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A NEW GRB FOLLOW-UP SOFTWARE AT TUG

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RESUMEN

Un nuevo sistema de seguimiento óptico para estallidos de rayos gamma (GRBs) ha sido desarrollado para el Observatorio Nacional de TUBITAK en Turquía. Hace uso del telescopio de 0.6m (T60) y puede responder automáticamente a las alertas recibidas a través de la Red GCN. Los telescopios apuntan de un modo relativamente rápido, pudiendo apuntar en 30 s. Cuando estén disponibles, tanto los telescopios de 1 m (T100) y de 2,5m (T250) también serán usados en el futuro. A modo de ejemplo, el software de seguimiento de GRBs (en el lado del servidor) en el telescopio T60 respondió de manera autónoma a una alerta GRB tan sólo 129 s después del evento.

ABSTRACT

A gamma-ray burst (GRB) optical photometric follow-up system at TUBITAK (Scientic and Technological Research Council of Turkey) National Observatory (TUG) has been planned. It uses the 0.6-m Telescope (T60) and can automatically respond to GRB Coordinates Network (GCN) alerts. The telescopes slew relatively fast, being able to point to a new target field within 30 s upon a request. Whenever available, the 1 m T100 and 2.5 m RTT150 telescopes will be used in the future. As an example in 2015, the GRB software system (will be server side) at T60-telescope responded to GRB alert and started the observation as early as 129 s after the GRB trigger autonomously.

Key Words: gamma ray: burst — telescopes

1. INTRODUCTION

The computer-based robotic telescope systems have the advantages of low operating costs with high operating efficiency and high scientific productivity (Boyd et al. 1985; Drummond et al. 1995). Some demonstrations of scientific usage of the robotic telescope were given in Akerlof et al. 2003; Boyd et al. 1985; Dindar et al. 2015; Drummond et al. 1995; Ferrero et al. 2010 and Nekola et al. 2010. Generally the term robotic in telescope systems stand for guiding a telescope to a given position and take images or more complicated tasks (Castro-Tirado 2010).

The term autonomous observatory in astronomy means a robotic telescope and dome are computer controlled in such manner, that all indispensable actions of observation are done automatically, including processing of weather conditions, dome driving, choosing objects to observe, exposing by cameras or other optical sensors, taking calibration images, and so forth. Neither human interaction nor activity is necessary for observation (Nekola et al. 2010). Removing humans from the observing process allows faster observation response time, so that makes robotic telescopes respond quickly to alert broadcasts from satellites and begin observing within seconds. This property lets the astronomers to observe transient events (e.g. gamma-ray bursts and other sources) in the sky. That reason is to motivate us for implementing the new software module to catch the GRB alert in Talon (Dindar et al. 2015).

2. TELESCOPES AND INSTRUMENTS AT TUG

TUBITAK National Observatory (TUG) is located at an altitude of 2500 m, on the top of Bakirlitepe mountain in Saklikent region of the city of Antalya which is located on the Mediterranean coast of Turkey; Lat. $36^o\ 49^{'}\ 27^{"}$ N., Long. $30^o\ 20^{'}\ 08^{"}$ E. It resides in a longitudinally important region, because there is no other active observatory along and around this longitude on which TUG is located. Besides it fills a significant gap, on the map from far east to the west of Europe.

TUG deserves to point out that the Observatory site is exceptionally good in terms of climatologic conditions. The observatory has $1.57^{"}$ average seeing value and 210 clear nights/year (Ozisik et al. 2015). Four active telescopes are being operated at the site; the largest being RTT150 followed by a T100 fully automated, T60 and 45 cm ROTSE III-d robotic telescopes. Two more new robotic telescopes will be in operation soon.

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TABLE 1

RTT150 TECHNICAL SPECIFICATIONS

Optical design	Ritchey-Chrétien	
Main Mirror diameter	1500 mm	
Focal Length	11611 mm	(Cassegrain)
	72257 mm	(Coude)
Focal Ratio	f/7.7	(Cassegrain)
	f/48	(Coude)
Image Scale	18″/mm	(Cassegrain)
	3″/mm	(Coude)
Dome	Observa-DOME	
	10.5 dia.	

