A 3D PRINTED F5 NEWTONIAN TELESCOPE: DEVELOPMENT OF A STUDENT PROJECT FOR OUTREACH, EDUCATION, AND DISSEMINATION

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ABSTRACT

An Engineering student´s Final Degree Project based on the design and manufacturing of a 3D printed telescope is presented. The project involves both optical, mechanical, and electronic design, the construction of the instrument, and the numerical and experimental analysis of the prototype. Furthermore, the project explores the possibilities offered by the current 3D printed technologies for the manufacturing of telescopes that may be used both for teaching and disseminating Astronomy and the basis on how to build such instruments.

In this communication the current development of a student Final's Degree Project, consisting of the design and construction of a 3D printed Newtonian telescope, is presented. Both the project and the learning experience are shown as an example of the possibilities of this kind of study at the final stages of the academic formation of engineers, and the possibilities for outreach, education and dissemination of both science and engineering are explored.

1 INTRODUCTION

1.1 3D printing technologies

Since early 2000's, 3D printing technologies, which were originally introduced in early 80's [1], have done nothing less than keep expanding through the globe and becoming key in technological developments in fields such as medicine, fabrication methods or even in the aerospace industry with the design and fabrication of new rockets with many of its components 3D printed.

As an example, a recent work [2] has shown the possibilities of the practical implementation of 3D print optomechanical hardware with high-performance rates and with a cost much lower than if conventional commercial hardware was bought. This reference is an illustrative example (among many others) on how 3D printing technologies can be a game-changer in research and development in many areas of the optical industry.

1.2 Amateur Astronomy

Amateur Astronomy is a field in which different technical skills and needs converge. The amateur astronomical community is formed by thousands of motivated people that want to know more about the Cosmos and to transmit that knowledge to the public. Furthermore, a huge fraction of that community is also interested in do-it-yourself projects, such are specific arrangements and adaptations for the cameras used in astrophotography, among others.

The basic tool for amateur astronomers is the telescope. Telescopes are optical instruments that, in the context of amateur Astronomy, can be divided into three types: refractors, reflectors and catadioptrics [3].

Refractors ara based on the use of refracting elements (lenses). Despite there are several configurations and designs available, the main basic design for this type of telescope is the so-called Keplerian telescope, which is compound by two positive (i.e, converging) lenses (the objective and the eyepiece), and it is the principal design used nowadays (despite optical corrections such as the use of achromatic doublets or inverters for the case of terrestrial telescopes). Another common design is the Galilean telescope, which uses a negative (divergent) lens as eyepiece.

On the other hand, reflecting telescopes are based on reflection law instead of refraction. The objective is in that case, a mirror (the so-called primary mirror). Parallel beams of light enter the tube by the top opening and travel through the whole telescope until they reach the bottom, where a parabolic (or spherical) mirror reflects the light to a secondary mirror mounted on the spider at the top of the telescope. This secondary mirror reflects light to the eyepiece. One of the most popular designs of reflecting telescopes used by amateurs is the Newtonian telescope.

Finally, catadioptric telescopes are a combination of the characteristics of both refractors and reflectors, combining the benefits of the two approaches in order to obtain better images.

2 METHODOLOGY

2.1 Design and development of the telescope protoype

Considering the different commercial configurations used by the amateur community, and the commercially available low-cost optical components, a Newtonian configuration was chosen for that project.

The optical specification of the design is a F5 Newtonian telescope. The aperture of the instrument os 6 inches (152 mm) and the focal length of 760 mm.

For the mechanical design, a CAD software (SolidWorks) was used. Several iterations were done for the design and development of the components and a numerical analysis (by enas of finite-element analysis, FEM) has been carried on.

Figure 1 shows a view of the final CAD design.

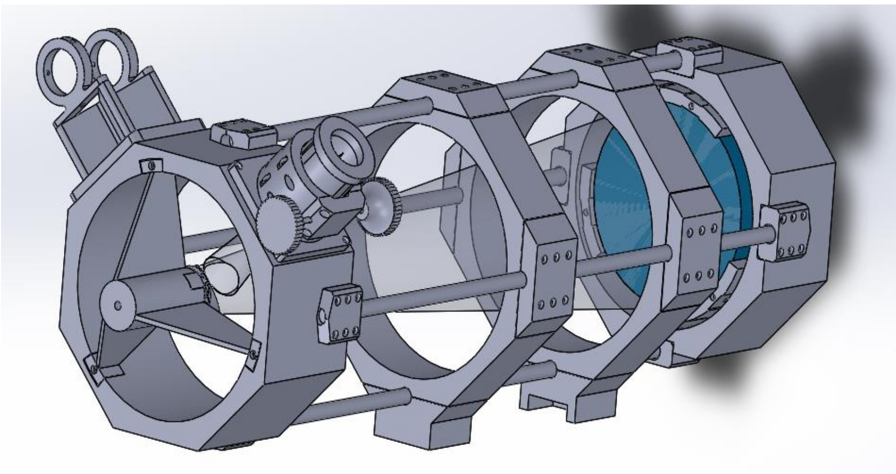

Fig. 1. Telescope design CAD. The shadowed surface represent the light-cone inside the optical path.

Despite the optical components (mirrors and eyepiece) and some aluminium and other metals parts (such as the bars), the instrument is fully manufactured with 3D printed components using PLA.

A wavefront analysis is going to be implemented in the next months for evaluation of the laboratory optical performance of the telescope, and the mechanical performance and stability of the instrument would be tested. Preliminar field observations had been done, as shown in the third section of this work.

