Applying augmented reality to historical telescopes images: the IMAGO project

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ABSTRACT

The IMAGO (IMAGer with mOdified eyepiece) project is finalized to the realization of a prototype for the application of Augmented Reality to what can be normally seen when putting the eye at an historical telescope. The main motivation for such a system is to offer an innovative experience to the public, who can be quite unimpressed after a first glimpse through a telescope, especially under bad seeing conditions, thus increasing their interest in astronomy and possibly revitalizing those telescopes, no longer suitable for scientific purposes but still impressive and evocative. The idea behind IMAGO, the IMAGO prototype design and possible future developments are here described.

Keywords: Augmented reality, historical telescopes, eyepiece

1. INTRODUCTION

The idea behind IMAGO (IMAGer with mOdified eyepiece) originates from two main needs often raising during the observations carried out through historical telescopes: the need to observe even in bad seeing conditions and the need to satisfy the public's growing expectations. We identified the use of Augmented Reality[1] (AR) as an effective solution to enhance the planetary images provided by a certain class of telescopes, through a modern eyepiece, able to display also digital contents, so that the observer can experience a gradually improving resolution and eventually appreciate finer details of the planet surface. Therefore, we have designed a prototype to prove the feasibility of the concept, based on some simple requirements, among which: easy mounting to the telescope exit focal plane, adaptability to a certain class of telescopes used for didactic purposes, compactness and portability. The main goals of the project are: using AR for teaching and dissemination, capturing the attention of increasingly larger audiences, giving a second life to many historical telescopes (no longer suitable for scientific purposes but still impressive and evocative). The idea behind IMAGO, the IMAGO prototype design (still ongoing) and possible future enhancements are here described, as well as some of the main challenges connected to the prototype development: the production and management of the AR contents, the design of a compact, portable and user-friendly system.

2. PROTOTYPE DEVELOPMENT

A conceptual design has been developed considering the optical and mechanical characteristics of the Cooke & Sons Refractor telescope, located in the Teramo Observatory. Figure 1 shows the cad model of this historical telescope (with a brief description of its main optical features) and the conceptual cad model of IMAGO mounted on its focal plane. All the devices that are part of IMAGO are commercial components, while the mechanical parts (interface with the telescope, camera mount, case) will be designed and built in house. In general, all the devices are required to be light and compact, because they will be enclosed in a single box (case) cantilever mounted onto the telescope focal plane flange.

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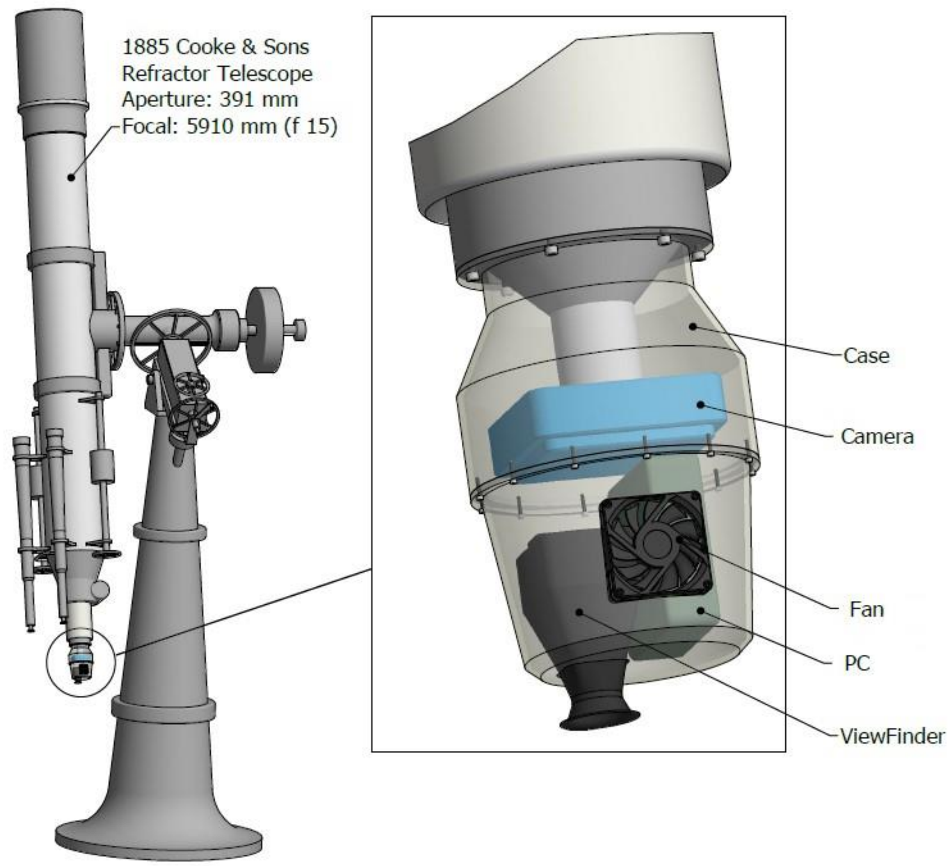

