Tican Observatory Transient Survey - system overview

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Abstract

In 2017 Tican Observatory started the sky survey program with aim to discover potentially hazardous asteroids and provide a follow-up observations for large sky surveys. As they started producing significant amount of data, the idea was to use their imagery for supernova search. During the Visnjan School of Astronomy 2018, group of high school students and their mentors started developing a pipeline for transient object search. Pipeline consists of 2 main parts: backend and frontend. Backend part is performing image acquisition, calibration and processing. The frontend part is used for visualization and classification of detected objects and events. The next step is to expand the search on other transient objects and to start citizen science project for transient object detection and classification.

Keywords: supernova search, sky survey, transient events, object detection and classification, transient objects database

1. Introduction

In the last few decades, time-domain astronomy is one of the most active areas of research. In 2010 we started developing software for La Sagra Sky Survey - Supernova Search project (LSSS-SSP) [1]. During the 3 years of operations (2010 - 2013) we discovered 20 new supernovae. We also built a database with more than 300 000 galaxies, 900 known asteroids, 65 known SNs, 763 high proper motion stars, etc.

During the last 30 years Visnjan Observatory became one of the most prolific discovery sites for small bodies of the Solar system with more than 1700 minor planets discovered to date. Due to the increased light pollution in Visnjan, scientific activities were moved to the new location few kilometers on north to Tican hill. In 2002, the new 1 m telescope was installed on Tican Observatory and first light in test mode was accomplished in 2014. In 2017 Tican Observatory started with sky survey program, trying to disover potentially hazardous asteroids and support large surveys with follow-up observations. Beside the scientific activities, Visnjan observatory is involved in many educational projects. Visnjan school of astronomy is one of the oldest that gathers high school students with interest in astronomy and space science. In 2018, one of the groups started to work on supernova search project.

Based on the previous experience, we started developing an improved version of the LSSS-SSP system adapted to the Tican Observatory imagery. In this paper, we present the developed system that is still in test phase at Tican Observatory.

2. Observations and data reduction

Tican Observatory (MPC code: L01) uses 97 cm reflector (Newton type) telescope (Fig 1.) with 2877 mm focal length (f/2.9). It is equipped with Moravian G4 - 9000 CCD camera. Resolution of the camera is 3056 x 3056 pixels and CCD sensor array size is 36.7 x 36.7 mm. Limiting stellar magnitude of the system is 22.0 mag. Telescope is fully automated and operated remotely. Limiting declination the telescope could reach is -25 degrees.

Usually, the telescope is observing and measuring the objects listed on NEOCP page [3]. These are the newly discovered near earth asteroids that are waiting for a confirmation. In addition, telescope is surveying the sky in a search for a new asteroids, mostly close to ecliptics. Thus, the system is optimized for small solar system bodies search and follow-up, not for supernova search.

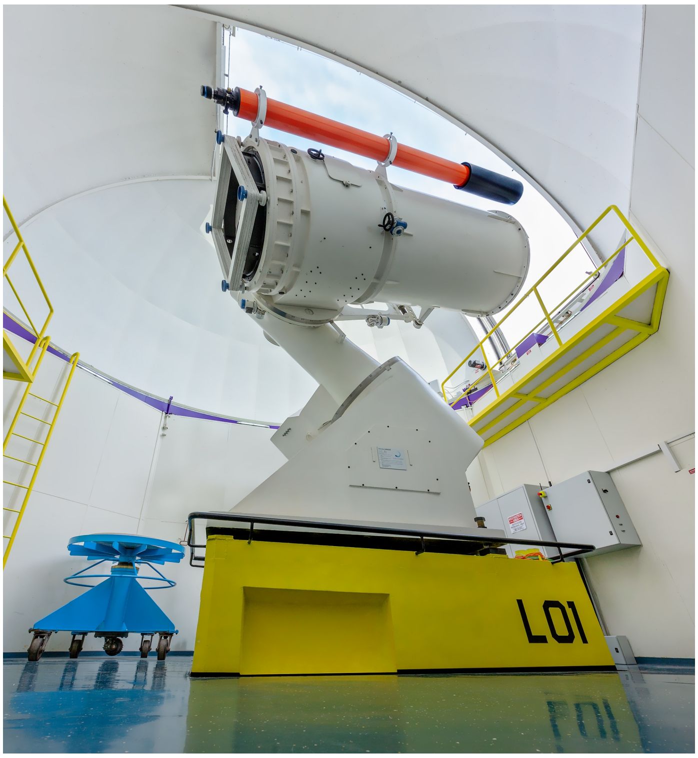

Figure 1: Tican Observatory 1 m telescope.

