ROBOTIC TELESCOPE BART

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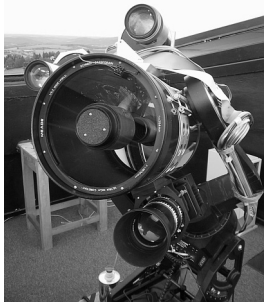
ABSTRACT.
BART (Burst Alert Robotic Telescope) is a small remote controlled robotic CCD telescope, devoted to rapid observation of prompt gamma ray burst transients. During its operation since early 2001, it had three prompt observations with world–competitive response time. The constraints to object magnitude were estimated and published in GCN circulars. Telescope is located in Astronomical Institute of the Czech Academy of Sciences in Ondřejov. This poster describes its basic properties and its new control system, named RTS2, which is in service since February 2003.

Key words: Telescopes, robotic.

1. BART's basic properties

The robotic telescope BART is a complete robotic system for observing the prompt optical emission of gamma ray bursts. It consists of the main telescope tube — 250mm 1:6.3 CCD telescope equipped with the filter wheel and three wide field (d=64mm) CCD monitors used for primary search for the transients.

The purpose of the WF cameras is to observe the GRB as fast as possible, even with a low-quality location information. Their field of view is 5x5 degrees in three photometric filters V,R and I with limiting magnitude of about 14 for 60 second exposure. The telescope provides the possibility to observe the burst in it's slightly later phase, with a limiting magnitude about V = 15.5 for a 60 second exposure.



2. RTS2

The new operating software RTS2 is designed as a networked system for driving of robotic telescopes. It is composed of several device servers, central server and various observational clients cooperating over a TCP network. For the communication, there is a private protocol, ensuring speed and reliability. It is intended to be independent on used astronomical HW, with access points for controlling of different types of mounts, domes and CCDs. Observation entries, requests and results are kept in database. Positions of GRBs are received from the Internet, and observed either in prompt mode, or added to list of observation targets, depending on weather and other conditions influencing the observation. The idle time, when there is not any request for GRB observations, spends the telescope monitoring various objects. The database lookup entry point is accessible at http://lascaux.asu.cas.cz/bartdb.

New system has been recently implemented also for cooperating Spanish–Czech BOOTES experiment. It is installed and performs well on stations BOOTES-1 and BOOTES-2 in southern Spain.

The system may be used on most Linux distributions. The vast majority of the code is written in C programming language and uses PostgresSQL database.

The new system already successfuly observed test GRBs, send by GCN network.

3. Image analysis

Observed images can be processed with any image analysis software, which is able to run on UNIX based operating system. Currently we use modified Opera package, which was developed at Madrid. It writes sky coordinates in standard World Coordinate System (WCS) header to processed images. Coordinates of processed images are being sent to the telescope driver, to be used to fine-tune its tracking.

Main scheduler takes care of obtaining pictures for flat-fields during dusk and dawn. It also obtains dark-frames at predefined time interval.

Lascaux is an 2GHz Intel Celeron PC compatible computer running Debian GNU Linux. There resides central server, database, web server for database access and from there are usually run clients for observing.

Other PCs are low–end Pentium or 486 class computers. They run stripped–down Debian, which occupies vast majority of their hard drive.

The computers are interconnected by an industry standard 100Mb switched Ethernet network. Possible network bandwidth largely exceeds the needs of our system, the readout speed of our cameras is 30kHz at 16 bits per pixel, not exceeding 4% of possible network throughput per camera.

4. GRB receiving

Primary GRB receiving is done through dedicated client. It's connected through socket to GCN server in NASA-GSFC. If it gets GRB event, which is currently visible, it asks central server for priority, moves mount and after mount movement has been finished, it asks for camera exposures. Pictures from cameras are downloaded during readout through network to computer running GRB client. There they are stored, get WCS, and keep in database.

In case that socket connection fails, backup system uses reliable e-mail receiving. GRB event is then observed from main scheduler. Main scheduler also takes care of observing GRB error box, which were bellow horizon when they occurred, or which were received when system wasn't operational due to bad weather conditions.

5. System stability

RTS2 is observing in Ondřejov for half a year. Majority of errors in program code have been tracked down. System is running there in semi automatic mode, with staff available to check it 24 hours a day. The restriction is given by the lack of automatic roof control, thus the need of person to watch the weather nightly.

In Spain, at BOOTES-2, RTS2 have been implemented recently, without any trouble in a few days, it performs well until the moment of this writing. Here it works in fully automatic mode, without human intervention in place, controllable only through the Internet.

RTS2 is based on experience gained from RTS1, which had been running on BART for two years.

5. Observations

BART itself, although being succesfully used to observe cataclysmic variables and other targets is an instrument built to follow-up the gamma-ray bursts. Such a business requires a very short response time to the alert. The telescope operating software has thus been designed with an eye on watches, allowing the telescope to move to any defined position as fast as the mount allows. The original version of software has been unable to stop the oncoming exposure and was written in PYTHON, a scripting language. The reply to a GRB020327 was for this reason delayed for 75 seconds — 70 seconds was the exposure remaining time, one second for computing and 4 seconds for the mount to reach the position (but the delay of the alert was 56 minutes). For two other GRBs the response was similarly fast, but we had to wait for the night for a few minutes to hours.

BART is included to INTEGRAL ground segment observation programme. It's observing targets of interest for INTEGRAL group in Ondřejov. These targets are cataclysmic variables, active galactic nuclei and supernovae.

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