HOLOGRAPHIC VISIONS FOR ARCHITECTURE IN A PARK

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ABSTRACT:

The Monza Park, with its more than 7 square meters of green area, divided between lawn and woods, its 110,000 tall trees, its 13 farmhouses, 3 historic villas, 13 m of fences and 90,000 visitors on spring Sundays, represents an irreplaceable source of wellness and sustainability for those who live near it. The pandemic situation of the 20s and 21s by reducing the movements and the possibility of coexistence of a large public in an open space has suggested the possibility of new forms of use and interaction of the same, even remotely, reproducing accurate Virtual Reality experiences. With this paper, the authors intend to illustrate a workflow from Scan to VR applications, taking advantage of the opportunity to explore digital acquisitions and additional materials available and functional to convey the values of open space and historical monuments immersed in them. The VR experiences have been structured for the navigation from the scale of architectural detail to the environmental one, with the goal of using the accurate model results for two different and remote instrumentations: a 7m diameter 360° theatre and a Holographic table, Euclideon Hologram Table©. Both situations, as opposed to hardware tools such as headset, favour the fruition for small groups of users.

1. INTRODUCTION

Due to difficulties of transmission of data and details linked to the digital object, part of the complex BIM based system, developers struggle to find user-friendly applications; accomplices of this difficulty are the continuous updates of proprietary software, the size of the files and the amount of data to be processed in relation to the hardware equipment, the still complex management of interoperability, the peculiarity of the digital model referred to the existing. The association of information to an architectural model or the detailed texture in Cultural Heritage field is a phenomenon that increasingly makes use of web-based platforms as they generally represent the most interoperable system for data exchange. This research tests a case of a large-scale digital model, formed by monumental buildings spread in a park, developing a customized workflow for the interfaces provided both for the Round Theatre for Immersive Visualization and for the Unlimited Detail technology (Euclideon, 2013) used in Euclideon Hologram Table© for Holographic Visualization. The aim is to visualize the best quality of the models in the two environment having interaction possibilities.

The research question is

- to verify the real possibility to use Mesh models couped to GIS models in the two environments.
- to visualize fine texture of the models in the two environments with reproduction of colours and materials with a high quality detail
- to be able to display information automatically in an - accurate scale- or, on the contrary, adding them directly in the environment provided by the table, using the visualization as the real work environment

2. RELATED WORKS

This paper is part of a research activity developed to explore holographic visualization techniques at the table Euclideon Hologram Table© (Bolognesi et al. 2021). Before these experimentations several holographic visualization techniques have taken strength from research activities carried out of Architectural research, mainly in the medical field through augmented reality environment utilizing holography (Brune et al., 2019, Desselle et al., 2020) or similar techniques and they are part of literature. Some researchers have investigated to understand the mathematical and optical rules that support holograms work (Makey et al. 2019). Recent studies have been developed to coupe the two environments (Pepe et al.,2021) such as buildings and ground, BIM software and GIS, (Barazzetti, 2021) have explored and used in many platforms as well (Virtanen, 2020). The structure of the workflows is always specialized according to the finalities (Teruggi, 2021); and in the discussed case the finality is clearly the accurate visualization for multi users. From this point of view, the literature on the accuracy of virtual reality is not yet consolidated and often refers to worlds related to edugame if not to gaming itself. While it is an important and debated themes that concerns the definition of the surveyed model and the accuracy of the mapped surfaces (Lo Turco et al. 2017) where themes regarding visualization of the texture of Cultural Heritage architecture are deepened, becoming the discriminating factor between an accurate survey and not (Calcerano, 2021).

3. DEVELOPED METHODOLOGY

3.1 The ground

The deliverable of the research grows from the need to integrate architectural objects surveyed with laser techniques and photogrammetric activities at a scale of 1:50 in a park for the best visualization workflow; the ground where the architectures are supported is described or by an existing cartography or incidental surveys acquired from scans when the building survey was carried out. The land looks excessively wooded and full of obstacles, it does not facilitate surveying of a ground surface with normal lasers. The methodology undertaken has preliminarily considered the issue of integrating the architecture survey, i.e., the point clouds obtained from the digital survey, into a cartographic database acquired from the regional Open Data portal in the .shp format. But the accuracy of the digital survey, carried out with RTC360 Laser scanner and tested on buildings

