MONET/North: a very fast 1.2m robotic telescope

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ABSTRACT

The first of two 1.2m MONET robotic telescopes became operational at McDonald Observatory in Texas in spring 2006, the second one will be erected at the South African Astronomical Observatory's Sutherland Station. About 60% of the observing time is dedicated to scientific use by the consortium (Univ. Göttingen, McDonald Obs. & the South African Astron. Obs.) and 40% is for public and school outreach. The alt-az-mounted f/7 RC imaging telescopes are optimized for fast operations, with slewing speeds up to 10°/sec in all axes, making them some of the fastest of their class in the world. The unusual clam-shell enclosures provide the telescopes with nearly unobstructed views of the sky. The new observatory control system fully utilizes the hardware capabilities and permits local, remote, and robotic operations and scheduling, including the monitoring of the weather, electric power, the building, current seeing, all software processes, and the archiving of new data.

Keywords: Telescopes, robotic, remote, direct drives, torque motors, fast slewing, education

1. INTRODUCTION

The MONET project is designed to give its participants access to the entire night sky via a network of two identical 1.2m autonomous telescopes, one covering the northern and the other the southern hemisphere. The telescopes and internet-based infrastructure are run by a consortium consisting of the Georg-August-Universität Göttingen (Germany), the McDonald Observatory of the University of Texas at Austin (USA), & the South African Astronomical Observatory. The capital funding of the project is mainly due to a generous grant from the *Alfried Krupp von Bohlen und Halbach Foundation.*

The first telescope, MONET/North, was installed at McDonald Observatory in Texas in December 2005. The dedication by the consortium of took place on March 28, 2006 and was accompanied by the first MONET Symposium (*Science and Education with MONET*). The second telescope, MONET/South, will be erected at the South African Astronomical Observatory's Sutherland Station by the end of 2006. Both telescopes are designed to do imaging through one of up to twelve different filters.

While about 60% of the observing time of the MONET telescopes is available to the scientists and students of the consortium, roughly 40% of the time is reserved for use by the Krupp Foundation's *Astronomie & Internet* project and is dedicated to use by school classes or similar educational institutions (museums, planetaria, school-labs) all around the world, a service which is completely free of charge.

The two 1.2m telescopes are built by Halfmann Teleskoptechnik in Bavaria, Germany. Technically, they are nearly identical to their sister telescopes - the *Hamburg Robotic Telescope* project (Hamburger Sternwarte) and the two *STELLA* telescopes (Astrophysical Institute Potsdam) - being commissioned to do automatic spectroscopic and photometric observations, e.g. of stellar activity.

This paper focuses on the hardware of the new telescope system, mainly on its novelties and particularities. Most important are the drives equipped with direct torque motors, allowing very fast slewing, accurate pointing, and precise

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tracking of the alt-az-mounted telescope. Separate contributions concentrate on software and the integration of MONET into a network of heterogeneous telescopes HTN (Hessman et al.).

2. THE MONET PROJECT

The MONET telescopes form the backbone of the *Astronomie & Internet* project: they provide the means of obtaining astronomical images from anywhere in the world and for a variety of clients:

- professional astronomers and university students at the partner institutions
- teachers and students at secondary schools all over the world
- networks of telescopes (e.g. the Heterogeneous Telescope Network (HTN) or Hands-On Universe(TM)
- educational institutions like museums, planetaria, and school-labs.

2.1 Science with the MONET Telescope

Scientifically, robotic telescopes open new horizons: because they can obtain measurements automatically, it will become possible to perform time-intensive projects which otherwise would require enormous efforts both in personnel and money. Examples for such typical MONET projects are:

- the discovery of extra-solar planets via the faint eclipses of the stellar light by the passage of planets in front of their parent stars or via the gravitational lensing of the light by another star accidentally along the line-of-sight to the star;
- the study of stellar variability in pre-main sequence stars and close binaries with accretion onto compact objects (cataclysmic variables, stellar black holes);
- follow-up observations of Gamma-Ray Bursts and nearby supernovae;
- photometric monitoring of objects which should be observed with large 8-m class telescopes like the *ESO Very Large Telescope*, the *Hobby-Eberly-Telescope* in Texas or the *Southern African Large Telescope* (the observatory in Göttingen is a partner in the latter two projects);
- simultaneous optical observations during the use of satellite-observatories like the *Hubble Space Telescope* or the XMM X-ray by astrophysicists at the partner institutions.

