OFFSET GUIDE OF THE ZEISS-2000 TELESCOPE

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ABSTRACT. We present offset guide of 2-m-Zeiss-RCC telescope of the Terskol observatory. The main goal of the device is to help in the observations of the faint or moving objects and made the process as much as possible automatic. The device is equiped with the optical system, CCD cameras and controller to connect the device to the computer. Hardware is controlled with the software written in our team. That software is working unger Windows operation system and is based upon the system level hooks which allow us to catch the messages from the mouse and keyboard and react accordingly. Second part of the software manages the messages sent to and received from the stepping motors microprocessor controller which are used to manipulate with the position of the optical system of the device.

There are two different setup mode of the offset guide: guiding of the inmovable objects and guiding of the moving objects like comet or asteroid. The management of the optical subsystem and CCD cameras is doing in both cases by software only.

First results of the observations with the new offset guide show us that the device is quite usefull in the automatization of the observation on 2-meter-RCC telescope.

Key words: Observations: telescopes: appliances; guiding: automatic systems: offset guide.

1. Introduction

During the observations of the faint objects, long time exposures and guiding of the objects with the apparent motions it is necessary to guide the telescope with high precision. Offset guiding allows us make quality observations as offset guide works in the same conditions as the other receivers on the telescope does, and take the light beams from the main telescope mirror. It means that geometry of the offset guide is very close to the geometry of any other receivers.

Offset guide doesn't use any of personal features. Equipped with the CCD camera it cancels a possible personal errors and helps us to save the observation time. Wasting the time during the observation caused with the list of the reasons. These are:

- slow movement of the platform with the observer; very often it is impossibe to place the platform in the position where the observer can reach the current position of the eyepieces of the guide and finder;
- long time for the selection of the appropriate guidance star;
- in the observation of the moving objects it is necessary to extrapolate the direction and possible cruising rate of the guide until its physical limits; the situations when the exposure still continues but there is no place to move should be totally avoided;
- sometimes the guide may move to the unreacheable position and it will cause the observer to finish the guidance, somehow in the middle of the exposure;
- we should be really carefull when manipulate the platform with the observer in the vicinity of the telescope or attached devices.

2. Hardware

Offet guide is placed in the telescope mounting zone behind the main mirror and the image is build with the optical system which may undergo some movements with the help of micrometer screws in the Cassegrain focal plane.

Focusing features of the offset guide itself allows additional focusing in the range of 12 mm. General field of view is 125×125 mm. Output part of the offset guide have the possibility to switch the viewfield and to set up different light filters.

General internal view of the offset guide is shown on the Figure 1. Numbers on the picture mean 1 - Y-coordinate carriage, 2 - collimator, 3 - mirrors, 4 - X-coordinate carriage, 5 - final switches.

Figure 2 shows the viewfields of CCD cameras installed with the offset guide. Field of view of the telescope $1^o10'$ occupied with two central cameras 1,2 (red and blue channels), wide field camera 3, special purpose camera 4 and offset guide camera 5. Part of the field of view (11') is directed to the CCD5 with the system of mirrors, shown as part 3 on the fig.1.

Overall architecture of the offset guide and its connections shown on the next Figure 3.

