Robotic telescope of Zvenigorod observatory

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Abstract The Institute of Astronomy is working on the develompent of robotic monitoring systems to solve a wide range of astrophysical problems. As a result of the work, a robotic optical system with the 20-cm wide-angle telescope was created. The special software has been developed. This software allows us making observations in the automatic mode without operator's participation. The robotic telescope IRT-20 is located in the Zvenigorod Observatory of INASAN. Photometric observations of variable stars and searching of optical transients are carried out with the telescope in a constant mode.

Keywords: Robotic Telescope, Photometry, Optical Transients

1. Introduction

Recently, robotized telescope systems have been mainly used to solve problems of monitoring the near-earth space and observing space objects. Recall that the term "robotized" means the ability of a software and hardware complex to perform its tasks and interact with the external environment without human involvement. The widespread access to the Internet and the rapid development of the hardware market have led to the fact that robotic telescopes are becoming more common. In turn, the traditional work of the observer in outdated observatories gradually gives way to automatics. Reducing the role of the human factor is a general trend that improves the quality of scientific observations.

According to a predetermined observation plan, robotized telescopes perform the necessary actions during the entire observation session such as directing telescope to a specific area of the sky, making frames in different filters and with the specified exposures. Such robotic systems allow to perform routine operations without the intervention of an observer and to achieve the highest possible speed of sight. With the help of a telescope robot, we can quickly respond to special events, such as a gamma-ray burst, which is given priority. An equally important part of the work of the robotic review is the stream processing of information using special software.

2. Robotic telescope IRT-20

In Zvenigorod Observatory of INASAN, a robotic telescope IRT-20 (INASAN ROBOTIC TELESCOPE) was created. The robotic telescope IRT-20 consists of Officina Stellare RH-200 wide-angle telescope, ASA DDM 85 mount, FLI Proline 16803 CCD camera with a UBVRI filter wheel and a focuser, ScopeDome 3M dome, special power supply and lightning protection equipment, a weather station for monitoring the weather parameters, control

computer and data storage. Parameters of the Officina Stellare RH-200 telescope are: focal length - 600 mm, field of view – 5 sq. deg, aperture 200 mm, focal ratio - 3. Parameters of the CCD camera FLI Proline 16803: chip size - 36x36 mm, pixel size - 9 μm, chip capacity - 4Kx4K.

The IRT-20 robot telescope is the first telescope in the series of robotic telecsopes of the observational optical network created in INASAN. Since 2016, telescopic observations are constant. The IRT-20 robotic telescope is fully automated, which makes it possible to carry out observations without operator intervention, and an Internet connection allows us to monitor the operation of the telescope from anywhere in the world. A general view of the telescope robot of the Zvenigorod Observatory of INASAN is presented in Figure 1.

Fig 1. *General view of the robotic telescope IRT-20.*

Each of the devices used in the observations has software and hardware interfaces for connecting to a computer. The software part of the robotic telescope includes:

- scheduler and observing session program;
- program-driver of the control of the slewing device AutoSlew;
- driver software for controlling a CCD camera, filter wheel, focuser;
- program-driver dome control ScopeDome 3M;
- software module for determining weather conditions.
- Apex II Special Streaming Software [1]

Most manufacturers of astronomical equipment complete their products with drivers that support the standard ASCOM (AStronomy Common Object Model), which allows us to simplify the development of a program to control such devices. The advantage of ASCOM is that a single set of control commands is used to control different types of mounts or CCD cameras, regardless of the manufacturer of the equipment. The ASCOM driver completely hides from the developer of the control program the lower level of interaction with the equipment.

3. The observation session management program

The observation session management program combines the control functions of all astronomical devices involved in an observation session. Figure 2 shows a diagram of the informational interaction of software modules and robot telescope drivers. The observation session control program operates according to the observation plan prepared by the operator. In observation plan, the coordinates of the objects to be observed, the tracking modes of the object, the required number of frames, the exposure time, the required photometric filter or the sequence of filter changes are specified. The observational session management program is able to respond to trigger events in the observation process, for example, urgent applications received from the Baksan Neutrino Observatory (BNO) or other events generated by the application server. Each image obtained with a telescope is stored on a data storage server, and key data about the file and the observed object are stored in a special database. At the end of the observation session, a report on the tasks implementation is generated, including the results of the tasks and the errors that have occurred are indicated. The end of the observation session (closure of the dome, and telescope parking) is performed either with the end of the observation plan, or due to weather deteriorating.