Figure 1. CAD model of the historical Cooke & Sons Refractor Telescope located in Teramo Observatory, with a view of the conceptual cad model of IMAGO, mounted on the telescope exit focal plane flange (with its main components).

2.1 Hardware

The IMAGO hardware (Figure 2) consist of three key devices: Camera, Viewfinder, PC.

The camera, mounted in correspondence of the telescope focal plane, is used for real-time acquisition of astronomical images. The main requirements are: suitability for planetary imaging, compactness and lightness, low-noise, low-cost, 12x12 mm of chip size as minimum, USB 3.0 connection. The chosen model is the CMOS camera *ASI294MC Pro* from ZWO.

The Viewfinder, used in place of a traditional telescope eyepiece, is composed of a high-resolution display and a lens system with an eyepiece that enlarges the display offering a wide field rendering of the camera output, including the additional multimedia contents. The main requirements are: compactness and lightness, HDMI input interface, Full HD resolution, low power consumption. The chosen model is *ACT EVF Pro* from ZACUTO.

The PC, needed to process the acquired images and to manage and reproduce AR contents in real-time, sends both real images and elaborated ones to the Viewfinder. The main requirements are: high graphic, processing and storing capabilities, compactness and lightness, HDMI connection, WiFi connection, USB 3.0 connection. The chosen model is *HX80G* from MINISFORUM.

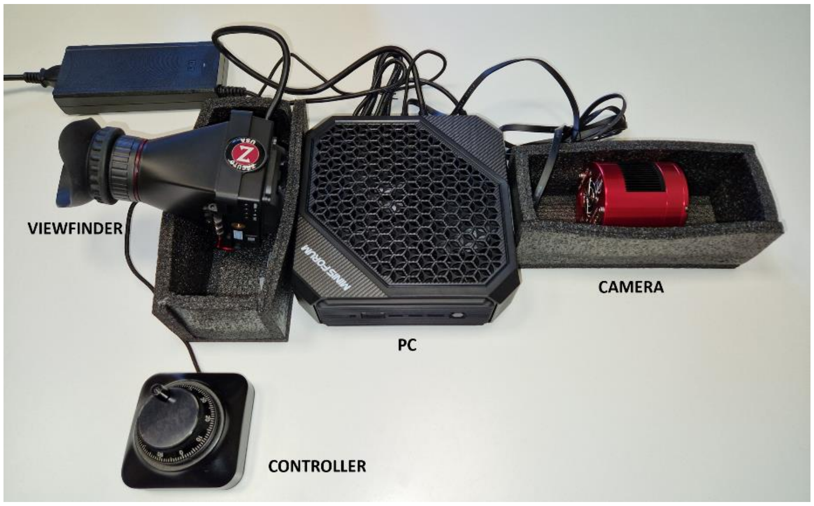

Figure 2. Main components of the IMAGO prototype, connected for the preliminary system test.

Figure 3. The CMOS camera mounted onto the telescope focal plane of the Cooke telescope for the acquisition of Mars' and Jupiter's images (an optical adapter is placed between the camera and the focal plane to test different magnifications).

