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Point cloud management for a holographic visualization

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Abstract. This document aims to describe and verify the workflow from a digital survey of a building of historical value to its set up in an innovative holographic view. Via Lulli is a low-cost building of the beginning of the century organized in a closed-block part of a complex with rather small courtyards; the research topic concerns the verification of the process from acquisition with digital survey to convert the survey dataset into a hologram, considering the huge potential of this display system. Comparison among different point clouds, with different accuracy and dimension are related to the final navigation when transformed in holograms; several tests have been carried out to compare cloud density with the ability to see holograms in details with different zooms in to display small details, and zooms out in real time to view the entire model. First possibility to extend workflow with unity support and other plug-ins are supposed.

1. Introduction

While digital survey techniques have recently progressed since the advent of early laser instruments both for accuracy and data resolution, both on technical instruments than algorithm, the model's digital projection methods and optical methods have developed improvements of hardware but not of mathematical models behind the projection, always performed through 2D screens. Holograms were associated with the optical process of reproducing 2D images with some depth used as static images. In their most current version, mediated by futuristic images of some Rock events or science fiction, they started to refer to a 3D digital volume [1] that occupies the three dimensions of the space in front of us, providing virtual reproduction navigable of the projected objects [2]. Objects can be enjoyed from different angles through specific glasses, and in the most emancipated version, they could also develop a type of dynamic structure [3]. This development follows the radical improvement of mathematical algorithms, and therefore interferences, called cross-talks, which were created among the large number of two-dimensional images assembled to create a three-dimensional effect [4].

1.1. The case study and the survey

At the end of the nineteenth century the problem of social housing in Milan became urgent. The municipal administration decided to set up a municipal company for public housing, also thanks to the facilities allowed by the law aimed at stimulating public, private and cooperative entities to build public housing. In 1908, in this historical, urban and socio-economic context, the Institute for Popular and Economic Housing of Milan was born and became active immediately. In the first five years realized, finished and assigned the following neighborhoods: Lulli [5] (new construction); Spaventa Lombardia,



Cialdini and Niguarda. These latter buildings were characterized as large buildings with a closed courtyard, arranged on four sides and composed of seven units: six buildings of 4-5 floors and one including three multi-family houses. The survey campaign was set up with a Leica RTC 360 scanner, with a survey campaign of the building in the inner and outer perimeter in one afternoon day of in situ activity. The instrument is a High-speed flight time scan with scans of 2 million points per second; it simultaneously captures HDR (High Dynamic Range) sferic images. It is equipped with visual inertial system (VIS) technology that automatically tracks the movement of the scanner, allowing semi-automatic data recording in the field without targets.

The point cloud obtained was pre-aligned cloud to cloud in situ with a Cyclon app and then registered in Register 360 obtaining a bundle of 19 set up with a mean absolute error of 0.004 m. for 157.692 MB.

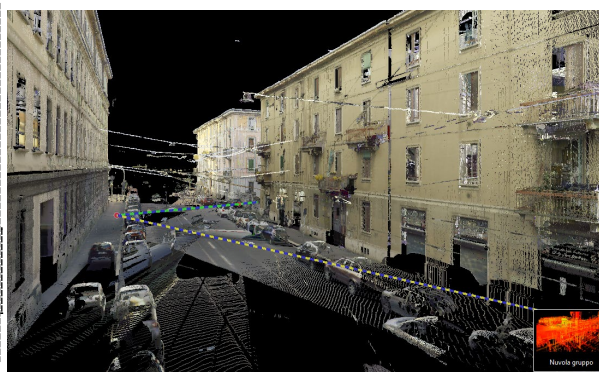


Figure 1. Screenshot from Cyclon 360 of the Point cloud of Via Lulli, on the right the building.



Figure 2. The inner court in via Lulli

2. Workflow from cloud to table

The survey campaign generated a project related to all scans recorded in a local coordinate system. The projects were managed using cyclone Register 360's, Leica proprietary format, recent software environment, which allows cloud-to-cloud logging to align. The cloud thus obtained was exported in an interoperable format (.e57) consisting of 19 setups, for a total of 1.910.042.179 points using a disk size of 43.980.468 KB (43.98 GB).

