Mem. S.A.It. Vol. 96, 87

Memorie della

Developement of a virtual tour for the Astronomy Science Museum at INAF OAR

M.T. Menna[1], R. Leoni[1] and F. D'Alessio[1]

Istituto Nazionale di Astrofisica – Osservatorio Astronomico di Roma, via Frascati 33, Monte Porzio Catone, 00078, Italy e-mail: `maria.menna@inaf.it`

Received: 21-10-2024; Accepted: 18-01-2025

Abstract. A Virtual Tour (VT) is a guided tour of a facility implemented through Virtual Reality (VR) technology. The focus of this paper is on VT in an educational context. We examine the advantages of acquiring the expertise and the skills to develop a VT *in house* and report our experience in creating a VT for the *Astrolab*, the science museum at the Astronomical Observatory of Rome in Monte Porzio Catone. We describe how to implement a Virtual Tour for educational purposes, from planning, image acquisition techniques, content creation and finally sharing and distribution.

Key words. Virtual reality, virtual tour, education experiences, facilities, technology.

1. Introduction

A Virtual Tour is a way of simulating a real location using videos or still images. Additional multimedia elements, such as video, text, or sound can also be included. VTs are now widely used to display a variety of environments, university facilities, industrial environments and laboratories, just to name a few. These tours can be used in several ways. On one hand, they offer the possibility of exploring places that, for various reason, could be difficult to access. On the other hand, for educational purposes, they can provide additional informative material. Moreover, VTs can provide a preview of what to expect in case of a visit in person (Rohizan et al., 2019). Certainly, physical travel and in-person experiences are a great educational tool. In our case, we offer educational tours of the site of the Astronomical Observatory of Rome, where both historical material, such as telescopes and scientific instruments from the collections of the Collegio Romano and Osservatorio del Campidoglio, are on display, and the *Astrolab*, a modern science museum, can be visited. A virtual tour of our facilities can be useful for teachers in making a better informed decision when evaluating a field trip for a class of students. Alternatively, in case a field trip would not be feasible for any reason, cost, logistics, etc., the virtual tour can be used to introduce the students to an experience through a medium that is both familiar and appealing to them.

There are different types of Virtual Tours. Specifically:

a) Video Tours, which are prerecorded videos that take users through a location. They often include a narrator or text to explain what is being shown, offering a clear and organized experience, similar to a guided tour in real life.

b) 360-degree virtual tours that allow users to see a location from all angles, creating an immersive experience. Users can interact with the tour by clicking and dragging a pointer to look around, giving them the feeling of exploring the space as if they were actually there.

c) Still photo tours, made up of a series of high-quality images showing different parts of a location. Users can move through the images at their own speed, allowing them to focus on specific areas and details within the space.

A VT of the main building was already implemented at the beginning of the COVID-19 pandemic, however, the *Astrolab* wasm not included, as at that moment, the structure was closed to the public. With the public visits resuming, we decided to include the *Astrolab* in the existing VT. We chose to focus on 360-degree panoramic tours. Additionally, we opted to acquire the necessary equipment and develop the expertise in-house rather than purchasing a ready to use package. The advantages are principally in terms of flexibility, being able to modify, add new areas or remove outdated content as needed.

Table 1. List Virtual tour software

Software	description
Pano2VR	Pano2VR is a powerful virtual tour software that converts your panoramic or 360° photos and videos into interactive experiences
HoloBuilder	Capture, view, and control project progress with 360° photos, enabling teams to stay on schedule and on budget
Mozilla Hubs	Online communities with a fully open-source virtual world platform
Cupix	Deliver 3D digital twin platform to builders and owners
Virtual Tour PRO, 3D Vista	Create interactive 360º virtual tours in the easiest and most pleasant way: 360º views (panoramas), 360º videos, embedded sounds, videos and photos, floor plans, and fully customizable frames

2. Virtual Tour design

The first step is the careful planning of the environment in which we wish to introduce the visitor. In a VT based on panoramic images, it is essential to design it with tan adequate number of images to provide a realistic sense of the place without causing confusing. Another crucial aspect is the message we wish to convey. In the case of the main building VT, we wanted to deliver informative material, so it was designed to optimize the positioning of the *hotspots*, that is the objects with which the visitor can interact and access video, audio, or text by clicking the mouse. In the case of the *Astrolab*, the intent was more to serve as a teaser, showing what to expect during an in-person visit. When creating a VT, several methods can be used to create 360° panoramic images. We considered VR360 cameras, now available from several makers, which surely have the advantage of ease of use and quick results, as they produce a complete sphere or 360° image in one take. However, this option was not feasible because these cameras perform best in open sunlit environments, whereas we have a variety of settings, from outdoor spaces to poorly lit indoor areas, where their performance is usually quite poor. Thus, we opted for a DSLR with a panoramic head.

2.1. Photography

The advantage of using a full-frame DSLR (or a mirrorless camera) is the ability to obtain much higher-quality images, as these cameras

Fig. 1. Sample fisheye image
The atrium of the Astronomical Observatory of Rome in Monte Porzio Catone taken with a circular fisheye

offer complete control over the shooting parameters, such as exposure and depth of field. Additionally, they allow shooting in an uncompressed RAW format, which can be subsequently developed using software such as Lightroom and Photoshop (Allenet al., 2011). In addition to a DSLR camera, a circular fisheye lens and a tripod with a panoramic head are required.

