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"ASTRONOMY FROM THE CHAIR" - A NEW WAY OF DOING ASTRONOMY OVER INTERNET

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Abstract. This paper describes how the emergence of the Internet enabled astronomy to become more prevalent as a hobby and contribute to the further development of the new concept of amateur astronomy, "Astronomy from the Chair" (example: Astronomy Live and Virtual Astronomy Telescope Project Group). In this paper we also present the observatories that make it possible to take direct control over their equipment and to conduct observation and photography (example: MyTelescope and Virtual Telescope Project Group), and virtual observatories which can be accessed huge databases and carry out its processing directly through the Internet (example: Galaxy Zoo, Planet Hunters and citizensky).

1. INTRODUCTION

The discovery of telescope raised the revolution in astronomy 400 years ago. Since that time, technological development dramatically improved the telescopes that allow us to observe the space not only in optical but in the whole range of wavelengths. In addition, it also produced new instruments for observing as well as recording observed phenomena. These are DSLR, CCD and modified web cameras, supercomputers, spectroscopes, information and communication technologies etc. For amateur astronomers, the development of optical and recording instruments plays an important role. Recently, the expansion of Internet became important factor for astronomy promotion and increase the number of amateur astronomers as will be shown in this paper. The goal of this paper is to present how the Internet affected the development of amateur astronomy and its popularization through concept called "astronomy from the chair" and to present several web services in which everyone can take place in astronomical research (robotised and virtual observatories).

2. ASTRONOMY FROM THE CHAIR

"Astronomy from the chair" is a term for new concept for amateur astronomers that gives ability to observe from their homes using the Internet. Users of this astronomy concept are able to:

- learn particular astronomical topics accessing large knowledge base available on Internet,
- be involved in space explorations,
- send their observational data and photographs,
- analyse available data in virtual observatories,
- perform observations using distant robotised telescopes,
- write and publish papers,
- discuss in Internet forums,
- attend on-line seminars (webinars)

This concept is the practical example of contribution of Internet in appearance of new products and services, evolving the existing and appearing the new forms of organizations. It means that the problems of geographical borders which made international cooperation difficult vanished, as well as equipment problem (which are inaccessible for many individual astronomers due to high prices). In this way the communication and cooperation with professional astronomers is also improved. Critics of this concept by some astronomers also exist. They claim that the direct contact with nature and night sky is depleted. Indeed, it does not offer real experience as it is on the field, but it provides efficacy of research and increase of productivity considering use of astronomical equipment and resources. Besides space one, the time problem is also resolved. For example, astronomers from Serbia can observe the night sky in New Mexico from 3h to 13h, during the daytime in Serbia. Observers do not have to spend the night on telescope or computer because the equipment is located at the night side while the observer can be at the other one. Even better solution is automated telescope, which can perform observations without operator's presence, and the operator can just take recorded material later. In this paper, we will describe two robotised observatories available to amateur astronomers (with an adequate fee) and websites where astronomers can take raw data, perform some operations on them, and publish their own data into a common database of the observed object or event. These are: MyTelescope.com (www.mytelescope.com), Virtual Telescope Project Group (virtualtelescope.bellatrixobservatory.org/ , www.virtualtelescope.eu), Astronomy Live (www.astronomylive.com), Zooniverse group (www.zooniverse.org) and Citizen Sky group (www.citizensky.org).

3. ROBOTIC OBSERVATORY AND ITS SERVICES

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 the 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 (meridian, zenith, celestial pole), 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. While large observatory instruments may be highly automated, few of them operate without attendants. Each observatory should also have its own weather station.