Once we achieved this result we took two different paths aiming at testing better solution regarding accuracy of the model related to new technology for first visualization tests:

- working with the project without any decimation in the import phase (large size and high quality of detail - precision)
- decimation of the point cloud, resulting in loss of quality and amount of data in favor of a small and more manageable file.

2.1. Case 1

Cyclone 3DR licensed software and a Dell Precision 7920 workstation with the following features were used for this work:

- Processor Intel Xeon Gold 6244 3.6GHz, (4.4GHz Turbo, 8C, 10.4GT/s 3UPI, 24.75MB Cache, HT (150W)
- Windows 10 Pro for Workstations operating system (4 cores and 01-threes)
- NVIDIA Quadro RTX4000, 8 GB, 3 DP, Virtual Link (XX20T) Video Adapter
- Memory 64GB 8x8GB DDR4 2933MHz RDIMM ECC Memory
- Disc rigid SATA hard disc of 3.5", 2TB, 7,200 rpm.

The .e57 file was opened in two attempts: the first with CloudCompare v2.12 alpha [6] with a timeline of about 30 minutes; the second with Cyclone 3DR, where it took about 20 minutes before continuing the subsequent stages of processing and export.

Once the import in Cyclone 3dr was carried out, a manual cleaning was carried out, removing all parts outside the area of interest and noise, improving cloud quality and reducing size. For this purpose, the setting chosen for the intensity parameter is 30%, after having carried out several tests even at 50 %, 70% and 78 %. In order to facilitate cleaning, the scans were exported individually and then re-assembled once the cleaning phases had been completed.

The workflow requires to export the cloud again in LAS, obtaining 36.154.774 KB (36.15 GB) size, enough to be read correctly by the Euclidean Presenter software. Euclidean Presenter, is the proprietary data preparation software to be displayed on Euclidean Holographics software © on the table. It supports Mesh Model format such as: OBJ, FBX (only data on the first layer is recognised), DAE, DXF, PLY, STL, PM. It supports Point Cloud Format such as UDS, LAS, LAZ. Euclidean's Holopro software in the free version do not have the ability to process such a large data; the use of UdStream cloud always processed by the Euclidean team gives the possibility to process large projects and obtain the file in the correct format allowed, UDS, that can be read by the table with Holo pro software. UdStream is a manager and 3D data digital manager to handle digital projects; it can easily share projects, manage and create visualizations and huge high-speed point-cloud data through the use of a proprietary cloud accessible from a desktop or browser. For files under 15 GB the open source version is available after registration. We've also been able to understand throughout the workflow that the .e57 format export process is quite time-consuming. As reported in the following case, we also found the presence of a proprietary form that allows after registration in Register 360, to export without loss of info, then facilitating the import operations on Cyclone 3dr and the related implementation.

2.2. Case 2

This second case regards a decimated cloud in the import phase, with a maximum number of points per scan of 10 million. 19 scans means a total of 190,000,000 points, weighing 6,518,136 KB (6.52GB) in .e57 format, and a .3dr file of 4,453,633 KB (4.45GB). The file reading time in Cyclone 3dr dropped to 8 min. compared to 20 minutes before. In this second case given the rather heavy initial decimation, we simply cleaned the cloud manually, avoiding deleting further information with the noise filter. The file exported to .e57 is 5,593,346 KB (5.59GB) in size, and the proprietary .3dr format is 3,830,943 KB (3.83GB). Finally, we performed an export in .LAS with the size of 4.141.537 KB (4.14 GB) which took place in about 30 seconds. This format can be read by the Euclidean Presenter software and exported in a presentation file for Holopro in .UDS. In the following case, import the .LAS within the software took 10 minutes; since we did not exceed the 5GB threshold for the input cloud, we used UdStream, which was indispensable, given the size in the previous case. The resulting file is 295.452 KB (0.29 GB) in size, and can be managed from the table smoothly for displaying our model.

