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The Impact of Light Pollution on a Proposed Automatic Telescope Network (ATN) and Vice Versa

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Abstract. We are proposing to operate a Network of Automatic Telescopes (ATN) for CCD imaging to conduct diverse astrophysical investigations and as a resource for science education. Coordinated utilization of telescopes at diverse sites provides the possibility of obtaining continuous photometry without diurnal interruption. We describe this project and discuss how it is impacted by light pollution, and conversely, how it might mitigate the growth of light pollution.

1. Introduction

The automatic operation of optical telescopes began with a 50-inch telescope on Kitt Peak, constructed with NASA funding as the Remotely Controlled Telescope (RCT). The initial intention was to develop techniques for controlling telescopes in space. It was soon apparent that this was not a useful approach to learning how to control a space telescope — the dynamics were very different, as were the scales of the budgets (personal communication, Steve Maran 1999). The RCT telescope focus then shifted to an attempt to demonstrate the operation of an automated telescope — something which the Whitford Committee suggested in 1964 as a means to enhance the productivity of small telescopes (Maran 1967). A decade of effort resulted in one astronomical paper (Hudson et al. 1971) and the realization that a human telescope operator was much more cost effective than telescope automation with the technology available in 1969 (personal communication, S. Maran 1999).

During the 3 decades which have transpired since the RCT telescope experiment, remarkable advances in technology have occured and telescope automation is now straightforward. It is likely that the 1960s vision of the Whitford Com-

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mittee of substantial gains in productivity through the automation of telescopes may soon be realized. The most important technological advances have been: (1) powerful, reliable, inexpensive, and compact computers; (2) intelligent controllers for mechanical motions; (3) charge-coupled devices (CCDs), and (4) the accumulation of experience in the most effective ways to control and use fully automated and unattended observatories.

A telescope equipped with servo motors and rotation encoders on both axes and driven by a computer with an accurate model of telescope flexure and pointing aberrations, can point anywhere on the sky with an open loop accuracy of $<10''$. Source acquisition is thus straightforward and easily automated. The CCD camera has liberated astronomers from the drudgery of the darkroom, and the anguish of the interpretation of non-linear photographic media. The CCD-based camera produces digital data with linear response, and with a quantum efficiency as high as $\sim$90%, two orders of magnitude better than photographic film. Also, CCDs can provide simultaneous measures of sky brightness and comparison star brightness, which permit accurate differential photometry even with a partly cloudy sky.

A number of groups are operating automatic telescopes and some are developing plans for networks of automatic telescopes. Hypertext links to those with web pages are maintained at http://gamma.bu.edu/atn/auto tel.html. One of these groups is the Global Network of Astronomical Telescopes, GNAT; see http://www.gnat.org/~ ida/gnat/. At least three manufacturers have designed telescopes of aperture 60 cm or larger which are capable of automated operation, Torus Technologies and DFM in the USA and TTL in England.

2. The ATN Project

The ATN project is developing a network of automated telescopes. To coordinate effort and disseminate information, a web site has been established at http://gamma.bu.edu/atn/. We anticipate that some telescopes in this network will be at sites compromised by light pollution. Therefore, we need to develop an understanding of how light pollution at each site will affect photometry in broad photometric bands, and the dependence of this on meteorological conditions. Conversely, this project can serve to publicize the impact of light pollution in the regions where participating telescopes are located, and thus help in its mitigation.

A coordinated network of automated telescopes at diverse sites will facilitate optical monitoring of the blazar class of AGN on sub-day timescales, a task which is not otherwise routinely feasible — although we have done this experimentally with a miniscule duty-cycle with the Whole Earth Blazar Telescope (WEBT) (see http://gamma.bu.edu/webt/).

Extensive blazar monitoring is expected to be extremely useful during the NASA GLAST mission (the next generation GeV gamma-ray telescope). It is currently scheduled to be launched in 2005 and to operate for a minimum of 5 years. NASA's URL for GLAST is http://glast.gsfc.nasa.gov. Multiwavelength monitoring can provide the opportunity to learn about blazars through correlating the variability of gamma-ray flux with flux at lower frequencies.

It is also expected that networks of automatic telescopes will be useful for studying other transient phenomena, e.g., binary stellar systems, gamma-ray bursts, quasar/galaxy lensing systems, microlensing events, and asteroseismology. A network which is sized to provide observing time for other areas of investigation will include more telescopes. Therefore, it will be more efficiently scheduled, and will provide better multi-longitude coverage for blazars and gamma-ray burst follow-up.

Automatic telescopes can also serve as a very valuable facility for science education. A network of automatic telescopes is being proposed by the Hands-On Universe Project (http://hou.lbl.gov/) to provide abundant, high-quality, CCD data for education.

3. Automatic Telescope Standards

Much remains to be done in the realm of software before automatic telescopes can execute a program such as the GLAST blazar monitoring. There are currently no standards in place to permit automated telescopes to be used coherently.

Therefore, an international working group is in formation to work with IAU Commission 9 on Instruments to develop standards for automatic telescopes. The web site is http://gamma.bu.edu/atn/standards/. These standards will expedite the creation and utilization of networks of telescopes for science and education.

The existence of a standard command set will form an interface between a specific Telescope Control System (TCS) and a higher level Observatory Control System (OCS). This will promote the development of telescope-independent OCS software, which will provide for instant robotization of additional new and refurbished telescopes that comply with the TCS standard.

The standards will also include appropriate protocol for Internet control of automatic telescopes. The existence of such a standard protocol will promote cooperative development and utilization of networks of robotic telescopes. This will provide for the utilization of more diverse facilities by all participants, increasing the range of projects possible, and the efficiency of telescope utilization.

References

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