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within the park at a scale of 1:50 resolution, has been first integrated within the only digital db available of the park that is a 1:2000 map. No topographic network reconstruction was used to verify the feasibility of integrating the architectural survey on existing cartographic tools but digital tools. First workflow: the .shp file already existing in the regional db was imported into the open-source software QGIS to verify the effective presence of the information linked to the altimetrical quotas and subsequently exported in .dxf format while the field "QUOTA", present in the attributes table, has been exported in delimited text format .CSV. The objective was to assign to each point the relative height to develop a faithful three-dimensional terrain modelling. The point - elevation association was carried out using Grasshopper software. The .dxf file relative to the points was imported into Rhino and then into Grasshopper (Fig.1) through "Point, set multiple points" while the .CSV file through "Read file". The dimension, present in the .CSV text file, was assigned to the Z component of the points through "Construct point".

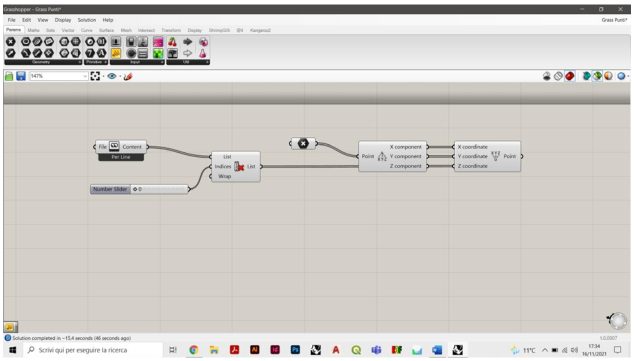

Figure 1: import of the 3 coordinates of each point of the park into Grasshopper environment.

The points where then imported in a modeler software, Rhino to be modelled through the Patch command. By selecting the area of points of interest, the Patch command generates a surface interpolating the selected points. The U-Subdivisions and V-Subdivisions indicate the number of subdivisions in both directions for the automatically generated surface.

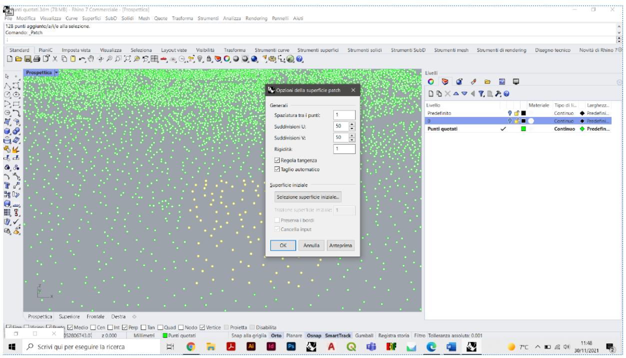

Figure 2. Patch command before UV subdivision.

Some different land areas have been surveyed in different survey season to collect more information from the ground and the point clouds have been integrated obtaining a more detailed model of the ground to be integrated in the general db.
A second paths, more precise, has been followed to connect architecture to the ground: this second revealed to be more accurate in terms of Holographic vision but still time consuming. Second workflow: a DTM (Digital Terrein Model) made available by the Ministry for the Environment, Land and Sea - National Geoportal has been used as a base. The DTM has a pitch of 1m x 1m, obtained from a LIDAR survey in 2008 - 2009. The data have an altimetric accuracy corresponding to an error of less than ± 15 cm, so the terrain modeling, in this case, was the most suitable for the correct location of the architecture.
Next, the DTMs with .asc file extensions were imported into QGis. Since the work is done on multiple map quadrants, it was necessary to generate a "virtual raster" composed of the eight inserted quadrants. Special attention has been paid to the reference system. The reference system of Lombardy is on time zone 32; EPSG 7791. The imported data are in the reference system EPSG 4326 which is the reference system in which they were created and made available. Then the following workflow has been adopted:
-a shaded map that provides a three-dimensional appearance to the topographic survey map has been created with "Processing", "Tools", "Shading".
-contour lines have been created using "Processing", "Tools", "Contour lines". In the mask that opens, in the "Input Vector" box has been selected the layer corresponding to the virtual raster generated by the union of all quadrants.
-the interval between contour lines has been set to 1 meter, instead of the default one set to 10 meters. It is important to enable the "Produce a 3D Vector" option.
-the "Contour Lines" element has been exported in .dxf format, specifying the geometry type "LineString", including in the export also the data related to the Z dimension.

