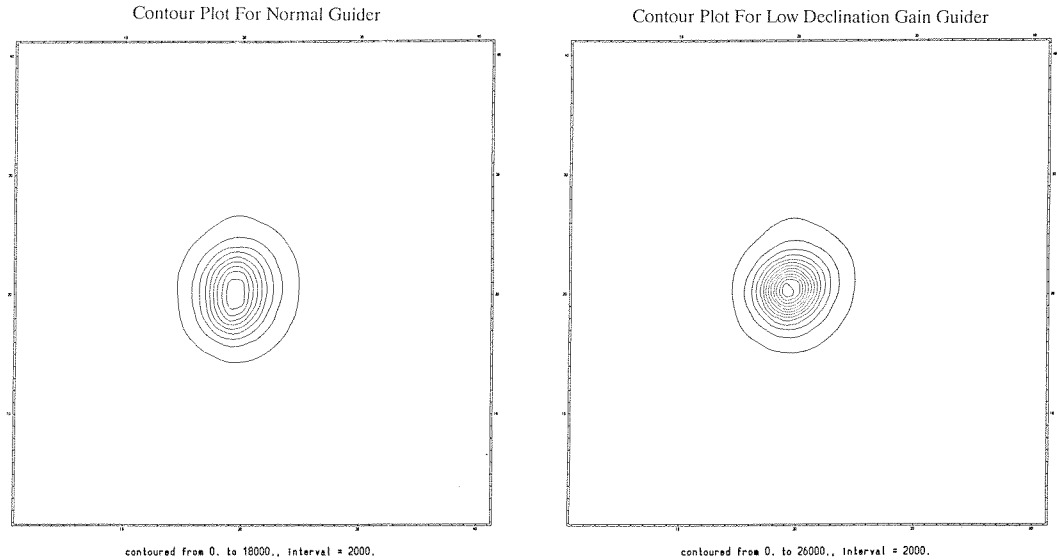


Figure 7a and 7b

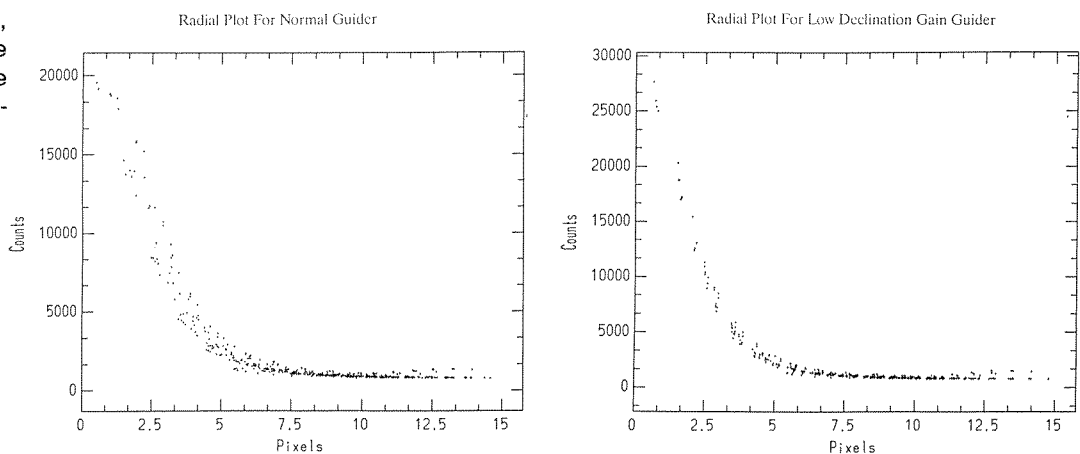


Figure 8a and 8b

Table 4: IQE Results		
Statistic	Low Declination Gain	Normal Gains
Pritchett Value	1.45	1.14
α Fwhm (arc-sec)	0.83	0.90
δ Fwhm (arc-sec)	0.83	1.22
Maximum	26865	18781
Background (edge average)	770	770
Mean	1214	1213

5. Other Changes:

A series of minor changes was also found to be in order.

Background Rejection: It was noted that the auto-guider would sometimes 'drop out', while the observer could clearly see the guide star. An edge based background calculation is now used instead of a full image based background. This appears to help during poor seeing and with very dim guide stars.

Big Error Error: A bug had crept into the main TCS control loop which caused guiding to be stopped when the 'BIG ERROR' state was entered. The auto-guider would still be running but its requests for error correction were ignored. This caused the guide star to sit at the edge of corner of the box. It also made it hard to recognize flipped optical senses. Now when the optical sense is flipped, the star is driven halfway off the screen. Also, the star can be bumped a long way out of the visual guide box and the telescope will now drag itself back.

Bonnette Rotation Encoder: Fully half of the complaints attributed to the auto-guider were in fact associated with the 'calibrate' program. And the primary reason to run calibrate was to determine the bonnette rotation angle. Since we now have encoders, it is a simple matter to include their use in the coordinate transformations found within the auto-guider. In short, calibrate does not need to be run just because the bonnette has been rotated. We not only have more precise guiding but we also save set-up time.

Configuration Files: Auto-guider parameters are now savable in named files for set-up tuning and run to run duplication. The most important parameters are the optical flip senses and the camera image scale. A standard set of files have been determined by the engineering staff. This feature when coupled with the use of the bonnette rotation encoder means that we can decommission the calibrate program altogether.

Camera Scales: It has been known for some time that the camera used for guiding does not have square pixels. With our new knowledge of the importance of separate α and δ gains it was time to take this into account. Otherwise, bonnette rotation would disturb our carefully chosen gain values. At prime focus it was found that our image scale was 0.218 arc-seconds/pixel horizontally and 0.317 arc-seconds/pixel vertically. The other foci have similar numbers. Keeping careful track of our camera scales has also made it possible to use a single set of gains for all foci.

Dynamic Tuning During Runtime: Parameters can now be modified while the auto-guider is running. The auto-guider parameters are now all in common memory so that a series of new commands can be used to change these parameters 'on the fly.' This provides for an extremely efficient way to fine tune these parameters during engineering sessions. It also provides the T.O.'s with a supportable set of control knobs for the auto-guider system.

6. Summary:

We have not seriously considered radical new approaches. We believe that we have a close to optimum implementation given our basic control approach. However, there is one further area that may be considered in the future. The pointing model should be differentiated and fed back into the tracking rate. This should have the effect of making our telescope track better when the auto-guider is not running.

Jon Brewster and William Cruise

RECENT TECHNICAL ACTIVITIES

The CFHT Network and Its Services

I. Background

CFHT has made rapid progress towards its goal of using modern computers to acquire, process and store the large amounts of data acquired on Mauna Kea. A brief outline of this expansion is detailed below

- September 1986 — CFHT has Vax 11/750 and HP1000's
- January 1987 — CFHT adds a Microvax II in Waimea
- September 1987 — CFHT purchases first Sun Workstation
- September 1988 — CFHT has 18 Unix machines on network

The reasons CFHT has been able to accomplish this expansion without a similar increase in manpower to implement and support this capability has been through the adoption of industry and astronomical standards. These are:

- IRAF: a vendor independent image reduction and analysis facility from N.O.A.O.
- Unix: an industry standard operating system supported across many architectures by different vendors
- X Windows: a vendor independent windowing system
- TCP/IP: a vendor independent networking protocol

This network currently includes the Waimea Headquarters and the Telescope Dome on Mauna Kea. In addition, the network is connected to the Internet through the University of Hawaii. With this connection CFHT will be joining the three major networks: Bitnet, Internet and Span.