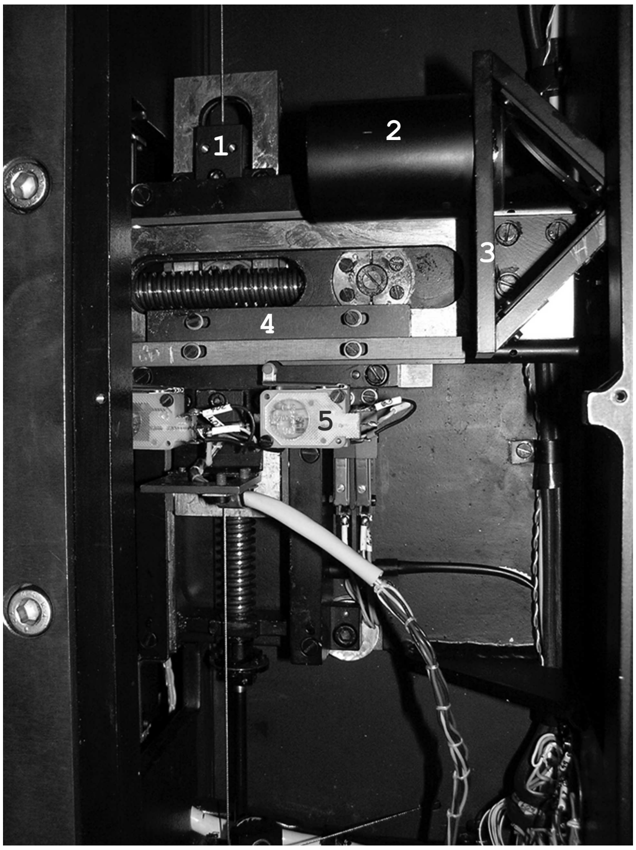

Figure 1: Offset guide internals.

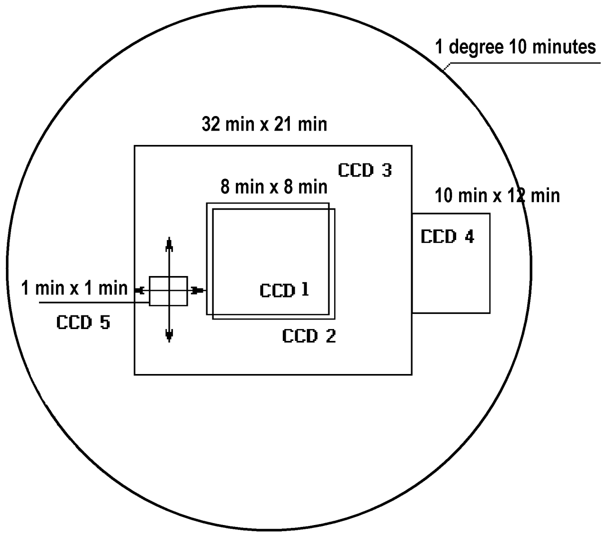

Figure 2: Viewfields of CCD cameras.

Table 1: CCD cameras used in the offset guide.

camera	pixels	seconds
ST-4	192×165	32×28
ST-7	768×510	76×51
SAO	600×400	75×41

One of the main parts of the offset guide is stepping motor controller C10, produced in Germany by the ISEL. The named controller has build in programmable memory to store programs. With the RC-232 interface it may be connected to the PC and programmed with the special set of the commands. It may manage up to three stepping motors with the different speeds up to 10000 steps per second.

We use only two motors to presicely move the prism of the CCD camera. Precision of the movement is nearly 0.0005 mm/step. Movement of the prism is possible in the square 125×125 mm. In-field testing of the mechanics set upper limit for the speed of movement in 4000 steps/second. Controller automatically interpolate the movements so the movement in any suitable direction is possible simultaneously in two directions.

The last point allows steering movement of the prism with the wide range of speeds and directions. In the real world it means the possibility to follow the most of the astronomical objects in the sky, excluding, possibly, only the fastest comets and asteroids.

Movement of the prism is doing quite pecisely. The scale factors in the hour angle and declination are near 154.10 and 153.00 steps per second of arc. Used CCD camera have 0.11"/pixel, so 15 steps move the mirror for the one second in coordinate.

ST-4 Star Tracker Imaging Camera was assigned for the guiding the telescopes. It has outlets to attach to the hand control device of the telescope. By the way, Zeiss-2000 is guided with the controlling unit through the sequence of the codes via wires and/or infrared channels. The controlling unit don't allow two or more movement commands in the same time.

The ciphering chip SAA1050 was added to the camera controller to resolve this difficulty. Afterwards the list of testing observations with automatic guiding was done and that observations showed us that continuous guiding with such the unit is quite difficult task.

There are near 15 parameters which should be estimated for every observation night and for the object coordinates. These are: allowed errors in the coordinates, sizes and rates of the object center recalculation, rate of the corrections, mechanical histeresises in the telescope systems e.g.

That is why without offset guide we still use visual guiding with the help of the operator.

3. Software

The guiding process is controlled with the software. First of all we use Guide 8.0 as a source of the object coordinates and an overall view of the eyefield. Operator can select the stars on the screen by inserting the preliminary coordinates into Guide search fields. The most interesting for the guiding process is that Guide 8.0 presents all necessary information in the legend, when requested. In standard case that legend is placed in the left bottom corner of the screen (See figure 4).