2.2 Activities

The final objective of this project would be to present a free kit, which will cover the following topics:

- Building your telescope: a 3D printing workshop. A full workshop based on the basic development of the Final Degree Project presented in this configuration. The 3D files and an assembly annual will be available for students and motivated individuals to build their own 3D printed telescope.
- Fundamentals of telescope optics. A basic course of optical principles (refraction and reflection), telescopes and Astronomy, with experiments and experiences using 3D printed components.
- Hands-on activity: astronomical observation. The telescope would be used either as a demonstrator in fairs or schools, or to perform educational public observations.

At the time this short paper is written, the different tool-kits and manuals are being developed, and the implementation of this different activities has been scheduled for next months.

3 RESULTS

A final prototype has been built ensuring each piece was correctly printed and all the components fits precisely without any critical load. The final assembly is shown in Figure 2.

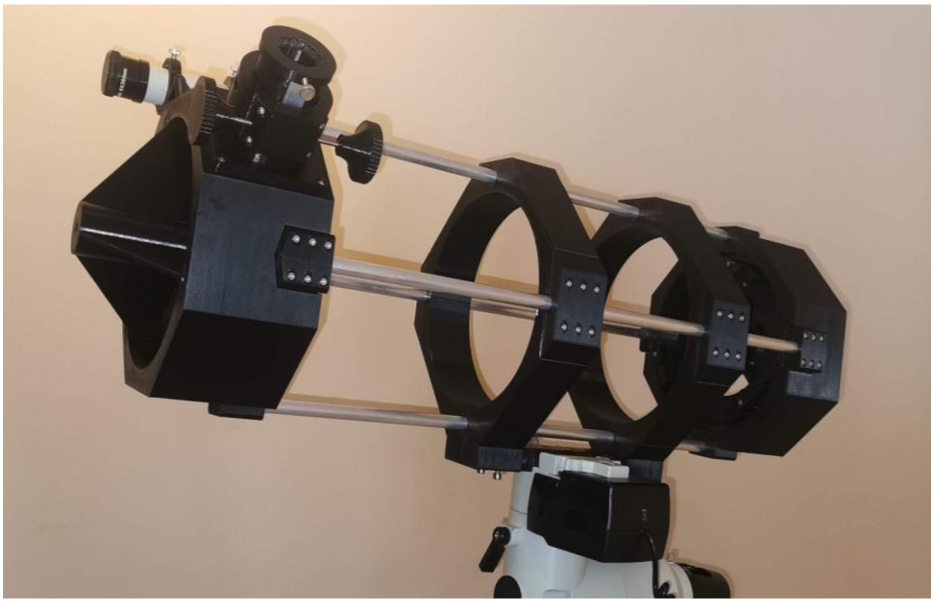

Fig. 2. Final assembly of the 3D printed telescope.

In order to test the capabilities of the designed instrument, an equivalent commercial system was borrowed to the COSMOS Mataró amateur astronomical association. The first test comparison is shown in Figure 3. Authors are currently waiting for an optimal observation night, to obtain full results of the telescope's real resolution and capabilities.

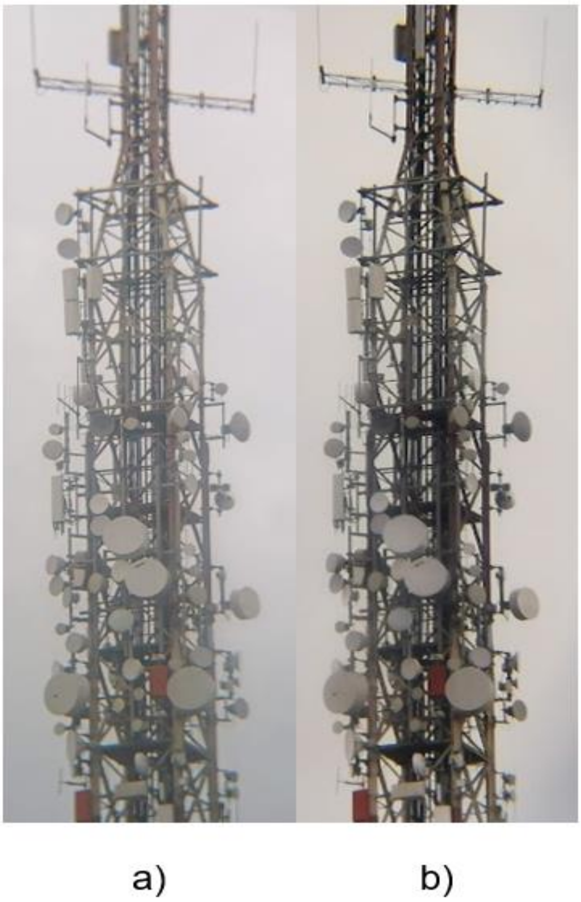

Fig. 3. Image of a telecommunication tower obtained with the Meade LXD75 telescope (a)) from COSMOS Mataró, and with the 3D printed F5 Newtonian (b)). Both images were obtained using the same equatorial mount.

4 SUMMARY AND ACKNOWLEDGMENTS

This work presents an engineering Final Degree Project based on the deign and manufacturing of a 3D printed telescope for educational purposes. A set of tool-kits and experiences using and working with such instrument are defined and will be implemented in the months after the SEFI conference.

Authors acknowledge their University and the COSMOS Mataró association for the possibility of develop such project. The corresponding author also wants to thank his family and friends, especially his parents, brother and uncle, who had inspired and encourage him to become a greater engineer.

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