2.2. Software

A fisheye lens is an ultra wide-angle lens that produces strong visual distortion (Kingslater, 1989). In the case of a circular fisheye, the image circle is inscribed in the sensor area see Figure 1

With a 180° field of view, it is of course necessary to take more than one photograph

Fig. 2. Panoramic head
Shown in red rotation around the nodal point and with black arrows backward and forward movement to find the no parallax point.

to reconstruct a spherical image. In principle two images are the essential minimum, but the stitching software that joins the images together, works by overlapping control points, so four to eight images (depending on the scenery) is an ideal range. In order to properly join the images, we must avoid parallax shift between them. A panoramic head (see Figure 2) is particular kind of tripod head that allows the camera to rotate around the lens's no-parallax point (also improperly called as nodal point).

This special no-parallax point is the center of the lens's entrance pupil. It is typically

Fig. 3. Equirectangualr projection
A series of spherical photos of the atrium of the Astronomical Observatory of Rome in Monte Porzio Catone taken with a circular fisheye and reconstructed equirectangualar projection.

found by trial and error, adjusting the rotation point so that foreground and background points remain aligned. It is then possible to reconstruct a spherical image in equirectangular projection as in Figure 3. The procedure involves setting the camera on the tripod with the panoramic head and selecting a scene with an object very close to the camera and a faraway panorama feature. Ideally, the greater the distance the better – for example, a tree in the foreground and distant mountain in the background. We first align the two objects at the center of the lens's field of view, then we check that they remain aligned at both the far left and far right of the lens's field of view. If this is not the case, we have to move the camera forward or backward in small increments (see Figure 2).

As we mentioned above (see section 2.1), to reconstruct the equirectangular projection we need stitching software. There are several options available, both open-source and commercial see table 1 adapted from (Cardona et al., 2025)

We chose to implement the PTGui software for its ease of use and versatility. The software relies on control points: in pairs of photos, it automatically detects common points and proceeds to reconstruct the entire image see Figure 4

Of course, the program's success depends on the type of image. In the example shown in Figure 4, there are many easily identifiable common points. However, in rooms with fewer features, the situation is different and requires taking more photos to achieve a seamless reconstruction.

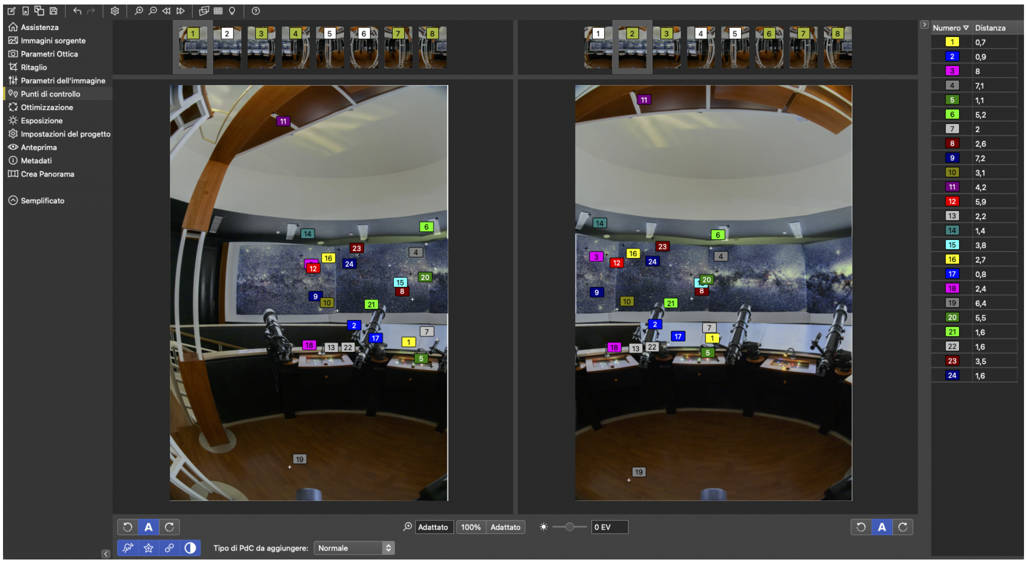

Fig. 4. PTGui stitching example

3. Conclusions

For the *Astrolab* VT, we used eight 360° panoramic views. As it is an interactive "touch and try" type of museum, we chose not to include hotspots, but rather a general description to give visitors a feeling of the place. It would be meaningless to describe each individual exhibit or to explain the broad themes covered in the museum, such as the solar system, the galaxy, stellar evolution, and so forth. The entire Virtual tour of the Astronomical Observatory of Rome can be viewed in the DivA (Divulgazione Astronomica) website at the address `https://diva.oa-roma.inaf.it/nuovo_Tour_Virtuale_2024/index.htm`.

Our future plans include acquiring a number of VR headsets to display the virtual tour in a more immersive way. This requires no further elaboration of the product, as it is already VR-ready in its actual form. The advantage of VR headsets is that they can be used at science fairs and other public engagement events outside our facilities. This will allow us to engage the public more fully through VR technology. As potential future developments, we envision adding a gaming element to the virtual tours (Ding et al., 2023), where users can interact more deeply, for example, by participating in a quiz or a treasure hunt within the virtual environment.

References

Allen, E., Triantaphillidou, S., 2011, The Manual of Photography. Taylor & Francis. ISBN 978-0-240-52037-7

Cardona, H., Lara-Alvarez, C., Parra-González, E.F., Villalba-Condori, K., 2023, TEM Journal. Volume 12, Issue 3, pages 1725-1731, ISSN 2217-8309, DOI: 10.18421/TEM123-55

Ding, H., Zheng, Y., Li, H., 2023, Research on the Application of VR in Education and Gaming. Applied and Computational Engineering, 8, 530-535.

Kingslater, R., 1999, A History of the Photographic Lens. San Diego Academic Press. ISBN 0-12-408640-3.

Rohizan, R.B., Vistro, D.M., Puasa, M.R., 2019, Journal of Physics: Conference Series, 1228(1) https:/doi.org/10.1088/1742-6596/1228/1/012067