

MANAGEMENT OF H-BIM MODEL IN HOLOGRAPHIC VISUALIZATION

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ABSTRACT:

This document aims to validate the workflow from a digital survey of a residential building of the early 900 century of historical value ready for future renovation to the transformation into a BIM model for its holographic fruition augmented by an automatically extraction of data and information contained within. Via Lulli is a low-cost residential district organized in courtyard blocks subject of future energy saving interventions; the research topic concerns the validation of the workflow from the 3D digital survey to the holographic visualization augmented with automatic extraction of information using the innovative Euclidean Hologram Table©. The possibility of interrogating an informative 3D BIM model visualized in a 3D space in front of the operator and not simply through a desktop is a completely new field in research with many potentialities; in the specific case study the abundance of these heritage buildings in the city must be considered as a relevant data to organize their whole renovation. After the previous validation of transforming the 3D BIM model to hologram, analysing the file formats, technical performance and specifications, file dimensions manageable, the successive implementation has been focused on the automatism of extraction of the different useful information from the model. The possibility of interacting to query the model in holographic representation represents an extraordinary tool for managing BIM which opens new research; it has been reached through tests for interoperability among formats, necessity of transformation of the BIM model without losing information and accuracy, friendly fruition in the Euclidean Hologram Table©.

1. INTRODUCTION

Digital survey and modelling techniques have progressed during the last years, both in terms of accuracy, data management and resolution due to hardware and software developments; in spite of this their visualization has always been performed in the same way through classical reduction in a 2D surface such as a screen. Since the advent of lasers in the 60's and digital images something is changed; holography has become a method of recording and reproducing three-dimensional images, using a beam of coherent light directed both toward the object to be reproduced and toward a plate of sensitive material, so that the interference produces on the plate a figure in some way assimilable to a diffraction grating (Yang X, 2019).

After a slow beginning where holograms were associated with the optical process of reproducing 2D images with a certain depth used as static images in their current version they have begun to refer to a 3D digital volume, supported by the concept of Voxel instead of Pixel, providing navigable virtual reproduction of the projected objects. This development of the first experiments follows the radical improvement of mathematical algorithms, largely aided by the improved computing capabilities of PCs, and therefore of the interference, called cross-talk (Makey, 2019), previously too noisy between the large number of two-dimensional images assembled to create a three-dimensional effect. The use of holography connected to the field of augmented reality (Gao, 2019) has then grown exponentially in recent years, driven by the need for applications in industrial and medical fields (Fraga-Lamas 2018; Brun 2019; Desselle 2020)

2. THE CASE STUDY AND THE SURVEY

2.1 Via Lulli district

At the end of the nineteenth century the problem of social housing in Milan had become a priority owing to the masses of population that the city and the new industries were polarizing. The municipal administration decided to set up a company for public housing, also thanks to the facilities allowed by law aimed at stimulating public, private and cooperative bodies to build public housing.

In 1908, the so-called Institute for Popular and Economic Building of Milan was born to answer to the urgent and critical problem of social housing in town (Grandi e Pracchi, 1998). Giovanni Broglio was employed with the task of directing the internal design office that was being formed; in this capacity, in the following years he designed many district of social housing and, among them, Lulli residential blocks which were designed with six buildings of 4-5 floors characterized as large closed courtyard (Figure 1). Between 1908 and 1913 viale Lombardia, Niguarda and Cialdini were built and Spaventa district were also completed.

This immense historical heritage, still inhabited, has urgent need for redevelopment, efficiency and management interventions that are so necessary if addressed in the light of BIM and smart tools for their management.

As well as other buildings of the same period, it belongs to the cultural history of the city of Milan, to its moments of great development, and need protection in the complex of the residential asset of the city, presenting further difficulties in its renovation.

