NEW CONCEPT OF HUNGARIAN ROBOTIC TELESCOPES

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ABSTRACT. As the result of a longer innovation of a few Hungarian opto-mechanical and electronic small companies, a concept of fully robotic mounts has been formed some years ago. There are lots of Hungarian Automated Telescopes over the world (in Arizona, South Korea, Izrael and atop Mauna Kea, just below the famous Keck domes). These are cited as HAT telescopes (Bakos et al. 2002), and served thousands of large-frame time-series CCD images since 2004, and the working team found already 6 exoplanets, and a number of new variable stars, etc... The newest idea was to build a more robust robotic mount, hosting larger optics (D > 50 cm) for achieving much fainter celestial objects, than the HAT series (they are operating with Nikon teleobjective lenses) on a still relatively wide celestial area. The very first sample model is the BART-1, a 50cm f/6 telescope.

The Baja Observatory and the Robotic Telescope System:

The observatory is located in south of Hungary, close to the Serbian-Croatian common border, at the Danube. Geographical coordinates are: N 46 10 48.6 E 19 00 39 (in WGS-84 system). We operated here a 40 cm Classical Cassegrain Telescope made in the Odessa Astronomical Observatory, between 1985-1991. Since 1995, the main telescope was a 50 cm f/8.4 Ritchey-Chrétien type equatorial fork mount telescope (made by OGS, US). The latest development was the design and built of a fully robotized 50 cm f/6 modified-Cassegrain type telescope (made by Fornax 2002 Ltd. and theirs collaborators in 2004-2005, Hungary). This project has been supported by the Hungarian National Fund of Development, grant no.: MFC-03 0501 04. The full cost of the project were about 74,400 EUR, including some important sub-systems (an all-sky night camera, an automatic meteorological station, and the main CCD detector) as well as all the necessary bricklayer works at the site. The development of the telescope is partly underlying the existing scientific-technology cooperation between our observatory and the Sternberg Astronomical Institute of Moscow State University. The main technical details of the mount:

- The control system is running under Real-Time Linux on an industrial PC (there were not any frozening during the continuous operation in the last 1 year!)
- Drivers and the graphical environment and the official web site are written in Hungary (by Mr. Lázár, J. in C++, Mr. Kiss, Z. in IDL, and Jäger, Z. respectively)
- The robust mount is driven by 3-phases stepper motors
- The resolution of the motors are $0.25''$/step
- The maximum speed of the telescope (in GOTO mode): about 3°/sec
- The periodical error of the RA axe: about $\pm 5''$ (valid for the base model)
- An existing optional upgrade: closed-loop PEC - with this $< \pm 1''$ (!)

Figure 1: BART.

- The focusing of the optical tube is not done by the movement of any of the optical elements (as usually worldwide), but by a stepper-motor controlled special-design modified Crayford-type focuser
- The optical system is re-modelled by Dr. Bíró (Baja Observatory) by OSLO software
- There were a subsequent refinements in the original design (calculated and built by Baja staff and of the Physical Institute of Pécs University).
- The automated large-format filter selector system is also Hungarian-made

The imaging capabilities of BART-1:

The relatively large (flat-corrected) field of view, together with a large-scale CCD chip are the inseparable parts of the "BART" series concept. The present optical system is an 50 cm f/6 modified Cassegrainian. The main CCD detector is an Alta U 16 (made by Apogee Inc., US) uses Grade 2 KAF16801E front-illuminated chip (4096x4096 9μ x 9μ format pixels). This combination yields an about 42x42′ wide field of view. This is presently the largest in Hungary, and also in CESE region (see the example single shot on Fig. 2).

The main technical details of the camera:

- imaging area: 36.86 x 36.86 mm (typical)
- digitization rate: 5 MHz (in 12 bit mode) 1 MHz (in 16 bit mode)
- Quantum Efficiency at the peak: 66% (at 580 nm)
- Linear Full Well capacity: about 100,000 e^-
- nominal dark current: 1 e^- /pixel / sec (at -20°C)
- cooling: Peltier, max. 40°C below ambient (water circulating is an option)
- read-out noise: about 15 e^- RMS typical (at 1 MHz)
- control: USB 2 interface (average download time of 1x1 bin: 11 secretary)
- programmable on-chip binning: from 1x1 to 10x4096

The present plans, scientific and educational programs:

BART robotic telescope system is specially designed for small observatories and universities of Central-East-South Europe, since it is a low cost, widely utilizable complete instrument. It can be started from as low as 37,200 EUR, which has no competing telescope at this range and at this level of automatization (of course, this lowest level of price is valid without any extras, CCD detector, etc., i.e. simply the base model, complete with the optical tube and of the control system, too).

Figure 2: h and χ Persei.

Science with BART-1:

- supernova search (in cooperation with Szeged Universitiy team)
- systematic crowded-field long-time-series photometry of selected fields (in cooperation with Konkoly Observatory)
- minor planets and comets (cooperation with Szeged & Modra Observatories)

Education with BART-1:

- the "deep sky in the classroom" initiative (remote observation by students)

References

Bakos et al.: 2002, *PASP*, **114**, 974.