2.3. Reading the project in the Hologram Table-Hardware

The table consists of a horizontal surface (2.1m x 2.1m) with four integrated projection devices and it is one of the equipments of the new LaborA - physical and virtual modelling laboratory (Politecnico di Milano). It is composed of a large and flat surface (2.1m x 2.1m) and a metallic frame structure to which all technological components required for the holographic display of 3D models as well as the wooden panel of the top plane are attached.

The workstation connected is a standardised Dell 5820 workstation (Dell, 2020) equipped with two Radeon WX 5100 graphic cards (AMD, 2020). One oversees rendering the view to a standard external projector. The other is used by the four main projectors of the hologram table to display the 3D model on the flat screen. Trnet switch allows to connect through a local network the projectors and the PC to a Crestron remote controller commanding the hardware power on/off and the start/stop of the software for holographic display.

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. The spheres on the wand and the glasses are used to compute their correct position. Tracking equipment consists of tracking domes and controller, Radio Frequency Dongle and Sync Emitter, which are USB connected to the PC. Sync emitter will receive light from glasses and wands and sync all devices to work together. Tracking domes work on the infrared wavelength of light, allowing tracking wand and glasses [7] position through the working session. 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.

CASE 1						
Scans	N initial points		N final points		Eliminated	%
Tot 19	1.919.042.179		1.770.165.876		-139.876.303	-5,65
CASE 2						
Scans	N initial points		N final points		Eliminated	%
Tot 19	190.000.021		163.113.600		-26.886.400	-14,15

Figure 3, 4 Point cloud not cleaned and after cleaning

Case 1: the quality and quantity of information is higher, consequently the higher density of the cloud can be perceived on the table. However, this goal required using the UdStream cloud because of its size.

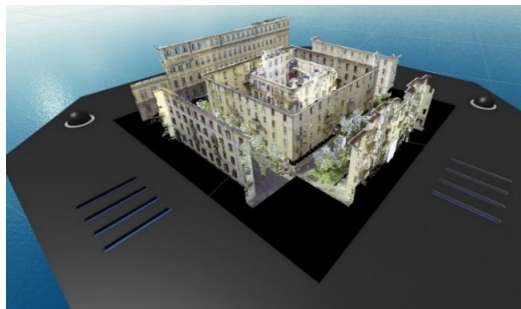


Figure 5. The point cloud inside Presenter



Figure 6. Image of the cloud inside Presenter.

Case 2: The quality of the perceived cloud on the table is lower than before, this due to decimation during import. Staying below 5 GB you can in this case use not only the UdStream cloud, but also Euclidean Presenter and get the file. UDS to be used on the table.



Figure 7. Hologram table by Euclidean Holographic©

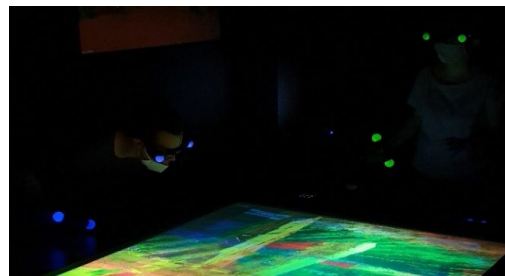


Figure 8. Photo of the hologram table

3. Conclusions

At the end of the processes, here the following considerations where we were looking the better visualization and faster navigation in the 3D space for users: heavy clouds, with quantitative degrees of data the ideal procedure, for a display on the hologram table: it is necessary to carry out all the fine-tuned with a processing software (in our case Cyclone 3dr) and then export to the appropriate reading format, switch to representation through UdStream of Euclidean and consequently on the holodeck with Holopro. For clouds less than 5GB, however, the second case under consideration can be considered, with the use of Euclidean Presenter, whose performance is directly proportional to the characteristics of the supplied PC. This second case reveal a lower accuracy considering visibility through glasses, however with a decrease less than 20% than the previous model.

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