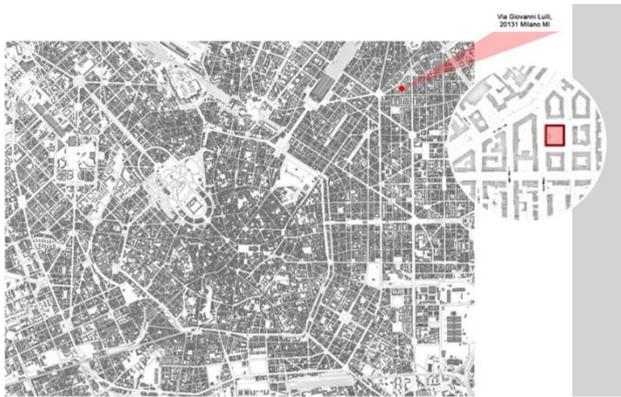


Figure 1. Lulli district and block in the urban area of Milan.

2.2 The digital survey

The survey was set up with a high-speed time-of-flight scanner, RTC 360 characterized by scans of 2 million points per second with simultaneous capture of spherical HDR (High Dynamic Range) images. It features Visual Inertial System (VIS) technology that automatically tracks the movement of the scanner, enabling semi-automatic data recording in the field without targets; the related project is registered in local coordinate system (Figure 2). The point cloud obtained was pre-aligned cloud to cloud in situ with Cyclon proprietary app and then registered in REGISTER 360 proprietary software, sampled to 5 mm resolution removing duplicate points and noise obtaining a cloud of 19 set up and 1.390.581.390 points. The survey campaign lasts one afternoon for outside elevations and common spaces.

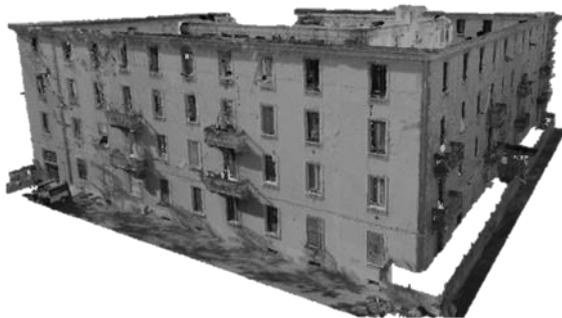


Figure 2. 3D point cloud survey with Cyclon 360.

3. HOLOGRAM TABLE

3.1 Set up and Software

The Hologram table is one of the equipment of the new Labora (physical and virtual modelling laboratory), at Politecnico di Milano (Figure 3). Since March 2021, it has been tested with several experiments hosting the visualization of point clouds and digital models already present in the research of the university teaching staff to test accuracy of the vision, dimensional limits of the projections, calibration set up, waving of the models connected to the movements of the users, future developments. Both point clouds and mesh models have been tested (Bolognesi, 2021) giving the possibility to appreciate from Giga bites .Las point clouds to light .Obj models. The software supports different Mesh Model such as .OBJ., FBX, .DAE, .DXF.,PLY,STL, PM; Point Clouds format such as UDS, LAS, LAZ. For the holographic presentation a high-quality visualization can be better performed after cleaning the raw point model, deleting all bad points from each scan station.

To summarize the main hardware features of the table, very shortly we describe it as composed by a large and flat surface (2.1 m x 2.1 m) and a metal frame structure to which all the technological components necessary for the holographic visualization of 3D models are connected.

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 is the central display where holographic display takes place.

The components are:

- a Dell 5820 workstation equipped with two Radeon WX 5100 graphics cards (AMD, 2020)
- four main projectors Vivitek D757WT (Vivitek, 2020) with the maximum supported resolution of 1920 x 1200 at 60 Hz to display the 3D model on the flat screen
- an external projector to externally visualize the hologram
- plastic supports on the projectors to support a filtering crystal that allows the light rays to be decomposed, to be recomposed in the final holographic 3D model
- an eight-port ethernet switch that allows projectors and A PC to be connected via a local network to a remote control