We plan to use the MONET network to improve the quality of instruction at the University: physics students will have the opportunity to perform their own projects with the unmanned telescopes even in the worst Göttingen weather and will be able to gain experience in carrying out independent scientific research.

2.2 Educational Use of the MONET Telescopes

Access to research-grade 1-m-class telescopes opens up a variety of possibilities for use by schools, and there are several different formal curricular programs available, including the Hands-On Universe™ Project. The required image-processing can easily be performed in a High School environment, e.g. using public-domain software like ImageJ. The use of the telescopes for educational purposes is fundamentally organized the same way as the professional use by astronomers at the partner institutions. After registration, teachers and students will use the same access portal as scientists.

However, the educational purpose is responsible for the distinct color scheme of the telescope: orange is the school color of the University of Texas at Austin.

3. HARDWARE

Both MONET telescopes are designed as very fast robotic imaging telescopes. Most important was to minimize the personal effort for operation and maintenance of the telescopes. A key element of the telescope are direct torque motors driving the telescope rapidly and precisely.

Although the tertiary mirror is fixed at the moment both Nasmyth foci are accessible in principle.

Table 1 summarizes the optical and technical layout which is identical for both MONET/North and South telescopes.

An automatic weather station integrated in the MONET observatory was delivered together with the telescope. Obviously recent weather data is essential for any robotic telescope operations.

Table 1. Optical and technical layout of the MONET telescopes.

Technical Data	
Aperture	1200 mm
Focal Length	8400 mm (f/7)
Plate Scale	24.55 arcsec/mm 0.33 arcsec/13.5 micron pixel
Optics	Richey-Chretien
Focus	Nasmyth
Max. FOV	about 20 arcmin
Mount	Altitude-Azimuth
Drives	direct torque motors
Operational Mode	robotic

3.1 Mount and Mechanics

The alt-az fork mount of the telescope is hydraulically supported. The tube is a Serrurier truss structure, mirrors are covered automatically. The M1 mirror cell is supported by 18 axial and 12 radial levers. A derotator compensates for image rotation. The filter wheel houses up to twelve filters.

The telescope within its opened enclosure as well as a satisfied installation team is shown in figure 1.

3.2 Drives and Control

The altitude and azimuth axes are driven by high-tech magnetic direct drive motors (torque motors) which enables the observer or the robotic control computer to slew and track the telescope rapidly and precisely.

Torque motors offer a number of advantages compared to conventional telescope drive systems, basically an extremely high performance regarding to accuracy and speed. They have very high continuous and peak torques at low speed yielding exceptionally homogeneous movements and excellent speed control. Since the telescope is coupled directly with the motors, classical gears can be avoided. The system gains mechanical simplicity and offers very high dynamics, rigidity, and regulation accuracy compared to conventional drives. Thus this drive solution provides high accuracy and repeatability.

Fig. 1.The MONET/North telescope at its final site at McDonald Observatory in Texas during installation in December 2005. One half of the wide opened clam-shell enclosure is seen to the right; one can also notice that the sky is nearly unobstructed by the enclosure. The installation team from University of Göttingen, McDonald Observatory, and Halfmann Teleskoptechnik is celebrating the first successful tests.

We use torque motors and controllers made by Swiss company ETEL in combination with high-precision absolute encoders by German firm Heidenhain. The drives are controlled via Profibus.

Slewing speed and acceleration are limited by software, a slightly faster operation may be possible. The required pointing and tracking accuracies were easily reached during the commissioning phase in March 2006. Primary characteristics are given in table 2.

