Popularization of astronomy through robotic telescopes and virtual observatories

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Abstract: *Robotic telescopes and virtual observatories have great impact on popularization of astronomy. In this poster we present several web services and observatories that allow remote control over their equipment, which have great contribution in astronomy promotion. In addition, the first Serbian amateur robotic observatory is presented (Night Hawk, Bačka Palanka). Finally, an economical review of this concept is done to consider its attainability to the general audience.*

Overview

Robotic Observatory (telescope) is defined as an astronomical instrument and detection system which allows the observation without the need for physical intervention of operator. In astronomy, a telescope is considered robotic when observations can be performed without operator intervention on the equipment (even if one has to start and complete a monitoring session on it).
Robotic telescopes are complex systems consisting of several subsystems. These subsystems include devices that allow: 1) control of the telescope, 2) control of the detector (usually CCD camera), 3) control of the dome (roof) of observatory, 4) control the telescope's focuser, 5) tracking of celestial objects within a few arc seconds to a few arc minutes, 6) to avoid wrapping the cord around the mount, 7) successfully navigate special points in the sky, 8) knowledge of the horizontal border movement of the telescope limits, 9) initial "parking" position of telescope, 10) exposure control and camera temperature, 11) filter control, 12) storing images and their subsequent processing using the dark frame and flat field, 13) synchronizing movement of the telescope with the sky and so on. Most robotic telescopes are small telescopes. The emergence of the Internet has enabled robotic telescopes to become accessible to a large number of users worldwide. In the past, a robotic telescope used graphical interface limited to only one type of computer platform or simple communication via e-mail. The development of one's own graphical user interface was a complicated and time consuming task, not accessible to a wide range of users. Internet helps to reduce costs in communicating with users. It also offers the possibility of a wider range of potential users to get to know how to control the telescope. Thanks to the Internet, robotic telescopes are becoming an important element in astronomy teaching. Internet also provides an opportunity for communication, data exchange and verification of observational data obtained by many research teams world wide. It can be concluded that the Internet in the concept of "Astronomy from the chair" is becoming an important tool for dealing with astronomy.

A virtual observatory (VO) is defined as a set of databases and software that use Internet as a platform for astronomical research. A virtual observatory operates in a similar way like a real one, which consists of telescopes. The goal is to provide transparent access to data to users worldwide. In this way, scientists can discover, analyze and combine natural phenomena and laboratory data collected in databases. There are website groups that allow amateur astronomers to take advantage of VOs to participate in scientific research. One such example is Zooniverse.

Virtual Telescope Project Group
www.virtualtelescope.eu

Virtual Telescope (VT) project started at 2006. It was one of the first projects related to public observations and conferences using modern information and communication technologies. This goal of this project is to provide access of professional astronomical equipment to general audience, which can use it to observe and manipulate data from their home. The equipment is used for research and for amateur astronomy. The system is configured to produce best results on photometry, but can also be used for other purposes. In addition, people without any astronomical experience can use the equipment with the help of technical stuff, which are also good science communicators. VT project uses the equipment of Bellatrix observatory which is built in 1997. at Ceccano, central Italy. The observatory has three telescopes (Celestron 14", PlaneWave 17" and Coronado SM 60) and CCD cameras with other components. With this equipment, deep sky objects, binary stars, star clusters, Sun, Moon, planets, asteroids and comets can be observed. Another Celestron 14" telescope and Takahashi for planets and Moon are announced. The observatory is completely computerized, equipped with 3 computers for image management and editing. The software used are CCD soft, The Sky, Iris, IDL and Astrometrica. The area of the observatory is 14 m^2 and it has removable roof. The founder of this project is Italian astrophysicist Gianluca Masi, which is leader of the project, and the assistant is Gisella Luccone. VT project organizes the following activities:
- telescope control
- public observations
- exclusive public observations

During 6 years, 1300000 people from more than 200 countries attended activities within this project. The use of social networks greatly contributed to the success. Facebook page of the project has more than 4300 members, and besides it, there are 2 more groups with 4900 and 890 members respectively (September 2012).

Citizen Sky
www.citizensky.org

Citizen Sky is the 3-years project (2009-2011) intended for wide audience. The goal of this project is monitoring brightness changes of ε-Aurigae star, which can be observed even from light polluted locations, creating light curve and analysing the causes of the eclipses. This object is specific due to periodical eclipse - every 27 years there is an eclipse that lasts 600 days and the cause is not discovered yet. The project operates as a database for exploring this star and everybody can contribute by sending information about magnitudes, whether the observation is done visually or by DSLR or CCD camera. The data are public and can be analysed using the tools provided on the website.