2.2 Software

The software development is the key part of IMAGO. The quality of AR multimedia contents and graphic interface drives the quality of the whole system. The development of both AR contents and user interface has been challenging and required the support of the specialized company ACKAGI Visual Arts[2].

The initial work carried out for Mars consisted in the creation of a video which simulates a zoom on a point of the input image, starting from images of the planet acquired with the Cooke & Sons telescope through the CMOS camera (Figure 3). The work, based on *OpenCV* Python library[3] on UBUNTU Operating System, foresees a complex pipeline architecture, needed to modify the input coming from the telescope.

After the initial step finalized to the input image transition and adaptation, the following steps were followed (Figure 4):

1) Acquisition of medium resolution images from *Google Mars*: acquisition of images in the equatorial area (maximum magnification) and in the polar areas (medium magnification) and organization of a mosaic of 30000x30000 pixels.

2) Mapping: the defined texture was mapped onto a 3D sphere, obtaining a mosaic render of four images of 15000x15000 pixels each.

3) Close-up image acquisitions from *Jmars* software: for the final phase of the approach to the planet's surface, a second mosaic of the Mount Olympus area was created, with a resolution of 20194x13034 pixels.

4) Color correction: a chromatic transition was realized, starting from the initial telescope image and ending with a reference image taken from the planet's surface.

5) Animation: the three images generated in first three steps were imported and registered as 3D layers in the compositing software and the movement programmed by linearizing the motion perception, then the images have been blurred, dissolved and masked together to obtain the illusion of a continuous motion.