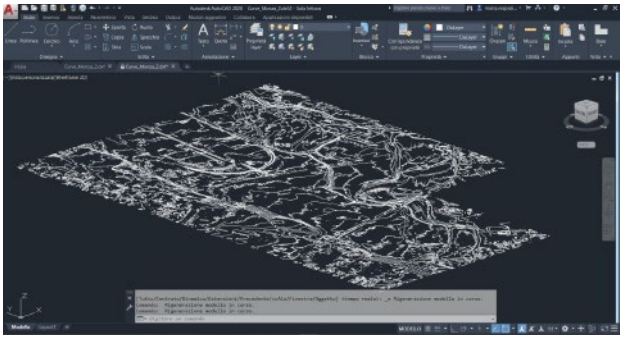

Figure 3. Imported Contour Lines in Autocad.

The .dxf file relative to the contour lines was imported into the previous modeler, Rhino, and then the terrain modeling was carried out using the "Patch" command that generates an interpolating surface.

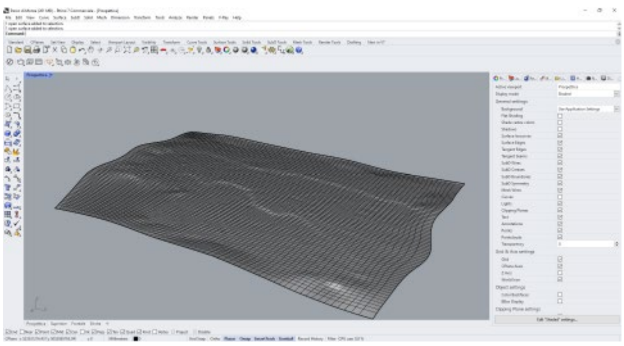

Figure 4. Interpolated ground through Contour Lines

In the two workflows developed, the software used for the first reading of the data was always QGIS. QGIS is an Open-Source software that allows you to analyze and edit spatial data and generate cartographic maps. QGIS supports both vector and raster data as well as major spatial databases. For the real terrain

modeling Rhinoceros has been used to develop shapes from and the data (elevated points or isohypses) exported in .dxf format from QGIS. The Rhinoceros software allows to create, modify, analyze, and translate NURBS curves, surfaces and solids. The terrain of the Royal Park of Monza has been modeled generating a surface interpolating points or curves from two different ground files.
The landing of the architectures into the terrain model required special attention. The three-dimensional models of the architectures had been generated with a local reference system derived from the survey produced by Laser Scan while the terrain model, being the result of topographic databases, had a global reference system. The insertion of the architectures was performed manually based on reference points inserted on the terrain model.

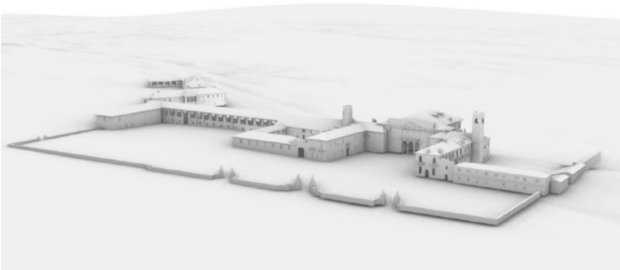

Figure 5. Figure placement and numbering.

3.2 The architecture: survey

All the buildings (4 complex) in the case study were surveyed over several days using Terrestrial Laser Scanner (TLS), RTC 360 and an initial cloud-to-cloud recording in the proprietary Cyclon Field 360 application.
The used Leica RTC360 is equipped with five cameras to track the scan stations and reconstruct the scanner trajectory with the Visual Inertial System (VIS). The integration of the IMU platform and the VIS allows a raw, real-time, on-site registration of the different scans. In addition, the instrument is equipped with 3 HDR cameras with five bracketing exposures for the simultaneous acquisition of 360° spherical panoramas, which are then used to colour the single point cloud (RGB values).
All the scans related to four buildings have been settled the resolution to a value of 6 mm at 10 m, mainly carried out using TLS: 20 to represent the external perimeters. Taking advantage of the VIS technology, which makes possible to check on-site that the overlap among the scans is always greater than or equal to 50%, it was decided to acquire the data in target-less mode. The raw registration of the scans was then optimised using a cloud-to-cloud alignment algorithm within the Cyclone REGISTER 360 software, taking care to eliminate all vegetation around the buildings.
Moreover, a small terrestrial photogrammetric survey campaign of the buildings was conducted using cameras in different situations: a Canon EOS 6D Mark II (Full-Frame CMOS sensor, 6240x4160 px, pixel size 5.75 µm) with a 24mm fixed lens.
The acquired data were processed according to the classic photogrammetric pipeline: image orientation (internal and external), calibration optimisation (Tie Point filtering), scale, dense cloud elaboration (image matching), polygonal model and orthoimages. The acquired data were processed according to the classic photogrammetric pipeline: image orientation (internal and external), calibration optimisation (Tie Point filtering), scale, dense cloud elaboration (image matching), polygonal model and orthoimages.

