Guiding System for the 60-cm Cassegrain telescope at Rozhen NAO. I: Actuators

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Abstract. An estimate of the parameters of electronically controlled actuator necessary for operation of the fine movements of the 60 cm Zeiss reflector was made as a first step towards automation of the process of observations. A test set satisfying the formulated requirements was constructed. Some results of the c conducted experiments are presented, confirming the potential of the actuator to maintain the position of the object with accuracy of approximately 1/10 of the star image ($0''.23$), supporting a wide range of velocities – from single step to $1'.5$ per second.

Key words: telescope control, Zeiss reflector, automatic guiding, stepper motor actuator

Гидираща система за 60-см Касегрен телескоп на НАО Рожен. I: Задвижване

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Направена е оценка на необходимите параметрите за електронно управляемо задвижване на фините движения на 60-см телескоп на Цайс, като първа стъпка към автоматизацията на процеса на наблюдения. Конструирана е експериментална установка, отговаряща на формулираните изисквания. Представени са някои резултати от изпитанията, които потвърждават способността на задвижването да удържа положението на обекта с точност от около 1/10 от размера на звездното изображение ($0''.23$) като поддържа скорости от единична стъпка до 1.5 ъглови минути в секунда.

Introduction

60-cm Cassegrain reflectors manufactured by Carl Zeiss – Jena are still used in many observatories, due to their good optical parameters and robust construction. Three such telescopes were delivered in Bulgaria and two of them are actively operated in Rozhen NAO and Belogradchik AO. At the beginning of their exploitation they were used mainly for electro-photometry and guiding of the telescope was performed manually directly at the telescope. Introduction of CCD Photometry changed the observational procedure since there are no means for visual control of the position of the object and its positions may be determined only after the readout of the frame – at the computer monitor, situated in the control room.

There is no feedback for the value of the manual corrections and often several iterations are needed to restore the initial positioning. This is time consuming operation and a lot of observational time may be wasted. For precise measurements maintaining the constant position of the object on the CCD chip is critical requirement and it is impossible to be achieved by manual guiding. Depending on the precision of the clock movement a limitation of the duration of the exposure is imposed and this limits the detectable magnitude of the system since the "blind" guiding is practically impossible.

1 Actual condition of the tracking of the 60-cm telescope

The original clock is been powered by fixed frequency generator and there is no possibility for adjustment of the frequency. Sometimes unpredictable shifts in the position may occur, probably for mechanical reasons. This limitation combined with imperfect positioning of the axis, refraction and other effects limit the duration of good exposures to 2, rearly 5 minutes.

During long patrol runs, consisting of many comparatively short exposures, there is considerable drift of the image in the field of view. As a consequence, some of the comparison stars may leave the frame. Displacement of the objects in the frame may move them through pixels with different sensitivity and this is manifested as artifacts on the light curve. Clearing those needs individual assessment of the every individual case and correct reduction is not always possible.

All those limitations may be overcome by introducing of an automated system for correction of the telescope position.

2 Automatic guiding

There are different methods for automatic guiding: using additional small telescope devoted to guiding only, allocation of some part of the field of view for another CCD chip (offset), use of the image from main CCD for calculation of the necessary corrections, etc. Whatever the choice, there is need for some actuator to perform the necessary shift of the position of the telescope. There are no suitable motors in the original construction of the telescope to allow for precise correction of its position.

Our approach to the design and tests of the actuators was based on the concept of minimum interference in the original construction. We designed the equipment consisting of:

- stepper motors of appropriate power
- power driver for the steppers
- signal and power supply cables
- reduction gear
- PC interface
- power supply
- control software
- safety boxes

Following are some remarks, considering the choice of the components and their placement:

- Eight watt stepper motors were selected to have enough power for moving the worm-gear of the fine adjustment movement of the telescope.
- Standard stepper drivers are too low-powered for our motors and booster stage was added to supply the required power.
- Adequate cables were made to ensure transfer of impulses to the stepper coils and power to the boosters. Reduction gear is placed at the vicinity of the worm-gear box to eliminate the slack in the gimbals.

– We decided to place the power supply quite far from the telescope – at the control room to protect it from elements.
– The control software have to allow choice of number of steps, velocity, direction and acceleration.
– Safety box not only protects the observer from unintentional contact with the moving parts but also serves as a protection from the dust particles which are abundant during specific seasons in the region around the Observatory.

3 Trial results for the test assembly

To study the performance capacity of our design we assembled a test system, based on the above mentioned schematics and components. Figure 1 shows its positioning on the telescope.

Fig. 1. The test set mounted directly on the worm-gear boxes of the telescope

We found that the system operates at maximum speed of 400 steps per second, corresponding to about $1\rlap{.}'5$ /sec. Continuous movement at the maximum speed may be considered as "stress test", as usually slower speed and only a few steps are necessary for precise guiding Steppers move the telescope at $0\rlap{.}''228$ increments and this value is reproduced with $0\rlap{.}''004$ precision. The backlash was found to be 51 steps with dispersion 2.3 steps. Of course, the backlash should be taken into consideration only when the direction of the corrections changes. Corrections can be committed during the readout time of the CCD.

4 Discussion and conclusions

During the trials we observed some undesirable increase of the temperature of the transistors in the amplifier when the power to the steppers is left on during the exposure. So the cooling arrangement needs to be redesigned.

The load to the motors can be significantly lowered if the worm-gear is kept well greased.

The next step in the automation of guiding at the 60-cm telescope may be the use of additional small optical tube for feedback to the actuator.

Our experiments show that it is high time to introduce automation of guiding on the older manually operated telescopes in our Observatory.

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Fig. 2. Tanyu Bonev and Vasil Popov at the Conference