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Modernizing legacy instruments:

The case of Telescope Obelix at the Observatório Abrahão de Moraes

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Abstract. Remote observing with robotic telescopes has become an important observational strategy in contemporary astronomy, enabling high-quality and efficient data acquisition. At the same time, many telescopes from previous generations often do not offer technological support for remote operation. Such instruments have substantial potential for research, teaching, and outreach activities, yet they remain underutilized due to the lack of technical support or available personnel. This work aims to describe the approach and solutions developed for the automation of the Obelix telescope, highlighting the potential of this type of project and perspectives for its expansion to other similar instruments. Obelix features a 40 cm aperture commercial Schmidt-Cassegrain optical system, mounted on an alt-azimuth fork mount, installed at the Abrahão de Moraes Observatory. It has been used for scientific and educational observations since its installation in the early 2000s. However, recently it had become underutilized, with a strong dependence on legacy hardware and systems. Using an architecture based on open-source software, the team sought to integrate Obelix with more modern systems, enabling its automated and remote operation. Control was orchestrated by the open-source software N.I.N.A., connected to the various instruments that compose Obelix through dedicated drivers and the ASCOM platform. In addition to the integration challenges and the approach adopted for the modernization effort, this work reports the instrument characterization tests. The results obtained during the telescope's "new first light" are also presented, including successful imaging observations of globular clusters as a means of verifying performance and demonstrating potential scientific applications. Future development steps are discussed in terms of hardware and instrumentation improvements, as well as the expanded possibilities for scientific and educational use of the telescope.

Resumo. A observação remota utilizando telescópios robóticos tornou-se importante estratégia observacional em astronomia atualmente, permitindo coletar dados com maior qualidade e eficiência. Ao mesmo tempo, muitos telescópios de gerações passadas nem sempre possuem o suporte tecnológico à observação remota. Muitos desses instrumentos possuem grande potencial para o desenvolvimento de atividades de pesquisa, ensino e extensão, mas acabam sendo subutilizados por falta de suporte técnico ou pessoal disponível. Este trabalho objetiva relatar a abordagem e as soluções desenvolvidas para a automatização do telescópio Obelix, destacando o potencial desse tipo de projeto e perspectivas para sua expansão para outros instrumentos similares. O Obelix conta com uma abertura de 40cm, ótica Schmitt-Cassegrain comercial, montada em montagem alt-azimutal em forquilha, e está instalado no Observatório Abrahão de Moraes. Realiza observações científicas e didáticas desde sua instalação, no início dos anos 2000. Porém, recentemente vinha sendo subutilizado, com forte dependência de hardware e sistemas legados. Utilizando uma arquitetura baseada em softwares abertos, a equipe buscou integrar o Obelix a sistemas mais modernos, permitindo sua retomada operacional automatizada e remota. O controle das observações foi feito por meio do software aberto N.I.N.A., conectado aos diversos equipamentos que compõem o Obelix por meio de drivers próprios e da plataforma ASCOM. Além dos desafios de integração e a abordagem adotada para sua modernização, o trabalho relata os testes de caracterização do instrumento. Os resultados obtidos na "nova primeira luz" do telescópio também são apresentados, com imageamento bem-sucedido de aglomerados globulares, como forma de verificação do desempenho e demonstração de potencial aplicação do telescópio. Próximos passos de seu desenvolvimento são discutidos, em termos de melhorias de hardware e instrumentos, e também as possibilidades de aplicações científicas e didáticas do telescópio.

Keywords. instrumentation – remote observations – telescope automation

1. Introduction

Remote operation of telescopes has become a central trend in contemporary observational astronomy, allowing for greater access, optimizing the use of instruments, and promoting applications in teaching, outreach, and research. However, many legacy telescopes have technological limitations that hinder their integration into modern control systems. The Obelix Telescope, installed at the Abrahão de Moraes Observatory (IAG/USP) in the early 2000s (see Figure 1), is an example of this situation: despite its 40 cm aperture and significant scientific and educational potential, it was underutilized due to its lack of integration with contemporary automation standards.