Figure 6. West facade. From left to right: coloured point cloud, orthoimage, and false-colour point cloud.

3.3 The architecture: models and texture

The quality of texture has a dominant contribution of realistic visualization. Having built Rhino model with blank surfaces, the texturing objective is to tell the same feeling of original buildings with correct building information as much as possible.

Figure 7. From the point cloud to the Nurbs Model

But the point is that the whole project has several building volumes with hundreds of faces for each to be manually unwrapped with maps. The speed, output quality and procedural simplicity is therefore worth discussed to improve work efficiently. The output should be guaranteed to reach the same taste with real world objects in a most rational workflow (Jouan, 2021). Related to the best accuracy in visualization it was discuss and optimized a way to texture relating quality, speed, and simplicity for so many buildings: the objective is the selection of a texturing procedure without loss of detail to achieve an accurate output within the Unreal Engine software, useful both for Immersive Theatre and presentation formats for Hologram Table.
While the algorithms present in the NURBS modellers give a perfect correspondence of geometric and metric parameters, more complex is the attribution of those notes, textures, shapes typical of heritage buildings within the platform used to develop immersive reality. Indeed, if on the one hand, the growing need to transfer content, both cultural and recreational, pushes towards the use of open platforms for the management of virtual projects, allowing the creation of complex virtual environments such as this, the theme of the reproduction of the elements of coating geometries needs a decided in-depth study.
Inside the Unreal Engine platform, the VPL allows a wide range of development of blueprints, useful to increase the experience in terms of movement and fruition. But the rich libraries of materials provided cannot meet the requirements of heritage modelling, necessary to increase the levels of immersion and interactivity if not by modifying them and using additional VPL nodes to modify materials in specially added platforms.

Though the software varies in their ways of creating 3D assets, they perform the same principle on projecting texture information: UV mapping. U and V is two directions of a surface, and the map is 2D image carrying the texture information by pixels. Within a model, every 3D block can be regarded as one or several 2-dimension faces which can be unwrapped into a plane. The way of texturing is always by projecting the information of pictures on these planes. By adjusting the UV vectors, the direction and density of a same projected maps can be different and the best result at present comes from align and adjust surfaces with photos little by little. For this reason, UV mapping is a quite a manually process and time consuming. To fulfill the complexity of materials in real world, there are also many kind of maps providing information through different aspects. To most used are: the base color map (always be regarded as the foundation one) which provides the color information of surface, the normal map that provides the information of detailed height difference information, the roughness map telling where and how much the areas on the maps reflect lights. The work efficiency depends on the speed of UV mapping and the quality of final output depends on the maps we adopted.

To adjust material in Unreal Engine could be the most direct way of texturing because it is the final representation platform to be transformed in the Immersive Theater or the Hologram Experience. As a fact of there is an abundant material library in Unreal Engine, but the aim is to create blend material from library to reach as similar as possible to the real world. From a scientific view this is not correct for the loss of information. The similarity is limited as the material is obtained from online library instead of site photo and some of crucial building information cannot be expressed. There is the possibility to create manually referencing to the photos, but this is more applicable in countable small volumes than many of mass buildings.

Even if the process is as straight and clear the result Is not accurate.