3. Results

3.1 Backend processing pipeline

Backend processing pipeline (Fig. 2) was developed in Python programming language and it is responsible for processing of images acquired by the Tican telescope. Images are stored in the standard astronomical FITS file format [4](Pence et al. 2010). It is assumed that images are already properly calibrated, i.e. corrected with dark, flat and bias frames. Also, images should be plate solved with world coordinate System [5](WCS, Griesen, Calabretta 2002) information present in the FITS header. This is all done by the telescope operator and image acquistion system. Each image (frame) from the observation run is first rotated so that North points up and East points left, for easy comparison with archive images. Since supernovae are most likely to appear in galaxies, the next step is to identify all visible galaxies inside the frame.

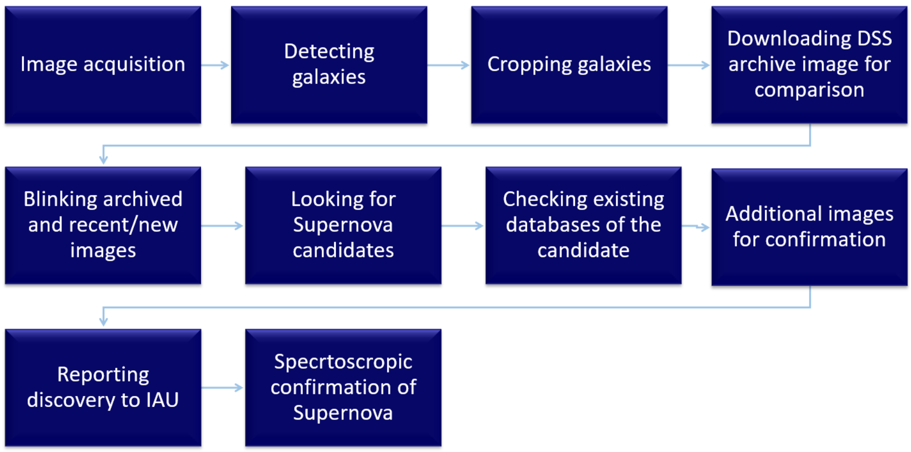

Figure 2: Backend processing pipeline.

We use GLADE catalog [6](Dálya et al. 2018) which contains more than 3 million galaxies covering the whole sky. 5x5 arcmin areas centered on galaxies are cut out from the frame and saved. If there are two or more galaxies very near each other and fit inside one cutout, only one cutout is saved. Usually, there are several tens of cutouts per frame. A frame is then checked for known asteroids by querying the Minor Planet Center's MPChecker tool [7] and for recent transients by querying the Transient Name Server [8]. If any of them falls inside a cutout, their coordinates and relevant information are saved into a database. Cutouts are uploaded to the web server by FTP protocol with their properties stored into the database. Figure 4 (Appendix A.) shows a typical single frame with galaxies, cutouts, asteroids and transients marked in red, white, green and yellow color, respectively.

Since Tican Observatory Sky Survey is primarily oriented towards discovering asteroids, several frames of the same region of the sky are taken in a single night. The supernova search backend takes only one of those images. If a supernova candidate is found inside the frame, only then we check the rest of the same region frames to check if the candidate is real.

3.2 Frontend processing pipeline

Frontend processing pipeline (Fig. 3) is basically a web page running on the web server as a supernova search user interface. It was developed in PHP, HTML/CSS and JavaScript languages with MySQL database to store data. It features a user management system, cutouts processing, marking of potential candidates, various candidate checks, statistics on (un)processed images and sky coverage, and a gallery of marked objects.

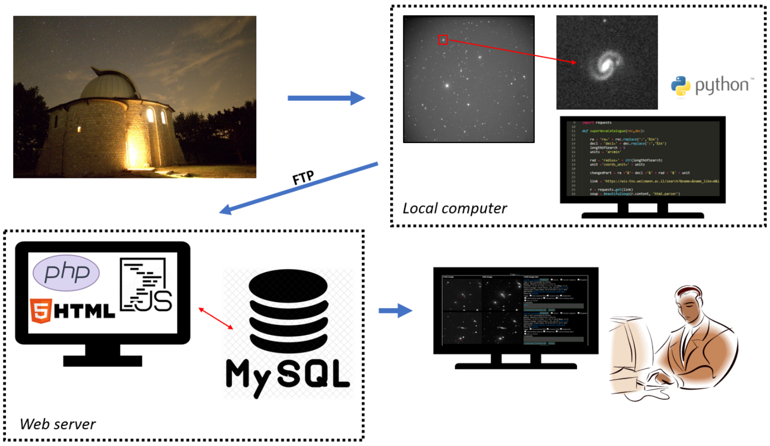

Figure 3: Frontend processing pipeline.

