ROBOTIC TELESCOPE BART IN ONDŘEJOV

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ABSTRACT

This paper mentions Ondřejov observatory's robotic telescope BART. It's main target are the optical transients of γ-ray bursts, but as those are rare last time, telescope stays most of the time in monitoring mode, when it observes high energy sources like blazars and cataclysmic variables.

This paper is also in further detail describing the telescope's operation software RTS2. It combines hardware issues (like camera readouts or mount operation) with planning, alerting and image archiving system throughout a TCP/IP network.

Key words: Robotic telescopes, OTs.

1. INTRODUCTION

BART 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 also its new control system, named RTS2, which is in service since February 2003.

There are four separate optical systems used for detection of an optical emission with CCD: Main tube, 25 cm Schmidt Cassegrain equipped with filter wheel and field of view 22 arc minutes; two identical WF (7°x5°) cameras using different filters (I,R) and a 300 mm lens with field of view about 2 degrees.

BART is well suited to provide follow-up optical observations of GRBs detected by INTEGRAL and other satellites. The experiment is also capable to provide simultaneous and quasisimultaneous optical data for selected targets observed by INTEGRAL.

2. HISTORY

BART was observing in Ondřejov since April 2001, using it's old software called RTS until February 2003, when the new, completely rewritten version came into service. Majority of it's errors have 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 weather sensors, thus the need of person to watch the weather nightly.

The instrumentation also develops slightly: the original setup consisted of one wide-field lens on top of the main tube, the second WF with I filter has been added together with new version of software. A 300mm lens with large format CCD has been added recently and is under testing.

3. GRB RECEIVING

Primary GRB receiving is done through dedicated client. It's connect through socket to GCN server in NASA-GSFC. If it gets a GRB event, which is currently visible, it asks central server for priority, moves the mount and after it finishes, it asks for camera exposures. Pictures from cameras are downloaded during readout through network to computer

Figure 1. BART - telescope picture

running the GRB client. There they are stored, get WCS, and stay in database.

In case of socket connection failure, 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 below horizon when they occurred, or which were received when system wasn't operational due to bad weather conditions.

4. PROBABILITY OF SUCCESS

Having the speed of the mount about 5 degrees per second and keeping in mind (memory) where the GRB may occur so keeping the optical tube not too far from the expected alert position, we can target the telescope within about 15 seconds from any reasonable position. Taking into account the brightness of a typical optical transient and limiting magnitude of 30s exposure about 13, we have about 8 minutes to catch the event. There's further possibility to get some information from longer exposures taken later up to about 30 minutes after burst at most.

The weather allows us to observe about 35% of the nights. The better weather are during summer time, but also winters offer some good observation possibilities.

Location reachability conditions as Sun enough below horizon, Moon far enough and burst high enough in the moment of explosion yield an overall geometrical probability of 15% for the event to be observable. Together with weather this gives us about 5% of observable bursts.

5. DERIVED INSTRUMENTS

Although nearly all the possible time observing, BART system is intended especially as a developing device for it's 24/7 staff availability. There are several derived experiments based on software

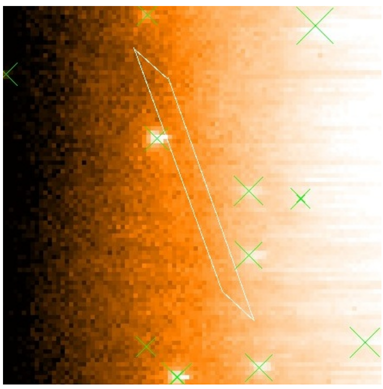

Figure 2. GRB031111A I filter image 25×25

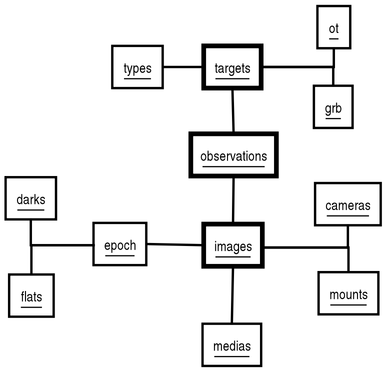

Figure 3. Database structure overview

developed on this platform including BOOTES1 and BOOTES2 (Castro-Tirado et al., 2004) which recently showed their possibilities while observing GRB optical transients (De Ugarte et al., 2004). There's close collaboration between BART and BOOTES people.