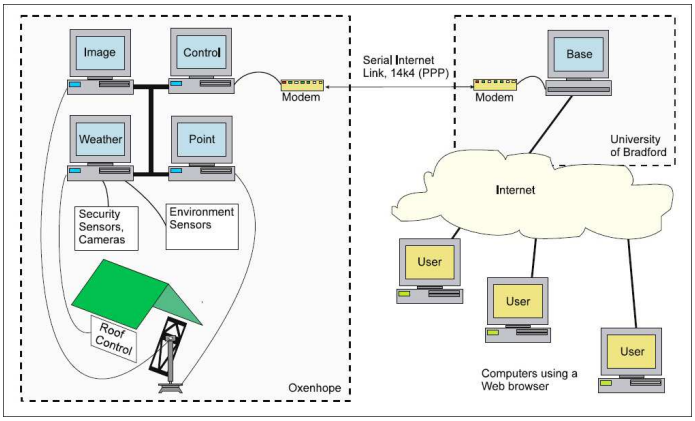

Figure 1: Schematic view of robotic telescope system at the University of Bradford [3].

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. The development of electronic commerce and money enables a simple and easy way to make a payment for the use of these services. 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 is becoming an important tool for dealing with astronomy. In continuation of this paper we will describe two groups: MyTelescope.com and Virtual Telescope Project Group that rent time for work on their robotic observatories and the services they provide to their customers.

3. 1. MYTELESCOPE.COM GROUP

MyTelescope.com is a group that rents their observational equipment from the site and let the users take control on it. The equipment and services are available to

all citizens, astronomical societies, schools etc. The group started in 1998. The goal of their work is to provide service of observational astronomy which will be available for an acceptable price. Also, another goal is to allow users to experience the work with semi-professional and professional telescope. The equipment of this group currently resides on two locations: New Brunswick and New Mexico. For both locations, weather conditions such as clouds, transparency, seeing and wind are provided. In addition, the time as well as Moon phase and position according to observer's geographic coordinates are displayed graphically. This group has 10" Schmidt Cassegrain f/10 (focal length 2500 mm) telescopes, Sony ICX085 Hyper HAD primary camera, monochromatic camera 1300x1300 pixels. Each telescope has also a set of filters: blank, neutral, IR-block, red, green, blue plus opaque. Other equipment are focuser on primary camera, finder or secondary camera CMOS (Sony ICX 254AL) 510x492 pixels (conversion to 768x480) and an external camera for monitoring the telescope itself, so operators can see its environment and moving. Group members have built the mount themselves. The user has not the possibility to manage the roof remotely, so the group members always open it before each session. The roof can be open completely or partially, according to wind speed, so if the coverage exists in some amount, the price for using service is accordingly reduced. The operator has direct control over the telescope. At the beginning of each session, automatic focusing is performed (there are a priori defined focuser positions, the targeted object is recorded automatically with each position, and the operator chooses the best focused one). Operator has complete control on telescope moving using interactive maps, developed by the group, control on filters, exposition of primary and secondary camera, as well as opportunity to monitor telescope work using the external camera within the dome. Objects can be recorded using expositions from 1/4000 s to 1 hour. A set of several images with shorter expositions can be combined in order to form one, high-quality image. After taking the image, the observer can make corrections and save it in one of three formats (jpg, bmp, png). The image can be corrected using bias, dark and flat field frames or just take the raw images without any corrections. The software for telescope control is developed on Java platform and is very easy to use. This step allowed the broad availability for users worldwide, regardless of computer platforms or operating systems. During the entire session, the active help subsystem suggests the users appropriate filters or exposition for recording targeted objects. This group charges their services using PayPal. Telescope time can be leased just by selecting session start time and duration. The user needs to create account and to purchase some of available packages, depending of amount of time and type of use. There are trial, basic, medium, large, extra large and educative package. They can be purchased using PayPal system. In the future, this group is planning to develop courses of photometry for pupils and to find new locations to place their equipment. Arizona, Australia and New Zealand are considered. Arizona mostly because of ease of equipment transport, Australia and New Zealand to observe southern sky, but any other appropriate locations can also be considered.