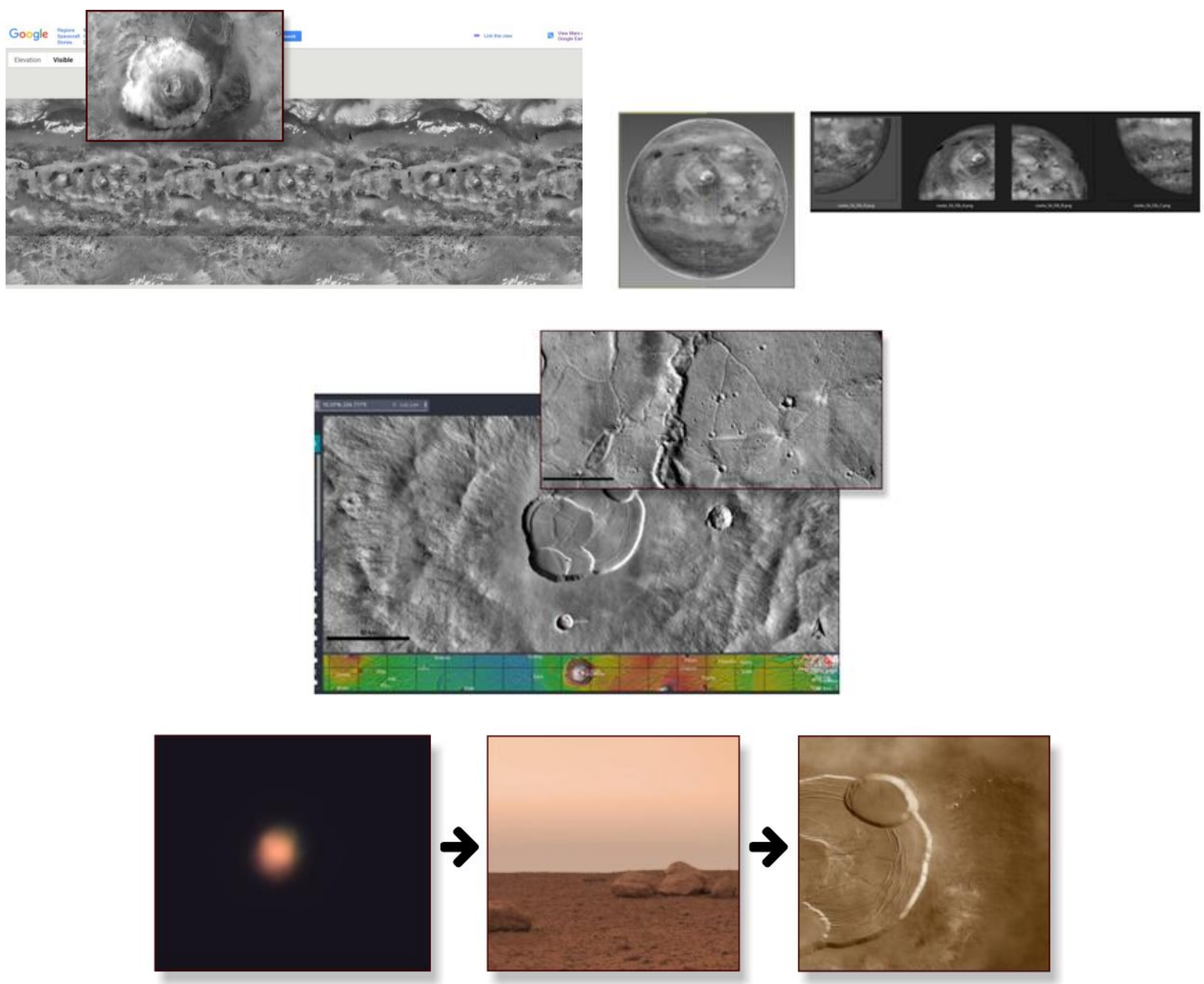

Figure 4. The different steps followed for the creation of the AR content for Mars: acquisition of images from *Google Mars* (top left), mapping (top right), acquisition of images from *Jmars* software (mid), color correction and animation (bottom).

Similarly, a second (upgraded) AR content was created for Jupiter. In this case a real-time compositing between images at different zoom levels, appropriately masked, has been introduced to improve the motion smoothness. As schematically shown in Figure 5, the sequence of image calibration and zoom is managed by a knob-controller (interfaced with the PC via USB), based on a timeline driven by the USB controller, that provides information about the knob speed and direction of rotation (for positive speed the timeline moves forward, otherwise it moves backwards).
For both the planets, the user can manage the zoom level through the controller, but does not directly control the transition between real image and digital content, happening at a pre-defined zoom level.

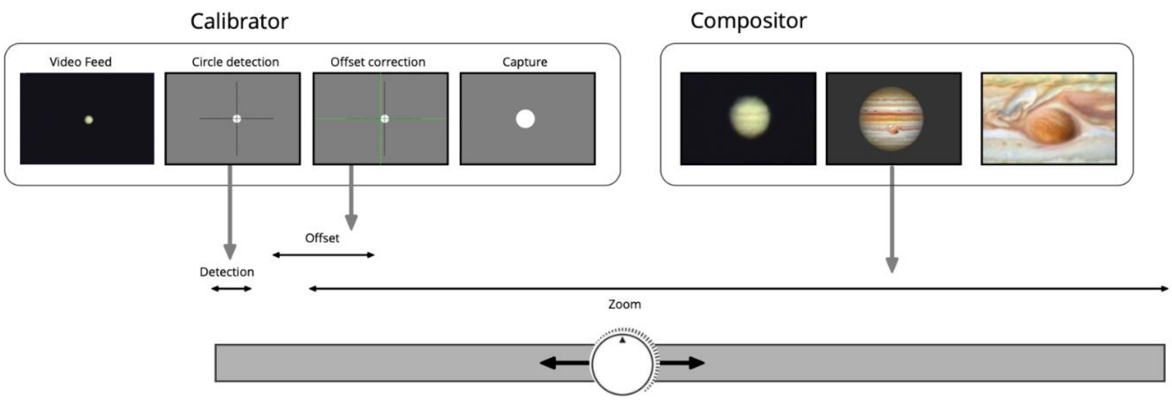

Figure 5. Conceptual scheme of the zoom level control introduced in the development of the Jupiter AR content.

The IMAGO graphic interface (Figure 6), is designed to be smooth and flexible. In this preliminary interface, before starting the observation, the user can choose for each of the two planets between LIVE and BLIND session. The first represents the primary use of IMAGO, with the real-time image coming from the telescope and the transition to the AR content managed through the controller, while the second shows on the display a recorded shot of the selected planet (a useful option in case of bad weather conditions, daytime visits, or in case of technical acquisition problems). The user can also choose whether to use the knob-controller or the mouse wheel and can manage the controller parameters.