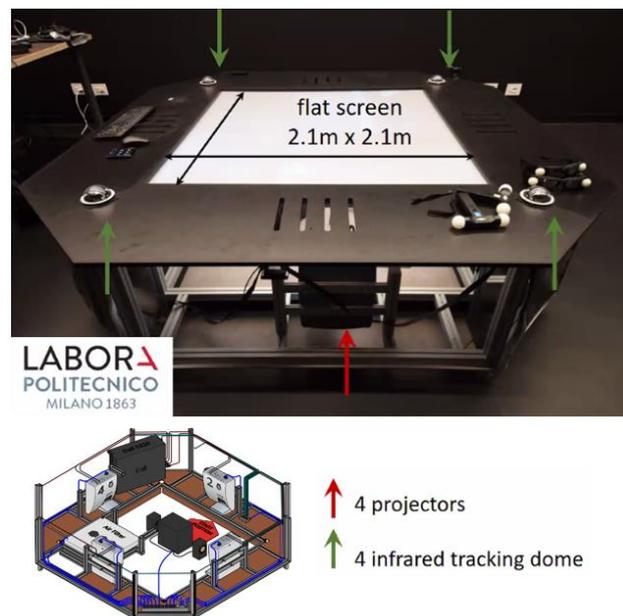


Figure 3. Euclidean Hologram Table©.

To manage the interaction with holograms a specially designed wand, and glasses, are provided; they use an infrared tracking system to calculate their position and orientation in space hosted among the glasses and 4 domes located at the corner of the table.

The system projects the 3D models so that they seem to rise from the center of the table in a hemispherical volume to a height of about 70 cm.

The space around the table: proper operation of the hologram table requires a completely dark room to work with projectors and lasers as light obviously interfere with the display of holograms and tracking devices.

Euclidean Hologram Table© manages 3D models using four software (Euclidean, 2013):

- i) Holoverse Present
- ii) Holoverse Professional
- iii) HoloTray
- iv) UdStream

The first software is an aid for preparing 3D models for holographic presentations. It allows the conversion of files in the UDS (Unlimited Detail Data Set) format proprietary of Euclidean.

The optimization of the model takes place through Holoverse Professional and allows you to save the Euclidean presentation in the UDP format. Finally, the background and application features are maintained and processed by HoloTray.

Ud stream is a proprietary Cloud accessible from desktop recently added by the Euclidean to support sharing and oversized models (Table 1).

SOFTWARE	TASK
Holoverse Presenter	Model conversion into propriety UDS file format and Holographic presentation setup (UDP file format)
Holoverse HoloTray	Background application maintaining all functions and processes of Hologram Table
Holoverse Professional	Holograms display on the Hologram Table.
UdStream	UdStream is a manager and viewer of 3D data through the use of a proprietary cloud that you have access from desktop or Chrome browser.

Table 1. Euclidean Holographic software, versions, and tasks.

4. METODOLOGY

4.1 Point cloud to Revit to Hologram Table

The point cloud obtained from the previous survey was processed in automatic cleaning through proprietary software to clean noise and redundancy of points; the e57 file (43GB) was then exported from into Autodesk Recap 2020 to obtain RCS format (4.13GB), allowing the upload in Revit 2020 and the subsequent modelling (Figure 4).

For the modelling, a LOD300 has been set, as it is strictly necessary and sufficient to verify the workflow and the information exchange required for the research in progress (Figure 5).

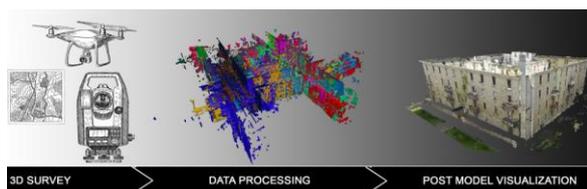


Figure 4: Process from survey to point cloud.

Once the modelling was completed, the ArtisGL OBJ plug-in was used for exporting to the reading OBJ format for displaying the model on the table.

The normal workflow proceeds with the import of the OBJ model in the proprietary software, Euclidean Presenter, with the creation of a UDP file allowing the visualization on the hologram table (Virtanen, 2020).

The limitations of this approach were evident immediately; the model can only be displayed in the views configured by the Euclidean software and the possibilities of querying a model depending on the intended purpose is not possible (Figure 6).



Figure 5. Process of modelling from point cloud to BIM model.