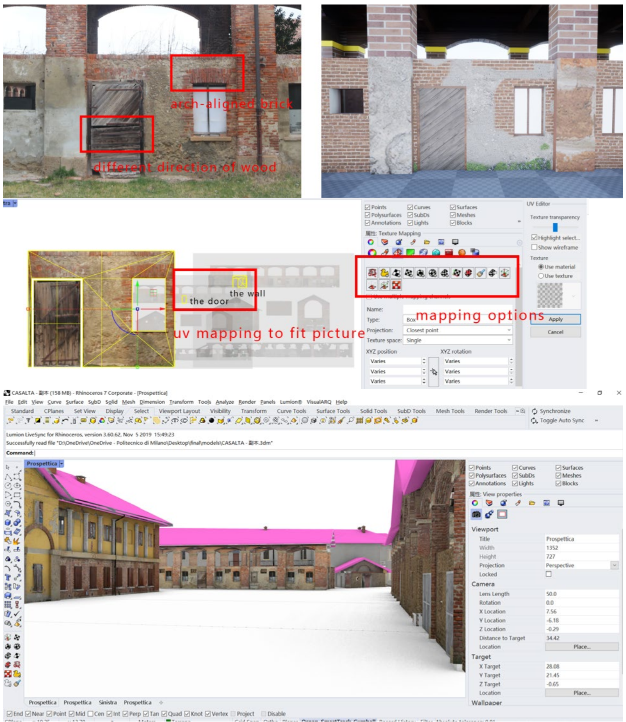

Figure 8. UV Mapping surfaces in Rhino7, technical issues in small or larger surfaces.

The second classical workflow is to Map Orthophotos in the modeller itself. Instead of using material library, the orthophotos obtained by survey of the building surfaces contains maximum accuracy and reality. To cast the photo as a material to model is the way to achieve higher quality considering the “same taste” objective. The steps are :

1. Obtain Orthophotos from Metashape (camera scanning) as maps.
2. Create picture as material in Rhino and UV Mapping the surface.
3. Transfer the fbx as model format from Rhino 7 to UE5.

Quality: The information can be expressed in a best possible way taking directly from site photos. The outcome can meet the requirement of project objective.

Speed: The UV Mapping application in Rhino7 can achieve the purpose of cast orthophotos on models. Each surface to be unwrapped demands a plan created to be attached. The model preview cannot update synchronously with the movement of UV. There could be better way of mapping process to save time and improve efficiency.

Simplicity: There is no third software involved in this workflow except the obtain of orthophotos. The procedure is also straight and clear.

The output quality through this workflow can reach the requirement of project. However, there are enormous numbers of surfaces to be unwrapped in this project and the efficiency of UV mapping process is essential. As for the result is acceptable for the project, a third way of optimizing the UV mapping process has been searched by applying a third software.

Blender, as a widespread 3D recreation software, is famous in its capability of its UV mapping tool an individual section, and has flexible options in UV unwrapping to speed up the process. Take this advantage, it can be involved into workflow as the following steps:

1. Obtain Orthophotos from Metashape (camera scanning) as maps.
2. UV Mapping the maps on surfaces in Blender imported from Rhino7 through obj format.
3. Export the fbx format model to UE5.

Quality: The information can be expressed in a best possible way taking directly from site photos. The outcome can meet the requirement of project objective.

Speed: Blender has UV Mapping Tool as an independent section inside the engine. It has more options compared with Rhino (project from view, etc.) What’s more, one the movement of UVs can update synchronously in the 3d layout window. These features can improve the efficiency and accuracy of mapping process.

Simplicity: the exchange between software causes the nurbs surfaces model in Rhino converted to meshes in Blender. As a matter of practicing, it does not affect much about the unwrapping experience.

Conclusion: through a third software always bring unpredictable bug, the process of introducing Blender as a UV Mapping intermediary proved to be practicable. The optimization improves the efficiency of UV Mapping to cut down the time consumption in manually process drastically. Compared with previous workflows, workflow 3 is determined as the final workflow.