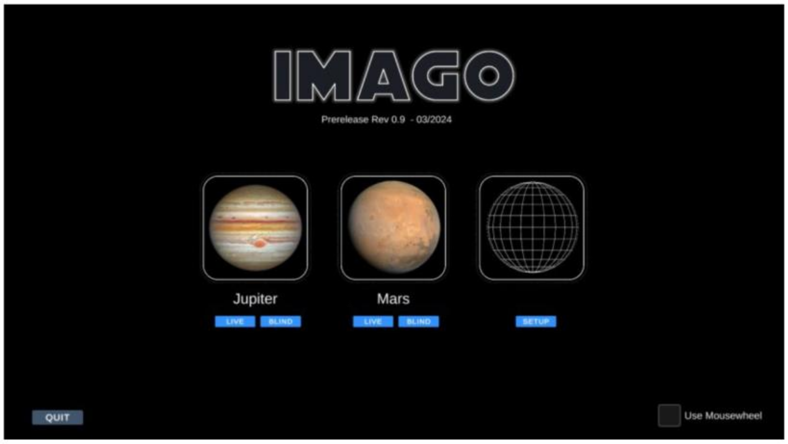

Figure 6. IMAGO preliminary user interface.

3. FUTURE PERSPECTIVES

IMAGO has the potential for further future developments, aimed at creating a flexible platform in which other planets to explore can be added, new features implemented and alternative solutions in terms of sensors, video acquisition and projection can be tested. Moreover, although the prototype development was based on the optical interface of the Cooke telescope, IMAGO is conceived to adapt to a wider range of telescopes. This requires the implementation of an optical adapter (for example a commercial telecentric objective with variable magnification), to fit different telescopes f-ratios and preserve the pixel scale on the camera, and, as a consequence, an accurate opto-mechanical design, because both adapter and camera positions shall be adjustable according to the telescope optical characteristics. The system portability is another key aspect to consider in this framework, with both size and weight to keep under control during the design phase. A possible IMAGO 2.0 concept is shown in Figure 7.

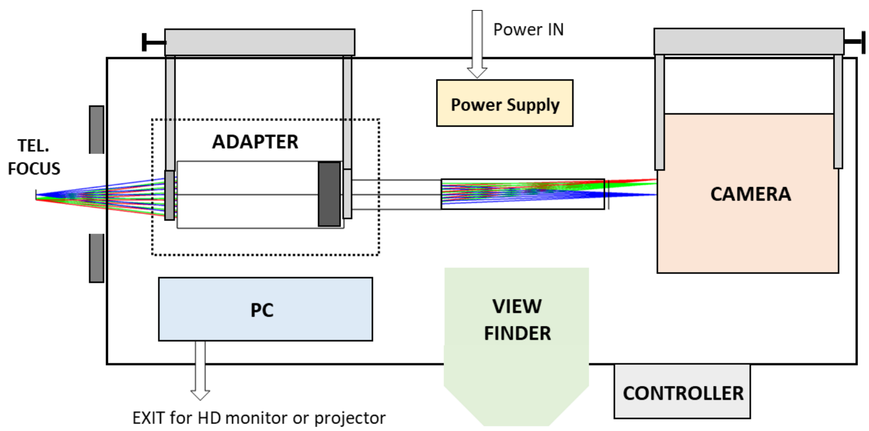

Figure 7. Conceptual scheme of IMAGO 2.0, with the optical adapter needed to fit different telescopes f-ratios.

4. CONCLUSION

The IMAGO prototype has been implemented and positively tested with preliminary AR contents. All the system components will be enclosed in a case, equipped with a standard mechanical interface, adaptable to different telescopes. The system could be furtherly developed to become a flexible platform, suitable to different telescopes, with more AR contents and functionalities.

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REFERENCES

[1] Hsin-Kai Wu, "Current status, opportunities and challenges of augmented reality in education", Computers & Education, Vol. 62, 41-49 (2013)
[2] www.ackagi.com
[3] www.opencv.org