6. SOME RESULTS

Several GRB events were followed, the more important for us shows the following table. There were several others alerts which were followed, but those have had much worse delay.

Of these events the most unlucky and exceptional is the first event of 11 November, when the telescope really followed the GRB within 30s after burst, but the very nearby moonlight destroyed most of the images. the only usable are images from the second phase of observing where the limits might be finally set.

7. RTS2 - THE OPERATING SOFTWARE

RTS2, the operating software, is designed as a networked system for driving robotic telescopes. It is composed of several device servers, central server and various observational clients cooperating over a TCP network. 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 active galaxies. The database lookup entry point is accessible at http://lascaux.asu.cas.cz/bartdb.

8. SYSTEM CODE

The system consists of three kinds of programs:

GRB #	BART delay	Total delay	limits	notes
GRB 020124	10h	11.5h	R>14	long HETE delay
GRB 020305	30m	10.5h	R>14.3	30 minutes waiting for night
GRB 020317	90s	58m	R>13.5	dark GRB
GRB 020331	4.8h	5.5h	R>12.5	daytime GRB, bad weather
GRB 030824	30m	10.5h	R>14.3	
GRB 031111A	15s	30s	I>13	overexposed, limit for T=4h
GRB 031111B	16s	1.2h	R>14.5, I>14.2	close to the Moon
GRB 031216	11m	11.2m	R>15.0, I>14.6	

Figure 4. BART observed GRB alerts.

server/client programs for accessing and controlling devices like cameras, telescope or weather controller paired with dome/roof controller

Client programs to control an observation - currently there is a scheduler client for regular observations, gamma ray burst client for prompt observations of GRB optical transients, console based monitoring client, stream based monitoring client and focus client for camera focusing

Central server holds list of all connected devices and clients. Every new device register to central server in order to be accessible to clients, and every client connect and authorise itself to central server in order to be able to access devices.

Access to devices is priority-based - only client with the highest priority can access state-changing functions of a device - such as mount moving, or exposing and readout of camera. During a long-running operation, if a client loses priority, the operation is cancelled and devices are able to serve a new request of a client having higher priority. That is important for GRB observing, where the lowest response time is the most tentative criteria.

Priority requests are being sent from clients to the central server. It holds a list of priorities of all connected clients. If it finds that the priority has to be changed, it informs all connected devices about such change.

Implementing a driver-layer of nearly any device daemon should be relatively easy thanks to a well-elaborated design of the upper layers.

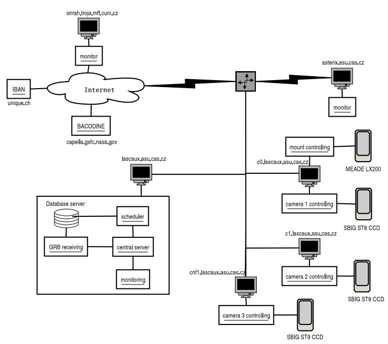

Figure 5. BART - system structure

9. IMAGE ANALYSIS

Obtained image data are sent to a real time astrometric and photometric pipeline. In fact any UNIX program may be run over the images. Currently we use rtOpera package, which is being developed together with BOOTES people. 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.

10. SYSTEM OPERATION

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

The system setup can be at best understand from an example. On Figures 3 and 5 is described current configuration of Ondřejov BART.

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 observations clients are usually run.

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

ACKNOWLEDGMENTS

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REFERENCES

Castro-Tirado A.J., 2004, BOOTES: A Stereoscopic and Robotic Ground Support Facility for INTEGRAL, (this proc.)

De Ugarte Postigo A. et al., 2004, GRB 030913: Hunting the afterglow, (this proc.)