Given this scenario, an opportunity was identified to modernize its operation through an architecture based on open technologies, consolidated standards in amateur astronomy, and interfaces compatible with legacy hardware. The objective of this work is to present the process of modernizing the telescope, covering the development of the hardware and software architecture and the initial characterization of the instrument, as well as the main challenges encountered and the first results obtained from operational tests.

The rest of the article is structured as follows. Section 2 presents the methodology followed for the development of the work, with special emphasis on the hardware and software architecture that was developed as part of the telescope modern-

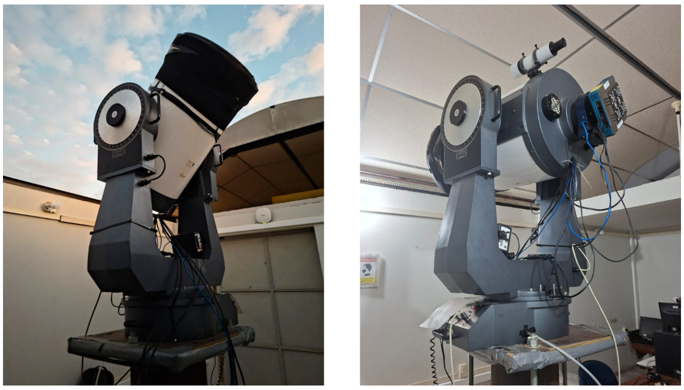

Figure 1. View of telescope Obelix at the observatory.

ization process. Section 3 presents the results of the integration tests performed, including the initial analysis of the instrument's characterization and images taken. Section 4 discusses the lessons learned and the next steps of the project. Finally, section 5 presents the conclusion and final considerations.

2. General architecture for telescope automation

The modernization was based on the adoption of open technologies, highlighting the use of the ASCOM standard, widely used since the late 1990s for communication between software and astronomical equipment via serial interfaces (ASCOM 2025). This standard is also used by the systems that originally accompany Obelix.

As the main orchestrator of the operation, we adopted the N.I.N.A. (Nighttime Imaging 'N' Astronomy; NINA 2025) software, a free, open-source tool with a strong community of developers and users. N.I.N.A. allows flexible connection of cameras, mounts, rotators, and other devices, in addition to offering complete automation of observational sequences. In addition, open source astrometry software was used for plate solving and telescope pointing (ASTAP[1]).

The architecture is presented in Fig. 2 and features three main hardware components:

- Telescope mount: Meade LX 200;
- Camera: Apogee Alta U9000;
- Field rotator: Optec Pyxis. Key component for alt-az fork mounts, which require field derotation for long exposures

Additionally, future expansions are planned, including autoguiding, motorized focus, observatory roof control, integration with a weather station, and incorporation of a GPS module for precise control of observation times. The GPS module is already present in the observatory, but has not yet been reintegrated into the system. In the diagram representing the architecture, expansions that have not yet been implemented or tested are indicated by dashed lines.

3. Results

This section summarizes the results obtained for the initial characterization of the Obelix instruments using the developed architecture, and the first test images.

[1] https://www.hnsky.org/astap.htm

3.1. Instrument characterization tests

Initial tests partially validated Obelix's operation and its suitability for observational requirements. FWHM and eccentricity maps based on the analysis of stars in the images revealed a tilt component and a linear gradient, which will be investigated for their impact on observations. This is shown in Figure 3(a) and (b). In addition, the effects of illumination in the field were analyzed from flat frames, shown in Figure 3 (c). Slight vignetting was observed in the CCD field (36x36mm), with the illumination of the field edge reaching 86% of the maximum illumination in the central region (vignetting of approximately 14%).

In terms of overall architecture, the system was able to operate the mount and camera, and the integration between the rotator and mount was achieved using the Optec Alt-Az Server, which functions as an intermediate driver. It was found that field dewarping in long exposures and the choice of a specific rotation for framing worked adequately in the tests performed.