Zooniverse
www.zooniverse.org

Zooniverse is the largest and the most successful project intended for citizen science. Zooniverse projects are developed and maintained by Citizen Science Alliance. The project started at 2007. with the project GalaxyZoo-Hubble. Beside this one, there are 9 more projects available today: Aincet Lives, Old Weather, Ice hunters, Planet hunters, The Milky Way Project, Moon Zoo, Galaxy Zoo (understanding cosmic mergers), Galaxy Zoo (the hunt for supernovae) and Solar Starmwatch. Here, we will describe Planet Hunters and Galaxy Zoo - Hubble projects.

Planet Hunters
www.planethunters.org
Planet Hunters is the latest projects developed within Zooniverse. Participants can get data from Kepler mission (star luminances), create light curves, and analyse them. Based on light curve analysis, users should find traces of possible planet transits. If significant number of such events are reported for the same object, scientists continue to further explore it. So far more than 4900000 analyses are performed and 34 of them are marked as candidates for extrasolar planet systems.

Galaxy Zoo - Hubble
www.galaxyzoo.org
Galaxy Zoo - Hubble is the first project under Zooniverse project. Before active work, users can take opportunity to inform about the project and the way how they can participate. By answering questions, they help researchers to classify Galaxies. First version of this project had 2 tasks: to separate galaxies in spiral and non-spiral, and if they are spiral, to determine the direction of arms. New version has more questions (18), but the number of questions that user actually gets depends on previous answers. During 14 months, since the first version started, more than 60000000 galaxies are classified.

Night Hawk
univerzumad.com

Night Hawk is the first amateur observatory in Serbia which is computerized and robotized. The communication exists in both directions through Internet. Users can remotely control the telescope and the cameraworks are delivered from the observatory to users. In this way, users have full control as if they were on the spot in the observatory building.

The observatory is open 16.4.2011, it is located in Bačka Palanka and belongs AS Univerzum. It is built by Janko Mravik, amateur astronomer, president of AS Univerzum. It is 6m×2,5m wide with the telescope room and working room. The building is covered by the removable and remote controllable roof. The observatory has the following equipment:
- Telescope. GSO 250/1250 on EQ6 sky scan mount.
- Main camera. CCD Astropix 1.4, mounted on the telescope.
- Inner camera. Used for monitoring interior (room and the telescope itself).
- Outer camera. Used for monitoring exterior and the building.
- Wide-field camera. 60°×40° of the sky. Useful for meteor observations.
- Meteorological station. Monitor weather conditions. In the case of rain, the roof is closed automatically to protect interior.
- 3 computers. Networked and connected to Internet. Used for observations and controlling the observatory.

During 1 year, the observatory discovered 1 variable star and recorded transits of 30 extrasolar planets. All events are confirmed by competent registries.
Although it is physically located in Bačka Palanka, the fact that it contains robotized telescope and remote control via Internet allows the observatory to be used by anyone regardless of geographical location and without need for physical presence in the object.

Economic analysis

Economic analysis is based on equipment similar to Night Hawk observatory, because it can be easily found on Serbian astronomical equipment market. The goal is to determine the payback period of investment in such observatory. The assumption is that the owner already has the building which does not need further investments.

Tube „Newton" 300/1500 on EQ6 mount	2000
ALCCD5 camera	256
Meade DSI III	1295
T/2 camera adapter	26
Baader solar foil	54
Ursa Minor software	22
Total	**3652**

Since the average salary in Serbia is about 350€, it means that this solution is not accessible for majority of people. If we consider that equipment for astrophotography costs 3625€ and one observational hour costs 10€, then for 3625€ a person can book and use a total of 363 telescope hours for his observing sessions. This is especially useful for people who rarely have the opportunity to engage in astrophotography and want above all to observe night sky, which can be done without any financial compensation by attending online public observing sessions which are free (example Virtual Telescope), or using a Astronomylive site (www.astronomylive.com).
Let's suppose that the owner rents the telescope for 10€ per hour and the annual inflation is 3%. Payback period is calculated using discount formula.

hours leased per month	total hours leased in 1 year	Payback period
30	360	< 2 years
15	130	3 years
10	120	4 years
5	60	7 years

This calculation does not include observatory construction, equipment maintenance, taxes and other expenses, so including them will extend the payback period. Nevertheless, this concept allows astronomical equipment to be used more actively and brings observations to general audience for much less price than it would be otherwise. In this way, robotic telescopes and virtual observatories greatly contribute to promotion and popularization of astronomy.