2.1. *RTT150*

RTT150 is established in 1995 according to a working protocol between Turkey and Russia. Members of the collaboration are TUBITAK, Kazan Federal University and Space Research Institute of the Russian Academy of Sciences. Installation of the RTT150 telescope was completed in 1998, then the first light was taken in September 2001. The RTT150 telescope has a Ritchey-Chretien optical design (Table 1) and there are Cassegrain and Coude focal plane modes. The instruments are TFOSC (TUG Faint Object Spectrograph and Camera), Andor CCD, Andor iXon EM CCD, Coude Andor CCD, Coude Iodine Cell and Coude DEFPOS.

2.2. *T100*

The 1.0-meter fully automatic T100 telescope was installed in 2009 at the south peak of the Bakirlitepe. The first light was taken in October, 2009. This telescope has the largest format CCD camera dedicated to wide-field imaging and high precision photometric observations. T100 is currently operated remotely from TUG Administration Building in Antalya. This telescope is mainly used in multi-band photometric observations of exosolar planets, stars and asteroids as well as follow-up observations of GAIA or GRB alerts (Table 2).

2.3. *T60*

The 0.60-meter fully robotic T60 telescope was installed in 2008. The first light was taken in September, 2008. This telescope is dedicated to object-based photometric observations. This telescope is mainly used in multi-band photometric observations of variable stars as well as follow-up observations of GAIA or GRB alerts (Table 3).

TABLE 2

T100 TECHNICAL SPECIFICATIONS

Optical design	Ritchey-Chrétien
Main Mirror diameter	1000 mm
Focal Length	10000 mm
Focal Ratio	f/10
Field lens	3-elements
Resolving Capacity	0.11″
Image Scale	21″/mm
Dome	Ash-Dome, MEBH
	6.86 dia.

TABLE 3

T60 TECHNICAL SPECIFICATIONS

Optical design	Ritchey-Chrétien
Main Mirror diameter	600 mm
Focal Length	6000 mm
Focal Ratio	f/10
Resolving Capacity	0.19″
Image Scale	34″/mm
Dome	Ash-Dome, R
	4.42 dia.

2.4. *ROTSE-IIId*

The ROTSE (Robotic Optical Transient Search Experiment) telescope is dedicated to a program of rapid follow-up observations of gamma-ray bursts (Akerlof et al. 2003). ROTSE was developed as a next-generation robotic instrument by the Michigan State University and other collaborative universities. There are four ROTSE telescopes in the world. Two are located in the northern hemisphere (United States and Turkey) and other two telescopes are located in the southern hemisphere (Australia, Namibia).

The latest ROTSE telescope which is called ROTSE-III-d was located at the TUG Bakirlitepe site according to a contract signed between TUBITAK and Michigan State University in 2002. Although ROTSE project is over, the ROTSEIII-d telescope continues to follow GRB alerts and carries out observational project proposed by Turkish astronomers (Table 4).

3. T60 ROBOTIC TELESCOPE

The T60 is controlled by Talon software on open source GNU/C UNIX platform. The telescope can be operated on robotic mode and the observations are made as object-oriented. T60 telescope control

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TABLE 4

ROTSE-IIID TECHNICAL SPECIFICATIONS

Optical design	Cassegrain(modified)
Main Mirror diameter	450 mm
Focal Length	850 mm
Focal Ratio	f/1.89(with field lens)
Resolving Capacity	0.31"
Image Scale	243"/mm
Filter	-
Dome	Clamshell type

TABLE 5

GRB RESULTS

GRB	Publication	T-GRB	Mag.
141215A	GCN17240	129 s.	17.04
V404 Cygni	-	88 s.	-
150626B	-	90 s.	>17.5
150619A	-	125 s.	-

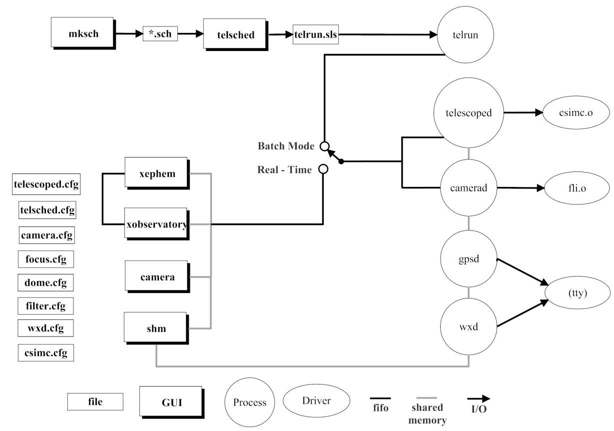

Fig. 1. T60 software architecture.