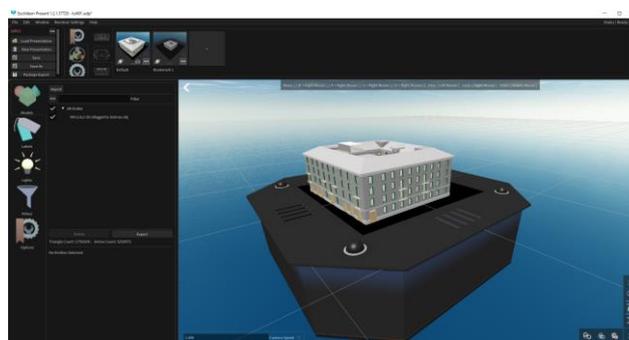


Figure 6. Revit Model on Euclidean Presenter.

4.2 Implementation Procedure: Revit – Unity – Hologram Table for reading data information

The research therefore focused on the possibility of reading not only the geometry but also with an automation the information data, images and detail elements in an immersive environment explored through the Unity platform, creating scripts and also using the tools of the "UnityToolkitSample".

The holographic table thus experiments with an interactive mode of visualization the possibility of implementing information on objects throughout the model, ready to be semantically enriched by users. The complete scripting procedure has been release for public (Calonca, 2021).

4.2.1 Asset importer

Once the modelling phase is over, the model has been exported from Revit with Datasmith Exporter Plugin-Unreal Engine (Unreal Engine Development Team, 2021).

This plugin allows you to obtain the following files still containing geometrical objects, Mesh and Texture exported from Revit (Figure 7):

- Model named .UDATASMITH (An xml file that has a tree structure of the scene).
- A folder containing meshes and the textures



Figure 7. Files from Revit plug-in export.

Unlike the classic procedure where an .obj file was exported, the .UDATASMITH was engaged. file is a standard format that works for importing 3D scenes into Unreal Engine.

Both resources, meshes and the .UDATAMITH files that contains the hierarchy of Unreal Engine Actors (objects) of the scene will be used in our program to recreate the model in Unity (Figure 8). Multiple actors (which take up the tree or "nested" structure in Revit) can also be associated to the same resource (mesh), and each actor can contain a set of keys and metadata values (which represent in the Revit environment the respective vestments associated with the objects).

4.2.2 Material – Mesh and Properties Assign:

The generated .UDATASMITH file has been placed within a Unity project in a the Assets/Resources folder where our program will automatically create a prefab.

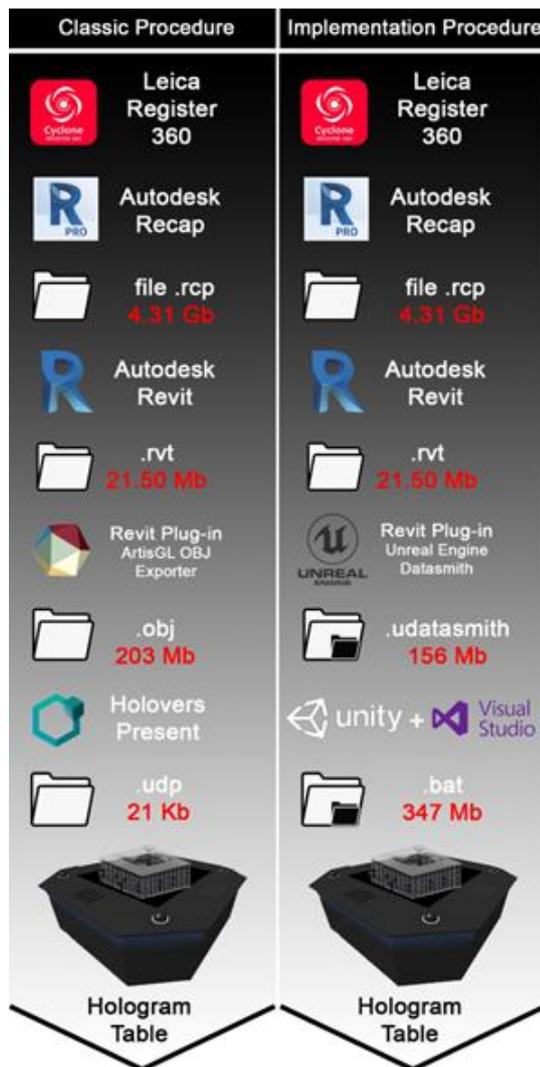


Figure 8. Traditional workflow vs Implementation – Unity advance.