This performance is making MONET/North and his sister telescopes to some of the fastest of their class in the world.

Table 2. Slewing speed and acceleration limits as well as positioning and tracking accuracies already achieved by MONET/North telescope during commissioning in March 2006.

Slewing	
Speed	up to 10°/sec
Acceleration	1°/sec²
Pointing accuracy	
Absolute	<5”
Relative	<0.2”
Tracking accuracy	
RMS	<0.3”/90sec

Fig. 2. The partially opened clamshell enclosure reveals the MONET/North telescope at dusk. In this position the enclosure can shield the telescope against wind gusts. In the background the horizon is shaped by lovely Davis mountains of western Texas.

3.3 Enclosure

The unusual enclosure has two mechanically simple quarter-cylinder roof sections which, when lowered to each side of the buildings, provide the telescopes with a nearly unobstructed view of the sky. Partially opened it can also serve as a wind shield. The enclosure is shown in figure 1.

3.4 Family of 1.2m telescopes

MONET's sister telescopes STELLA-I (imaging) and STELLA-II (spectroscopic) were inaugurated in May 2006. STELLA is a project of the Astrophysical Institute Potsdam (AIP) in collaboration with the Instituto de Astrofísica de Canarias (IAC) and is located at the Teide Observatory on the Canarian island of Tenerife, Spain. Primary scientific aim is the photometric and spectroscopic monitoring of stellar activity. A third sister Hamburg Robotic Telescope, operated by the Hamburger Sternwarte, is equipped with a fibre-fed Echelle spectrograph. Major purposes are follow-up observations of X-ray sources and simultaneous observations with space telescopes.

The hardware of all five 1.2m telescopes is very similar apart from instrumentation.

4. SOFTWARE

Although the standard operational mode is robotic, local and remote operations are obviously also supported by hardware and software. There will be further different means of using the telescopes which are called 'active internet', 'passive internet', and 'virtual reality'.

The new observatory control system fully utilizes the hardware capabilities, including the monitoring of the weather, electric power, the building, current seeing, all software processes, and the archiving of new data. More usual tasks controlled by the system include focusing, hydraulic engine, derotator, filter wheel, sensors and limit switch read-out, mirror covers and emergency action.

Fig. 3. This is a view of the telescope working taken with the internal webcam: in addition to a few lights from below, a half-moon beautifully illuminates the telescope, the open enclosure, and the rest of the mountain. The domes of McDonald 2.1m and 2.7m (partially covered by MONET) as well as smaller telescopes can be seen in the background. An average of 5 individual images was used to reduce the amount of noise.

Operating in robotic mode leads to much harder requirements on the reliability of hardware and software and the interaction of all system components. For example, if the weather station fails to alarm on bad weather or the software fails to close the enclosure on such a alarm the telescope may suffer severe damage.

Every action of the telescope – especially those initiated by students - can be monitored via webcams simultaneously. This is not only for safety reasons but also for a better motivation of the students works. In figure 3 a webcam image shows the telescope working during a half-moon night.

More details regarding software are given in Tuparev et al. (2006).

The integration of MONET into upcoming Heterogeneous Telescope Networks (HTN) was discussed during the first HTN Workshop in July 2005 (Hessman 2006). This discussion will be continued at HTN Workshop II in July 2006 in Göttingen. 'Operating a heterogeneous telescope network' is addressed by a separate contribution to this conference (Allan et al.).

5. SUMMARY

The entire MONET project depends essentially on the robotic layout of the telescope – anything else would have significantly overcharged the consortium institutions regarding to man-power. Besides the specialized hardware the development of very new software was necessary to meet the needs of professional astronomers and school students and to implement a common scheduler for robotic observations of very different clients.

Another major advantage of the MONET telescope is the fast hardware. For many scientific and educational projects speed is crucial. Anyway there is a significant gain in efficiency for any sort of project. The direct drives of the telescope stand also for precise pointing and tracking; these drives have shown their capabilities and fulfilled all requirements immediately during commissioning in March 2006.

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