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Small telescopes and robotics

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Abstract. Over the past decade, Small Automated Telescopes have been developed at various observatories. The operation of these telescopes and their related observations are carried out under the control of a computer and thus the technology comes under the field of robotics. The important merits of such a telescope are high efficiency and low costs, as compared to the general purpose telescopes for a particularly chosen class of observation like photoelectric photometry, automated search type observations etc.

IUCAA has developed a prototype version of such a telescope using a 14" aperture optical tube assembly from Celestron and it uses microstepping motors along with friction gears for the telescope drives. The pointing and tracking is done using a thermo–electrically cooled CCD. This technology is being extended to the University sector and the Bangalore University has started assembly of another such telescope at IUCAA laboratory for their own use. The telescopes will primarily be used for making photometric observations of variable stars using a photometer developed at IUCAA.

The paper describes various design and fabrication aspects of such a telescope.

1. Introduction

Several observatories in USA have now developed small automated photoelectric telescopes (APTs upto 0.5 meter diameter) and have been put into use for photoelectric photometry, automated supernovae searches, asteroid searches etc. The major advantages of these telescopes over the conventional large ones are lower fabrication and operational costs, unattended operation, remote control and programming for various types of observing schedules.

IUCAA has developed one such prototype telescope based on a 14" Celestron Optical Tube Assembly. This technology involves development of hardware/software for the operation of the APT under the control of a personal computer (a PC) and thus comes under the broader field of robotics. The basic aim of developing this technology is to have interested University groups involved in the design and fabrication of such a telescope to be used for their own astronomical observations from their respective locations.

The expected outcome of this effort is a group of active workers who will be exposed to the new technology of observing with automated equipments, PCs, software, hardware, digital communications, CCD cameras, image processing, etc. This approach would generate more interesting experimental astronomy within the Indian University environment.

2. Design and Fabrication Aspects

The APT is designed around the commercially available Celestron 14" Optical Tube Assembly (OTA) for the ease of the development, but it could well be modified for any other OTA. The OTA consists of the Schimidt-Cassegrain combination of a 14" primary mirror and a secondary mirror and corrector place all housed in a tube.

Figure 1 gives an outline sketch of the APT where the OTA is held onto the ends of the fork with two declination (DEC) bearing assemblies. Fork mount is best suited for this class of telescopes as it provides convenient space for changing eye-pieces and other back-end instrumentations. The figure also shows two large 24" disks on both right ascension (RA) and DEC axes which alongwith the 1" rollers (which are mounted on the stepping motor shafts) form the friction gear drives. The rollers are under constant pressure from 100 kg springs for rendering a constant and uniform line contact with the rim of the 24" disks and backlash free motion for both RA and DEC directions. Mild steel is used as the base material for the rollers and disks with contact surfaces hardened and hard-chrome plated with 50 micron thickness.

To make the ultimate step size on either axes comparable to the seeing conditions (about 2 arc-seconds), the stepping motors have micro-stepping translators to produce 25,000 steps per revolution and this when used in conjunction with the friction gear ratio of the 1:24, renders the steps of the desired angular resolution. The mechanical flexures constrain the pointing accuracy of the APT to a few arc-minutes without any external guiding unit.

A small commercial CCD camera/tracker is used for the real time guidance and it can track stars upto 9th magnitude in the visible to an accuracy of about 5 arc-minutes. The design incorporates a beam splitter at the main Cassegrain beam so as to use 10% of the light for tracker and the rest 90% for photometry etc. The error signals generated by the tracker are used to generate appropriate number of micro-steps to drive the corresponding stepping motors under a servo loop. The natural mechanical vibrations of the telescope are much larger than the required bandwidth of the tracker servo loop (which is of the order of 1 Hz). The drive torques for the motors are estimated mainly from the wind generated torques as there are much larger than the friction and acceleration torques.

The remainder 90% of the main Cassegrain beam is used for the main science channel of the APT i.e. for doing photoelectric photometry, imaging etc. based on light weight back-end instrumentation. The present design of the APT primarily aims for making photometric observations for variable stars by using a photometer developed at IUCAA.