During the import, the program read, stored in a key-value pair (e.g., **key:** name of the material on the .UDATASMITH file exported from Revit; **value:** material created in Unity) the materials, meshes and properties of the model.

Subsequently, it generated a tree structure like the original model and assigned to each node the correct parameters present on the initial export file.

Once the reassociation is complete, it is possible to read the parameters through the Unity metadata Manger class.

4.2.3 Optimization

Due to the considerable size of the case study file, slowdowns in the program were noted during the tests. To overcome this inconvenient, we opted for optimizations to make the model more fluid during its use with two different steps.

Level one: the first level consists of reducing the number of objects while maintaining the same number of triangles and vertices of meshes. To do this the original tree structure was kept using a script combining the meshes having the same material. The result was a list of meshes where each mesh had a different material and no two meshes had the same material.

The script is an upgraded version of a mesh combiner (Ennoble studios, 2020) but the new version supports objects with multiple materials on submeshes.

After launching the script a prefab was generated, which was added to the view, removing the MeshRenderers and MeshFilters from the original model (you can reverse this action by replacing the model in the scene with the original prefab created by the importer).

The objects will still contain the mesh colliders and the metadata to be able to interrogate the model.

The number of mesh polygons was optimized and increased, but the performance (fps) has also greatly increased allowing the model to be displayed on the table smoothly.

Level two: after the first level of optimizations, there were still slowdowns in the display of the hologram table while an experience even smoother was required and for this reason, we proceeded with a decimation of the meshes, reducing the number of triangles.

To increase the framerate, the meshes were decimated directly from Unity through the usage of a Unity Mesh Tool (Edlund, 2021).

The process involved replacing the meshes from the first of the optimization levels with a decimated version using the Decimate Wizard in the Unity optimization menu we created, which allows you to set a decimation value:

1. from 0 to 0.99 simplification with loss.
2. 1 represents a special value for simplification (almost) without loss.

Having chosen 1 as a value, the model is much more fluid and easier to use inside the hologram table (the FPS improve).

These optimizations are optional and depend on the size and complexity of the model we are going to interrogate (Table 2).

4.2.4 Scene composition for holographic table

The final phase of the experimentation took place in two steps. The first one with the sample project provided by Euclidean: "UnityToolkitSample".

For the visualization and management of our Lulli case study, the lands available was used to place the model and the related BIM objects to be queried to be able to make them visible and manageable through the glasses and wands present in the table.

In the case of very heavy models, where it is necessary to make the first and second level optimizations, to make visible the properties of the elements of the original Revit file it was necessary to maintain the original prefab imported with MeshColliders (Figure 9).

Workflow	STATISTICS LEVEL
	Ultra
Original	<p>Statistics</p> <p>Audio: Level: -28.4 dB DSP load: 0.2% Clipping: 0.0% Stream load: 0.0%</p> <p>Graphics: 9.8 FPS (102.3ms) CPU: main 102.3ms render thread 61.1ms Batches: 9029 Saved by batching: 126587 Tris: 16.3M Verts: 48.9M Screen: 1078x473 - 5.8 MB SetPass calls: 918 Shadow casters: 0 Visible skinned meshes: 0 Animation components playing: 0 Animator components playing: 0</p>
Optimization level one Combined meshes	<p>Statistics</p> <p>Audio: Level: -23.1 dB DSP load: 0.2% Clipping: 0.0% Stream load: 0.0%</p> <p>Graphics: 34.2 FPS (29.2ms) CPU: main 29.2ms render thread 6.6ms Batches: 616 Saved by batching: 1 Tris: 73.3M Verts: 219.9M Screen: 1078x508 - 6.3 MB SetPass calls: 272 Shadow casters: 336 Visible skinned meshes: 0 Animation components playing: 0 Animator components playing: 0</p>
Optimization level two mesh decimation	<p>Statistics</p> <p>Audio: Level: -22.2 dB DSP load: 0.2% Clipping: 0.0% Stream load: 0.0%</p> <p>Graphics: 78.1 FPS (12.8ms) CPU: main 12.8ms render thread 7.5ms Batches: 616 Saved by batching: 1 Tris: 22.0M Verts: 65.5M Screen: 1078x508 - 6.3 MB SetPass calls: 272 Shadow casters: 336 Visible skinned meshes: 0 Animation components playing: 0 Animator components playing: 0</p>

Table 2. Improved workflow statistics.