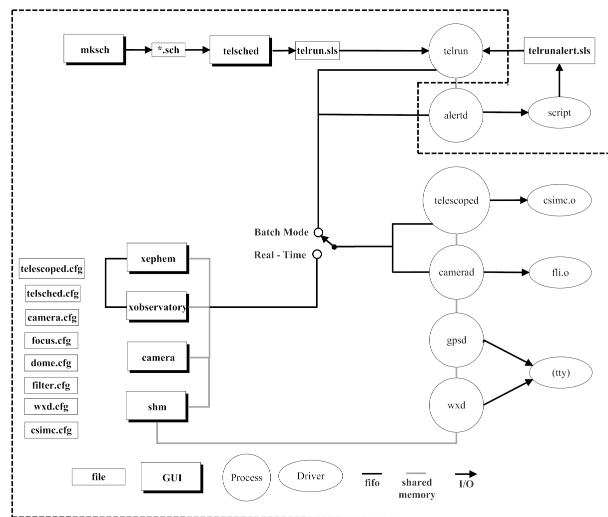

Fig. 2. T60 grb software architecture.

software, Talon, provides the users to control the telescope both in manual mode (by GUI) and in robotic mode (by batch mode). The users are able to prepare the observations by using the tools of Talon such as mksch, telsched.

The software architecture of Talon is based on the deamon processes. It has two main daemons of telrun and telescoped. The daemon, telrun operates the schedule on robotic mode by sending appropriate command to the daemon, telescoped. The daemon, telescoped controls the dome, focus, filter wheel and the telescope axes modules by sending the low level commands to the motion controllers in Figure 1.

4. NEW GRB FOLLOW-UP SOFTWARE

The maximum slew acceleration of T60 robotic telescope is 3.8 ^{o}/s^2 along the right ascension (RA) axis and 5.6 ^{o}/s^2 along the declination (Dec) axis. RA and Dec axes have maximum slew velocities of 11.1 and 8 ^{o}/s, respectively. With all those features, telescope are quite appropriate for GRB and transient observations, but the daemon which handles such a processes is missing part of Talon.

VOEvent is a good protocol to get immediate astronomical events with the intention of stimulating rapid and automated follow up from robotic telescopes. The new daemon has been designed and implemented in Talon by taking advantage of the VOEvent infrastructure. T60 GRB software runs in clear sky condition only and it checks the telescope dome and mirror cover status in case of any problem. It has two major components; daemon, alertd, listens the GCN/TAN NASA server via a TCP/IP socket interface and the scripts process the alerts and makes alert schedule as shown in Figure 2. The telescope points the alert and takes the sequence of the images as defined in config files of daemon [7]. The results of the GRB software is satisfied. The first 141225A GRB was observed and the results was published in Figure 3. The results are given at Table 5.

5. CONCLUSION

A new GRB software has been introduced in this paper and results has been given so far. The GRB software has already implemented at T60 telescope

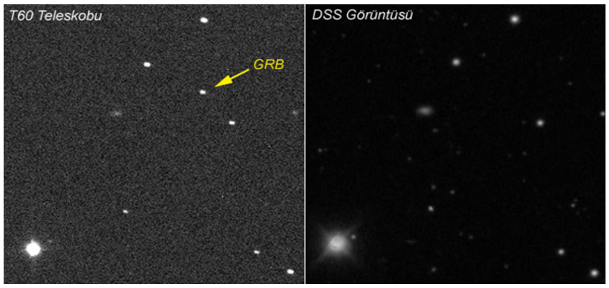

Fig. 3. T60 grb: 141215A.

but, alerts should be published to other telescopes at site. For this purpose, server-client software architecture was designed and implemented. Server software implemented on the T60 telescope and client software is implemented on the other telescopes.

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