3.2. Imaging

Due to weather conditions, it was only possible to operate the telescope fully on a few nights. Fully robotic operation was not yet possible, but operation by a remote observer and a technician at the observatory proved successful. Some test images were collected to verify the overall functioning of the telescope for imaging purposes. The target chosen was Omega Centauri (NGC 5139), observed without a filter ("clear"), with different exposures. The pointing was done automatically by the software, which allowed the object to be centered with an error of less than 1' (arc minute). The target was imaged with different exposure times, from 10s to 10 minutes. The results are shown in Figure 4. The 10-second exposure showed stars with good quality and no need for de-rotation. The image of the same field with a 1-minute exposure maintained good geometric quality of the stars, although an increase in FWHM was observed, probably explained by inaccuracies in the tracking of the mount. Finally, the tests with 10 minutes of exposure show the effectiveness of the rotator in derotating the field. First, a 10-minute exposure without derotation shows stellar elongation and demonstrates the critical need to reactivate the derotation module. Then, with the derotator activated, point stars with good quality are observed.

The results confirm that the telescope, despite its age, is fully capable of performing relevant observational applications, provided that automation is fully restored. It has not yet been possible to perform photometric observations to verify the accuracy and applicability of the telescope for this scientific case.

4. Discussion

Two main points stand out: the challenges of the integration process and the next steps planned with the robotization of the Obelix telescope. These topics are addressed sequentially.

The modernization faced a series of obstacles mainly related to the legacy nature of the equipment, including: discontinued software and drivers, often unavailable in official repositories; manufacturers that no longer exist, preventing formal support; incomplete or inaccessible component documentation. In addition, it was necessary to recover files through user forums and amateur astronomy communities, which sent the most up-to-date driver files for connecting the camera to the ASCOM platform (CloudyNights (2024)). In addition, there were some challenges for the correct functioning of the server responsible for field defeat, since the intermediate driver "alt-az server" proved necessary for the correct synchronization of the movement of the