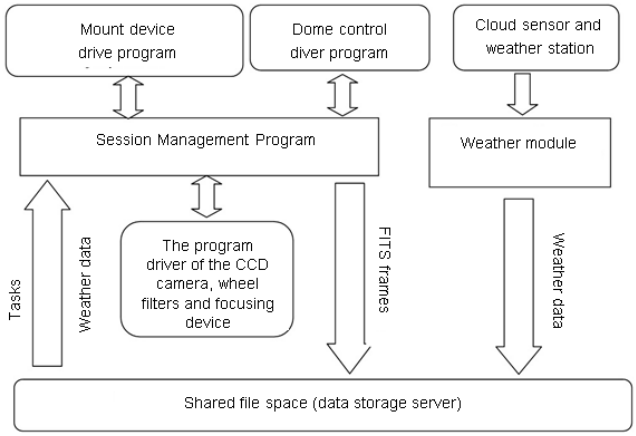

Fig2. *Diagram of information interaction of software modules and driver programs of a robotic telescope.*

Stream processing of data for the asteroids and transients detection is carried out using the Apex II software package and a special streaming processing software module that allows the forming of observation packages from a set of received fits frames. For example, with sky surveys for detecting unknown asteroids, a streaming processing software module forms a

packet of several (minimum four) frames of a single sky site, and starts processing this packet with Apex II. After detecting an unknown object, the streaming processing module generates a protocol for detecting a new object and creates a task for additional monitoring on the request server.

4. Meteo station and software for determining weather conditions

During the session, the observation session program receives weather data from the weather station. The weather station collects data on various environmental parameters from the AAG CloudWatcher cloud sensor, the Davis Vantage Pro 2 weather station and the Starlight Xpress Oculus-180 wide-angle camera. The meteo station and the program module for determining weather conditions operate independently of the robotic telescope during the whole day and night, thus collecting and storing information about the weather and climate at the telescope's installation site. The special database stores data on the ambient temperature, humidity, precipitation, cloud conditions, wind speed and direction. Continuous observations of weather conditions at the Zvenigorod Observatory in 2017-2018 showed that the percentage of cloudy, partly cloudy and clear nights in 2017 was 41, 28 and 31 percent, respectively. In 2017, the total number of clear hours was 928. In 2018, the total number of clear hours at night already reached 1200 hours.

5. Obtained scientific results

The IRT-20 robot telescope is mainly used for carrying out photometric studies of fast-variable stars, such as FC Com, LO Peg, BZ Cam, ET Dra, etc., as well as triggers from the BNO. The robot telescope allows us to observe objects up to 15m with 180 seconds exposure. The “seeing” image quality parameter for the Zvenigorod Observatory is about 3 ... 5 ". The accuracy of photometric measurements at good nights for bright objects is ± 0.01m. For example, Figure 3 shows two curves of the brightness variation of the FK Com star, obtained in March-May 2018. In general, over 2017–2018, more than 16,000 images of variable stars in various filters were obtained. The results of the observations were published in [2].

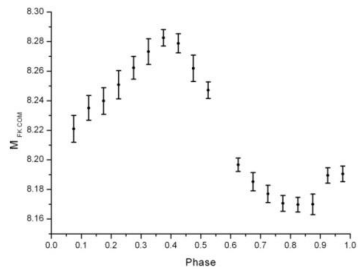

***Fig3**. V light curve of FK Com, obtained during March -May 2018 period*

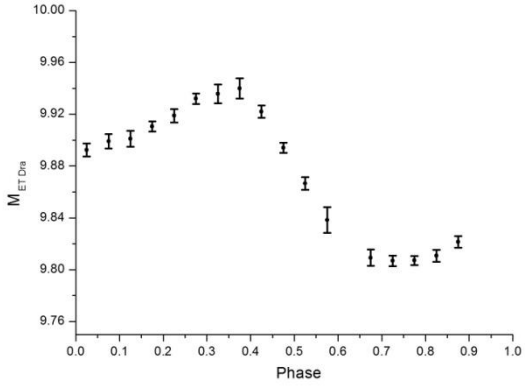

Fig 4. *V light curve of ET DRA, obtained during August -September 2018 period*

Note that the capabilities of the IRT-20 telescope for photometric and prospecting observations are significantly limited by a small image scale of 3.1 "/ pixel and large central screening. In addition, poor astroclimate and sky background illumination is limiting magnitude of robotic telescope IRT-20.

6. Robotic telescope MEADE LX-200

In 2019 a new 35-cm robotic telescope at Terskol branch of INASAN will be created. The main objective of the new robotic telescope will be to perform an operational search and subsequent study of astrophysical objects generating bursts of cosmic radiation of high and ultrahigh energy together with optical flares. The robotic telescope MEADE LX-200 consist of the Meade 14” telescope, EQ8 Pro mount, QHY 163M CMOS camera with a UBVRI filter wheel and a focuser. The automation of the 5-meter dome of the Meade LX200 telescope dome at the Terskol peak was completed in 2018.

References

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