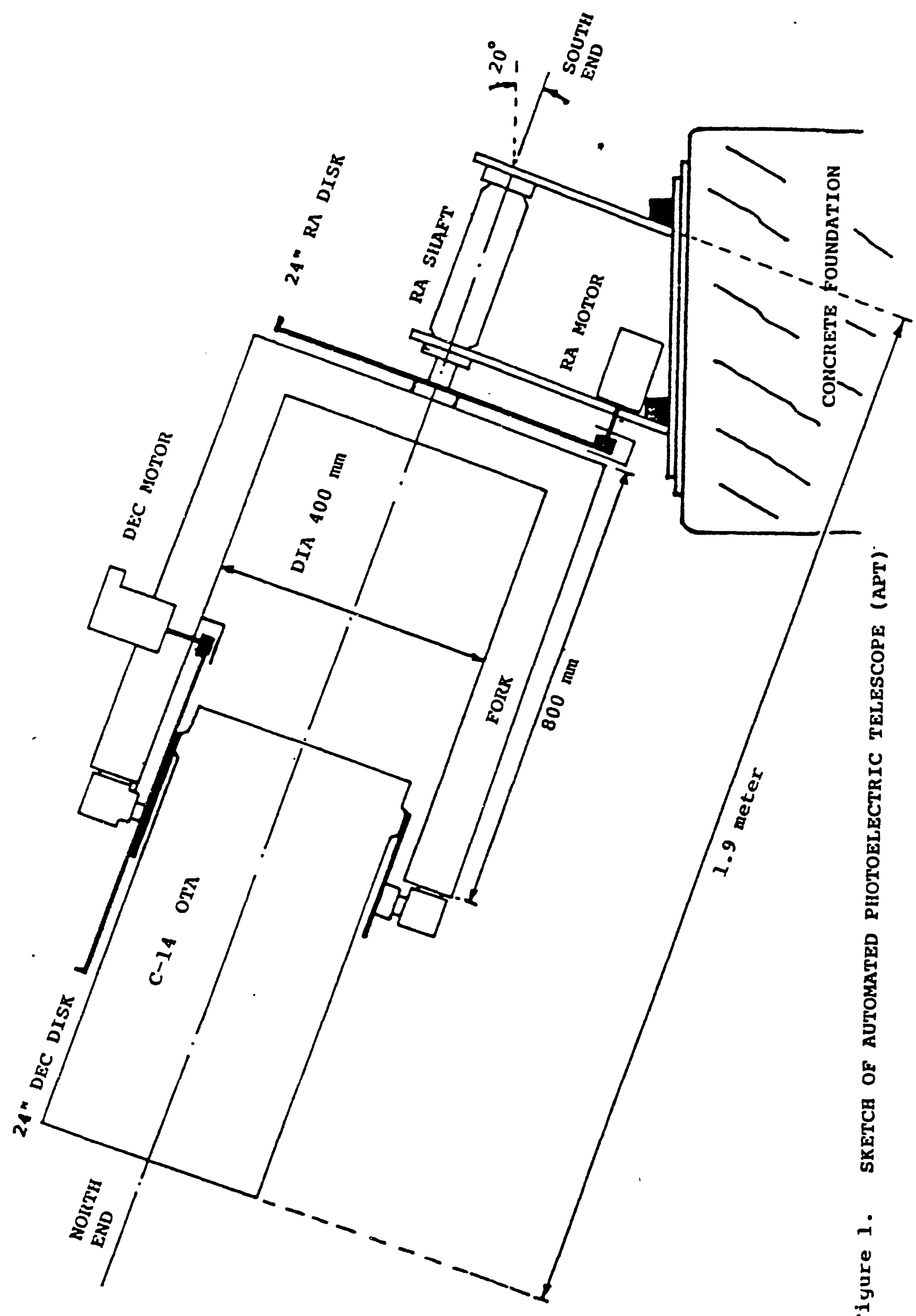

Figure 1. SKETCH OF AUTOMATED PHOTOELECTRIC TELESCOPE (APT)

3. Current and future plans

On the lines of the prototype APT developed at IUCAA, the Bangalore University is in the process of fabricating a similar APT (with all the modifications experienced during the prototype phase being incorporated) for their own use and have completed the opto- mechanical assembly of the telescope and also completed and tested the photometer which is to be used with it at the IUCAA visitor laboratory. Bhavnagar University has also submitted a proposal for building an APT under the financial support from the Department of Science and Technology.

A future extension of the back-end instrumentation will be to use the CCD camera itself as a tracker as well as imager for performing both these operations simultaneously and thereby utilizing the full Cassegrain beam. Also a fibre-fed back-end instrumentation is being considered for the purpose of spectroscopic observations.

References

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