3. 2. VIRTUAL TELESCOPE PROJECT GROUP

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. The 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 the leader of the project until now. VT organizes the following activities: 1) Live shows - activities for general audience, mostly free of charge. Durations of these shows are usually 1 to 1,5 hours. The exception is online Messier marathon which lasts whole night. Some of over 130 events are: Perseids 2011; Happy Birthday VT; asteroid 2011MD close encounter; Akashimatra and Virtual Telescope online star party; On-line Messier marathon etc. 2) Laboratories - users can download some images free of charge to practice their astrometric and photometric skills. 3) Courses - users can learn to use the equipment and to prepare to observe the sky with the help of professional astrophysicist. Courses are intended to students and to amateur astronomers who wish to engage seriously in observational astronomy and astrophotography. The courses are the following: Basic Astronomy, Modern Telescopes and CCD Astronomy. 4) Researching - the stuff from VT project is researching asteroids, comets (particularly NEO), variable stars, exoplanets, supernovae and transient phenomena. One of the remarkable activities of this group is equipment leasing. Users can manage telescopes from their home using the Internet. All they need to do is to book the time slot and the desired equipment. There are 4 models of lease, each with different price, depending on selected equipment and service. 1) Live mode - users have complete control over the telescope and CCD camera. 2) Service mode - members of the group will record desired object with selected equipment for the user. 3) Assisted mode - works exactly like the "live mode", but with the help of a support astronomer to get detailed assistance at the scheduling/observing and data reduction time. 4) Sky@mail mode - users can send a request to the Virtual Telescope to made recording of the desired object and in a few days it will be sent to user by e-mail. VT project has large number of visitors on every activity worldwide. Its success is partially due to use of social networks like Facebook for activity promotion, but also due to many activities during IYA 2009. Facebook page of this project has more than 4500 members as well as 2 more groups for information of current and future activities and reports. The reasons for great success of VT project are also: 1) Idea of the project 2) quality of technology 3) fine tuning and maintaining of instruments 4) reliability of systems for remote control 5) communication and cooperation with group members 6) modern methods for promoting project (Facebook, LinkedIn, Twitter and blogs).

4. VIRTUAL OBSERVATORIES

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, analyse 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. 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. Besides this one, there are 9 more projects available today: Ancient 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. For each of projects listed above, a short training in the form of text or animation is available, to allow users successful start of research. They can get detailed information about the particular topic. The motif of this project is to include human factor to overcome problems that technology and supercomputers are not able to perform appropriately. For example, detection of extrasolar planets orbiting around distant stars is hard. Humans are able to recognize these events as well as some unwanted phenomena that should be removed. We will describe Planet Hunters and Galaxy Zoo - Hubble projects. 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 is the first project under Zooniverse project. Before active work, users can take opportunity to be informed 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. 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.

5. ONLINE ASTRONOMY BROADCASTING

Online broadcasting is part of concept "astronomy from the chair" that enables users to get directly involved in astronomical observations organized by amateur astronomer

with a location in the world. All you need is the emitter to connect to the Internet and to use one of the available channels to broadcast his observation and for observation to use one of the available camera (web camera, DSLR or CCD). One of the Internet service that provides this type of service is Astronomy Live. Astronomy Live is the website created to inspire today's and future generations of astronomers to broadcast their observing activities and to share them with other Internet users. This group tries to join advantages of Internet as a communication infrastructure and astronomy as one of the widest hobbies, and to allow astronomy to be available continuously. Everyone can join the group, either as the observer or as the broadcaster. All that user should do is to create an account. Registration is free of charge. In order to broadcast observing activities, user need to connect to Internet, place the camera onto the telescope and select one of 10 available channels for broadcasting. The observation can also be recorded, and the video can be provided for broadcasting later. At the time of this writing (fall 2011), Astronomy Live team has 10 members and more than 1200 registered users.

6. CONCLUSION

In this paper, a new concept "Astronomy from the chair" is presented. Due to fast development of the Internet, a new communication channel and tool for amateur astronomers is created. Two listed examples, MyTelescope and Virtual Telescope, show how Internet is used and how the world of professional astronomy is brought closer to amateur astronomers worldwide. Projects like Planet hunters, Galaxy Zoo and Citizen Sky are real examples how resources from Internet and virtual observatories can be used in astronomy promotion, but also as a new educational instruments that can be used in schools and thus make the classes more interesting for pupils. In the future, new projects of this type should be deployed as well as improvements of existing ones. Through astronomical societies, workshops should be organized in which these projects can be used for promotion of astronomy and for education of young people who may choose astronomy as their future profession.

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