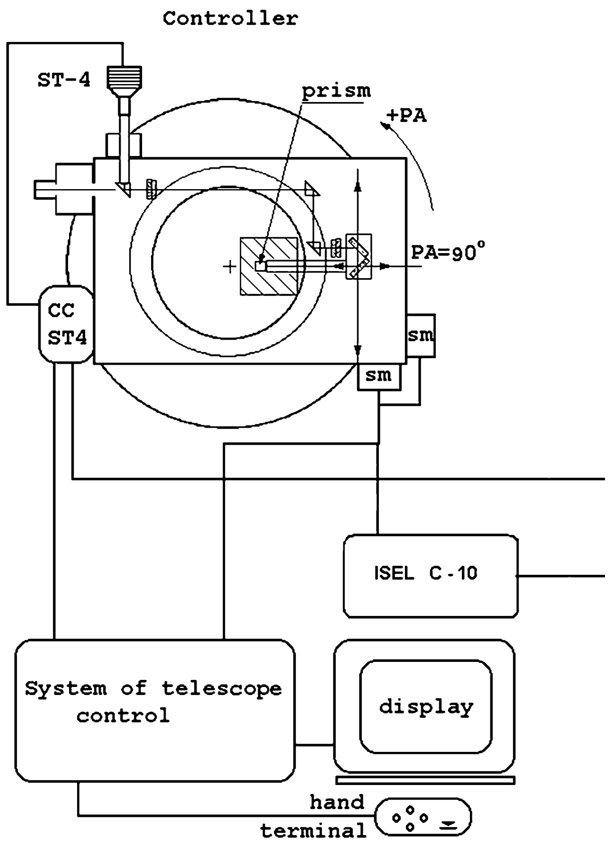

Figure 3: Schematic view of the system in general.

The Guide 8.0 is used as a binary module (unfortunately, the source code is not accessible). Taking the information from the screen of another program was our first problem. We wrote system level hook library (Hooker) which analyses any movements of the mouse pointer and pressings of the keyboard keys of Guide 8.0. This software component has only very little icon in the lower right screen corner and absolutely don't disturbs the process. Then our logic was added to the message passing process in the system.

After selection of the object operator must set up the appropriate coordinates in Guide and move the telescope to the final position. Then operator should press A button on the keyboad and click left mouse button on Guide screen in the vicinity of the telescope field center. Now the A button must be relesed. The operator repeat the explained procedure for the guiding star keeping D button pressed.

After releasing key (A or D) the Hooker reads the part of the screen with the legend and recognize the coordinates of the mouse (in this case that coordinates will be spherical right ascension and declination). The two pair of the coordinates (center of the field and guiding star) are packed and sent to Stepper component to manipulate with the offset guide mechanics.

Figure 4: Legend field of Guide 8.0.

Hooker is universal component which may be used in any case when one want to read some numbers or text from the window of another program. Hooker uses only low-level Windows API functions and may work on any existing Windows versions, even on 3.1. To make the recognition it uses neural network approach. At current moment it can recognize numbers and some subset of the latin alphabet. When used in the situation, showed in figure 4, Hooker produce 811551, 310857 and J as an result. That last symbol J give the information about coordinate system epoch. Be sent to the Stepper component these three strings cause Stepper to recalculate all necessary numbers and generate the commands to the stepping motors controller.

The Stepper component of the software is used to analyse the data from Hooker and to prepare the commands for the stepping motors. Main window of the Stepper presented on the Figure 5.

Standard ISEL controller attached to the COM port. But in most of the modern computers COM port absent or exists as an addidtional part. Most of the modern devices are controlled via USB ports. On the fig.5 one can see COM15 which is unbelievably huge number of the COM port. That is why it is really not a COM but emulation of the COM on USB. This is done with special COM to USB converter. Stepper, as we can see now may work on COM port or USB.

Before we start the observation we must first of all open the port. The buttons become to be "live" and we may manipulate with the software. Next step - homing the motors (Home button) and reloading (if necessary) the previous session parameters. (On the fig.5 we have the example with the port closed).