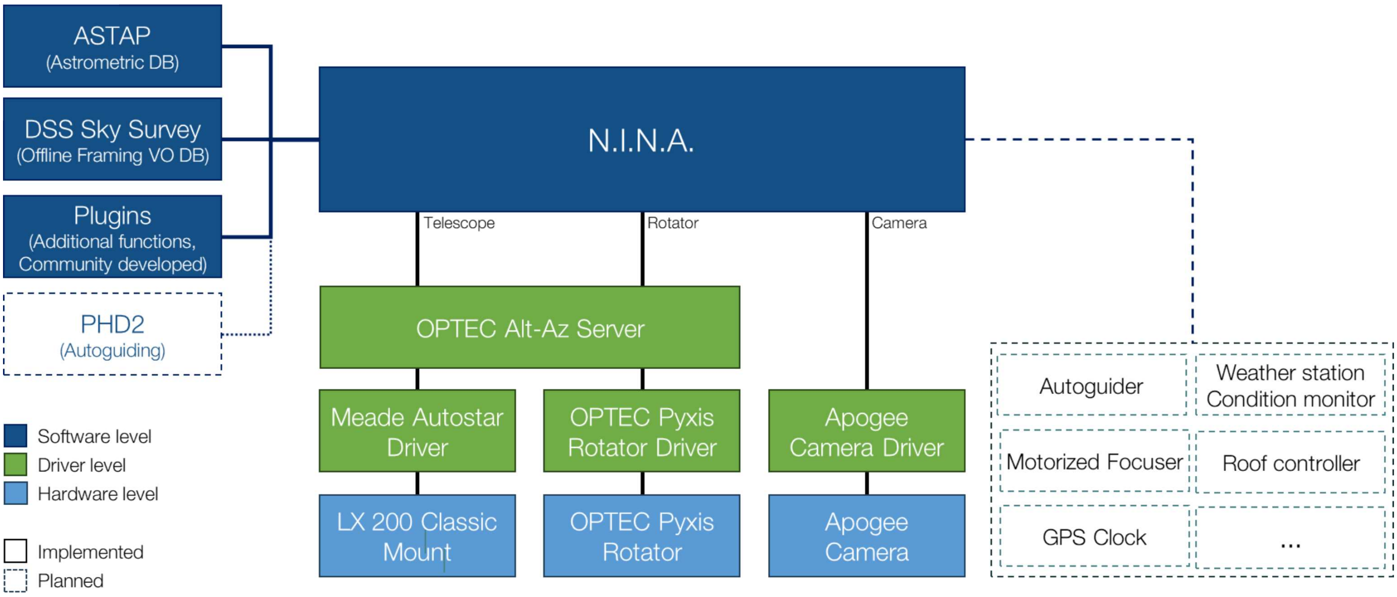

Figure 2. Overview of the hardware and software architecture for the Obelix Telescope.

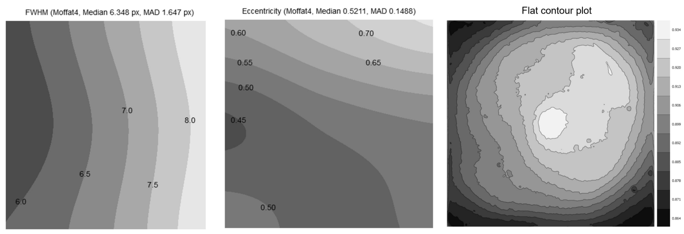

Figure 3. Instrumental characterization tests, including measurements of FWHM (a, left); eccentricity (b, center) of stars; and also a map of illumination contours from a flat-field image (c, right).

mount and the camera. In general, the historical recovery of the original system required manual reconstruction of parts of the software chain and iterative testing. A documentation file and user manual, including installation information, drivers, websites consulted, and sources, was prepared and became part of the Obelix document collection.

As next steps, the project will seek to further integrate Obelix with other components of the observatory, including the roof control system, which is not yet operational. The integration of a guidance system, autofocus, and GPS will expand Obelix's remote observation capabilities, moving it toward robotization.

We also intend to evaluate its photometric capabilities and explore observational programs: the observation of variable stars, the monitoring of exoplanet transits, as well as the obtaining of color-magnitude diagrams are some of the interesting scientific cases to be captured with the telescope. Such applications fulfill the dual objective of characterizing the telescope's performance and offering practical training to students in data acquisition and analysis. As future academic activities, we intend to use Obelix to offer extension activities that allow people from all over Brazil to make observations and use the telescope in undergraduate courses in the Bachelor of Astronomy program at USP.

In addition, the development of more comprehensive documentation should support the modernization of other legacy telescopes, an initiative that can benefit institutions with similar instruments. Additional improvements, such as the integration of complementary hardware and a motorized focuser, are also planned, with a view to achieving fully remote operation and strengthening its role in research, teaching, and extension activities.

5. Conclusion

The modernization of the Obelix Telescope demonstrates the value of revitalizing legacy instruments that remain technologically relevant but are limited by discontinued hardware and software. The work showed that integration with open solutions such as ASCOM and N.I.N.A. offers an effective and economically viable way to enable remote operation and expand the use of the instrument in research, teaching, and outreach. The challenges faced, especially the lack of documentation, old drivers, and unsupported components, reinforce the importance of preserving technical information on legacy equipment. Advances in architecture development and initial testing have allowed the Obelix telescope to be returned to operational status for observations. The next steps include the integration of other components for automation, as well as conducting more successful observations. In addition, it is hoped to explore the potential of Obelix for teaching and outreach activities, including its use for photometry, planetary transits, and training students in observational astronomy.