The second step involved the build of the project so that it could be started in the table through the generated .bat file. At this point, the user can move rotate and resize the model and view the properties of the elements present in the original BIM model. In addition, to facilitate the use to the user, a menu has been implemented, to be managed with the wand keys, where more options are available (visibility of all models, view reset and spherical marker insertion) (Figure 10). The screenshots inserted here are taken in simulation mode (game) of Unity on another machine, because it is impossible take a photo of a hologram, but the framerate on the table follows a specular behavior.

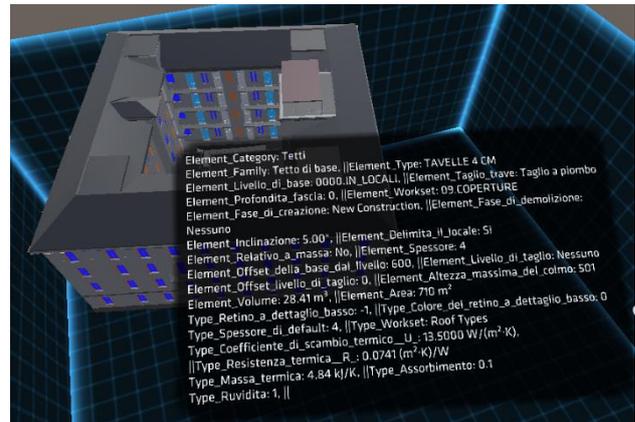


Figure 9. Automatic extraction of the data in the model projected on the hologram table.

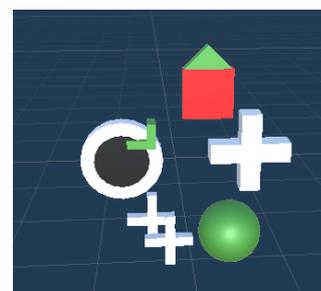


Figure 10. Tools implemented on the wand.

5. CONCLUSIONS AND FUTURE RESEARCH

This first experiment to develop a whole BIM fruition (visualization of a BIM Model+ automatic data extraction) through holograms outlines great potential.

Thanks to the implementation created the hologram table allows you to view any file size and any parameter of the BIM model that is queried.

This experimentation opens a new scenario for the visualization and interrogation of BIM models in a three-dimensional environment, which gives the possibility not only to view the model but also to query the single object data that compose it.

Navigation within the hologram allows the user to view and query the BIM model in real time with different scales of detail, with any type of LOD allowing decision-making processes fast and usable by multiple users, with the possibility of interventions on the 3D BIM model itself live.

In case of residential assets, it can be used for instant Energy evaluation, or Holographic renovation processes during meetings, shortening time decision among technical and no technical users.

To finalize the workflow, among others one aspect must be highlighted: to obtain the Holographic visualization of the BIM model it is necessary to define the objectives and correlate the appropriate LOD according to the use we plan to do during the visualization. It is quite important to understand the level of information we need to visualize to avoid waste of time in the process before the transformation for the Holography.

As any implementation of the workflow requires an adequate knowledge of the C# programming language also so a strict collaboration among users and developers is desired.

Here below a first comparison between the "guided" visualization method of Euclidean and that allowed by the

workflow created through Unity for BIM models from Revit software, which can be summarized in the following table:

 Present	
Unlimited detail tech	Unlimited detail tech
Only view and navigate	100% customizable for reading db of semantic enrichment, of BIM elements
Beginner level (no other external tools)	Advanced level (programming and developer skills)

Table 3. Pros and Cons.

The next steps of this research will investigate the aspects that have proven to be of interest for improved visualization results but not only. First of all the improvement of the effect of waving of the model that is peculiar during the movement of the user when the model has a certain dimension. Of greater interest is the possibility to replace or add in smart way the parts of model on which we work, adding different packages in substitution of the existing ones directly in holographic mode and therefore the constitution of libraries of useful objects to this purpose.

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APPENDIX

A short video of the presented work is available at the following link: https://www.youtube.com/watch?v=yBK_k-ecAMM