The white square, which occupied the most of the window is allowed field to move the guidance mirror. Clean red and blue lines with the little square near the intersection point shows us the future position of the carriage with the guidance prism. Another little square shows current position of the prism. There are many possibilities to manipulate of the prism position: by pressing the buttons, surrounded the white square, by using the mouse pointer inside the white square, by inserting the numbers into "Future pos" or "Difference" fields. All that numbers are steps.

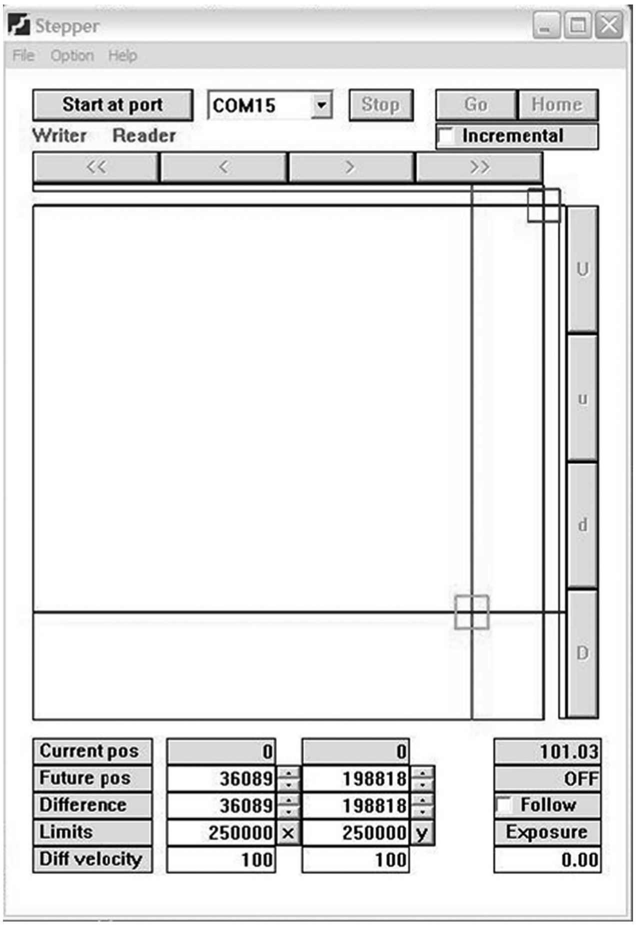

Figure 5: Overall view of the Stepper window.

There are two main setup modes of the Stepper: absolute and incremental movements. In the first case the movements are calculated from the home position of the motors. In the second - from its current position.

Another interesting possibility of the Stepper - automatic guidance with the given velocities. In this case we must insert proper numbers in the "Diff velocity" fields, setup exposure time and check "Follow" box. Stepper is quite intelligent and it allows movement of the carriage only within the specified limits (250000 steps in our case). Exposure time will be changed accordingly if with the given exposure that limits may be overcomed.

The Guide-Hooker-Stepper-Controller software works in very straightforward way - run Guide and Stepper, open port and home the motors, run Hooker. Hooker searches for that two software and if Guide and Stepper already run, the software system become ready.

All offset field is accessible with changing the angle of the telescope rotator. Stepper automatically takes the rotator angle into account. Stepper may correct the star positions for the precession and nutation if necessary. Refraction is taking into account by the telescope controller.

Review them and if all things are Ok, just press Go in Stepper window. Estimated time for carriage movement is shown in the toppest window in the rightmost window stack of the Stepper. All commands are controlled with the ISL answer. The answers are sent back to the Stepper after the finishing of the command. Until the answer is not received, the interface of the Stepper are "dead".

The Stepper is quite robust. It means that most of the operator errors are treated and the inserted numbers are just rejected. There is no possibility to move the carriage out of the physical limits. In the worst case, intermediate Home and then Go will repair the situation.

The Stepper options are managed with the special Option dialog. The information about home velocities and different shifts of the coordinate systems are presented and edithed there.

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References

Petzold Ch.: 1997, *BVH, Saint-Petersburg,* Windows-95 programming, 876 p.

Hart J.: 2005, *Wrox Publishing, Kiev,* System Windows programming, 592 p.