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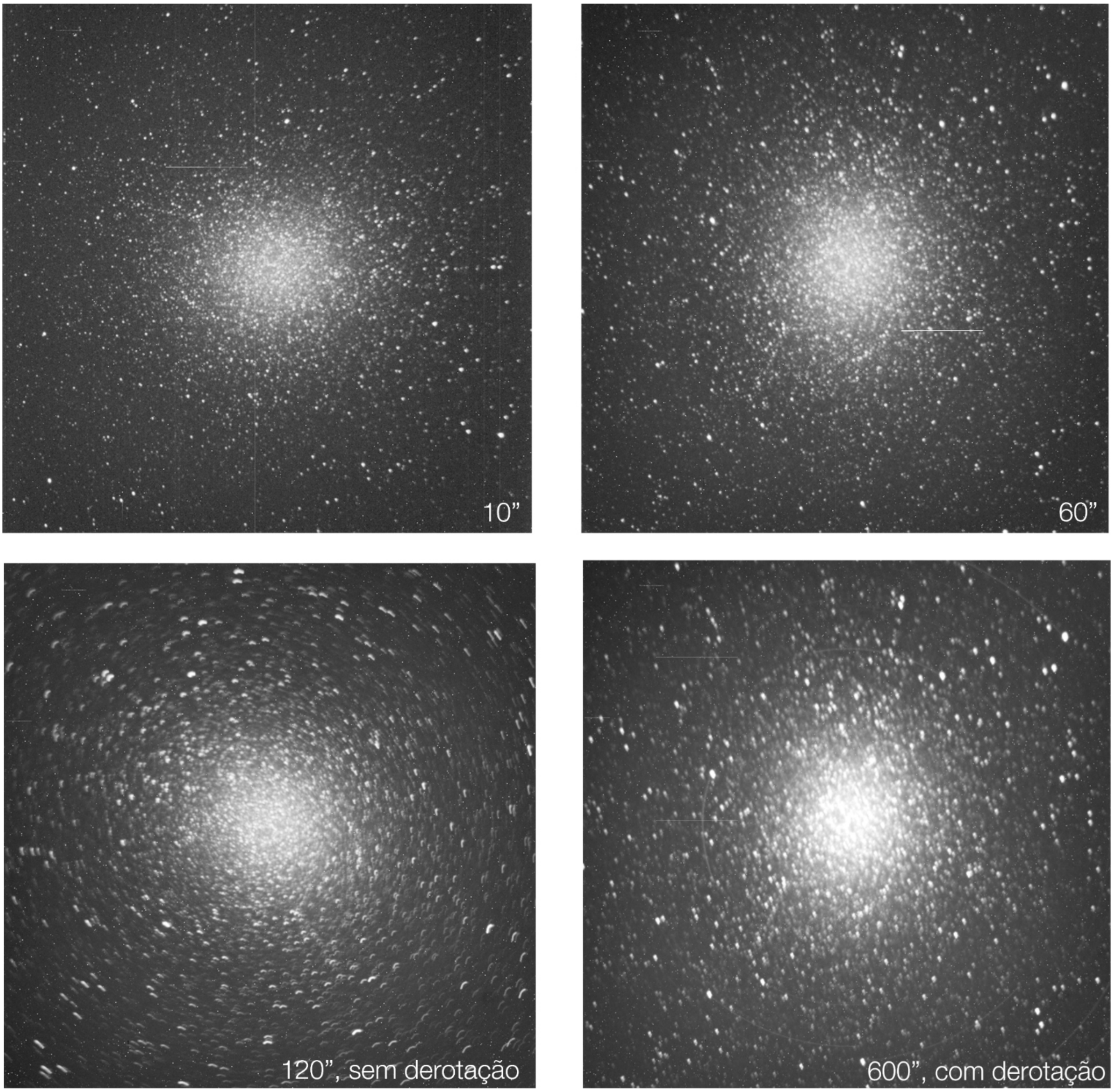

Figure 4. Test images captured. They show the Omega Centauri globular cluster (NGC 5139), with different exposure times.