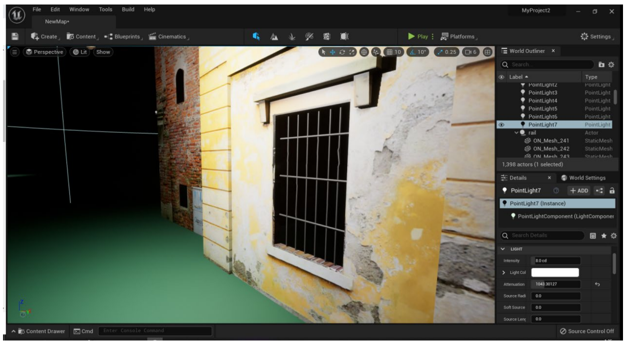

Figure 9. Final results of the mill model recreated in Unreal Engine

4. THE IMMERSIVE VISION

4.1 The workflow

The workflow presented has developed gradually different problems faced in succession with the aim of an immersive visualization of the park, with the tools available in LaborA, Virtual and Physical Modelling i.e. an immersive theatre 7 mt diameter for immersive fruition and the Euclideon Hologram Table©. The Hologram table is composed of a large and flat surface (2.1m x 2.1m) and a metallic frame structure to which are attached all technological components required for the holographic display of 3D models as well as the wooden panel of the top plane. Interaction with the holograms is performed with a specially designed wand, which, as though the glasses, uses an infrared tracking system to calculate their position and orientation in space through four tracking domes. The spheres on the wand and the glasses are used to compute their correct position.
The flat-screen area comprises a rear-projection material (white cloth) that is sandwiched through a 10 mm thick acrylic sheet and a 1.5 mm one. This area (1390 mm2) is the central display where holographic display takes place.
The system projects the 3D models so that they appear to rise from the centre of the table to a height of approximately 0.7m in a hemispherical volume.
The number of direct users (equipped with wand and glasses) that can view and interact with the hologram is two.
During the early stages of the work, the difficulties arising from the absence of a topographic survey of the terrain have directed the choice towards the modelling carried out by a Nurbs modeler; the same choice was done starting from the point clouds of the buildings remodelled in Rhino to be combined with land. This workflow had been used in the past for large amounts of data at the scale of the building and in manageable quantities to be visualized in the two visualizing environments, the Immersive Theatre, and the Table.

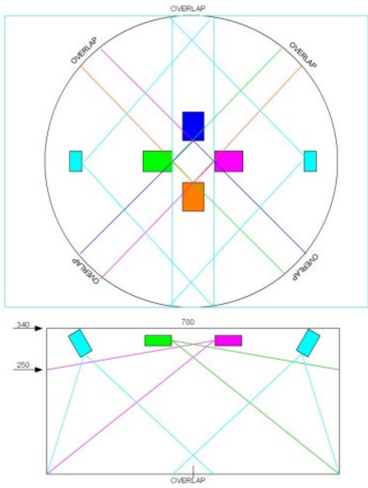

Figure 10. Settings of the projectors in the Immersive Theater

With the setting of the models of the farmhouses in the park on a larger area, the increase of the amount of information to be managed and especially of textures to be used for the faithful visualization of the Heritage buildings, the workflow has been supported by an additional software, Blender. This choice was further determined by the possibility of exporting the results for Theatre and the Hologram Table from this same software.
In the first case the model can be exported from Blender in the Unreal Engine environment; in the second case Blender can be directly translated in the proprietary format of the Hologram Table UDS. to be visualized, obtaining the best results in terms of time-saving, environment creation and immersive visualization.
For any automatic extraction of the information eventually loaded in the model the possibility offered and tested is through a customization of the previous toolkit in Unity Environment.
Some results can be described here after this work: the first result concerns the possibility to use cartographic databases through grasshopper as a base for the integration of both point clouds and mesh models for a holographic visualization or Rhino as a Mesh modeller of large surfaces too; the second result is the experimentation workflows for the accurate visualization of the projects using orthophotos and a bridge software between modelling, texturing and the visualization in the Theatre or on the Table; the third, not described here is the integration of Unity toolkit in the UDS software to join the visualization of any model with information considered necessary in the Hologram table.

Supported file format	
Supported Mesh Model formats	OBJ
	FBX *(only data on the first layer is recognised)*
	PM *(Euclideon's optimised mesh format – exporting to this will allow you to load mesh models faster next time)*
	DAE
	DXF
	PLY
	STL
Supported Point Cloud formats	UDS
	LAS
	LAZ

Table 1. Figure 2: file format accepted by the proprietary software UD stream of the Hologram table.

5. CONCLUSIONS

This first experiment to integrate models in a GIS environment for the visualization in the Theater or in the holographic table outline great potentiality. Navigating the high-quality park modelled is fluid and allows to view a greater detail level owing to the great care dedicated to the UV texturing.
Despite the significant reduction of on-site survey time, and of modelling informed or not, the integration of the texture with the architecture is the most consuming part of the workflow.
The interaction of Holographic content into the Unity environment offers a full interaction that we just start to implement, but it is not connected to immersive visualization. Adding data in the Hologram environment has been the first step, Data base extraction will be the following one.
The workflow defines more topics for future researches: the necessity to establish some metrics related to the holographic vision; the limits of the usability of these models, only in darks spaces; the development of augmented interfaces for the development of the data already nested in the model; the possibility to live the experience with wearable devices, insufficient to contain such amount of data.

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Of the three authors Cecilia Bolognesi realized the survey campaign, organized the models, decided the workflow and the structure of the experiment/paper. Maria Verpasiani elaborated the parts related to the terrain modeling; Yi Zangh, after having received the models, realized texturing and development for the immersive environment.

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