The typical workflow begins with a user logging into the system and requesting new (unprocessed) images/cutouts. The user then seraches for potential supernova candidates by blinking the cutout with an archive image of the same region of the sky. Digitized Sky Survey [9] is currently used as a source of archive images since it provides visually very similar images to those from the Tican Sky Survey. Marking of the candidates is performed by simply pointing and clicking on the desired object in the cutout. Tools are available to check the candidates for hot pixels (zoom tool) or known objects (queries to external databases). If the candidate survives all the checks we try to confirm it on the other frames from that night or by requesting new images of the same region. If it is confirmed, we report the discovery to the IAU Transient Name Server. In addition to supernova search, users also mark all objects they find interesting or unusual, such as oddly shaped galaxies, high proper motion stars, etc.

4. Conclusion

In this paper, we presented a system for transient object detection and classification. Although it provides a tools for supernova detection, it is easily adopted to any transient event type. The system is currently deployed at Tican observatory, but still in a test phase. It is easily adoptable to work on any kind of instrument. In the future, we plan to extend the search to other transient events such as unusual variable stars, novae and gamma ray bursts. In addition, we plan to develope more advanced methods for object detection based on machine learning. We also plan to involve more people to the project, especially students and start citizen science project for transient event detection and classification.

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Appendix A.

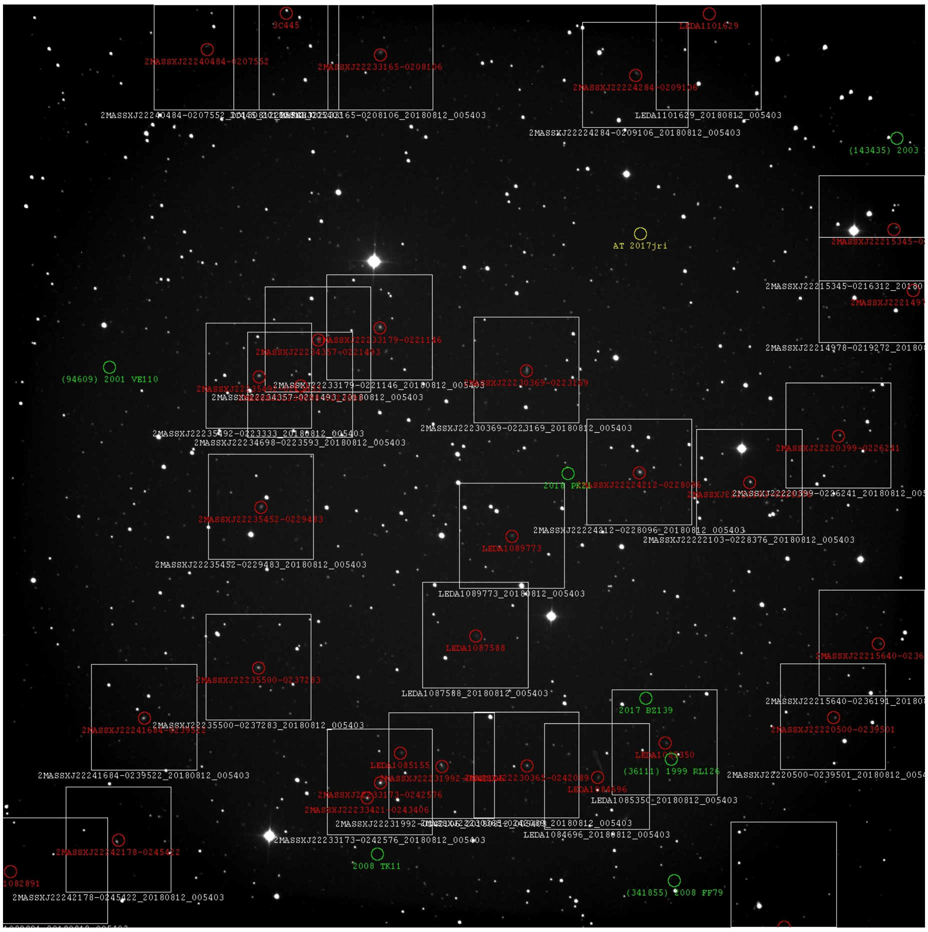

Figure 4: Single frame with marked objects.

References

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