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METHODOLOGY IN 3D LASER SCANNING OF A FARMHOUSE

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ABSTRACT: The urgent need to improve the quality in the refurbishment of traditional buildings has led to the adoption of many innovative technologies. 3D laser scanning is a non-destructive technique used in the study of architectural heritage. It consists of producing millions of accurate 3D points with a very high point density in a short time. For this reason, it is a valuable alternative or complementary technique for classical topographical measurements based on total station or digital photogrammetry. To get the complete 3D model, multiple shots must be taken from different directions that provide data from all sides of the building. These scans are integrated into a common reference system so that through a process of aligning the information obtained in all the stations, a complete model is achieved in a single file. This model faithfully reproduces the current volume of the building, including its deformations and collapses, and provides very precise information from which to make its geometric survey. With the aim of making a graphic survey of the farmhouse located in the UPV campus, current headquarters of the CEDAT Foundation (Service for Attention to Students with Disabilities), a 3D laser scan was carried out in March 2019. This paper describes the methodology of laser scanning, the specific step during scanning and the possibility of create 2D documentation from 3D model point clouds.

KEY WORDS: *3D modeling; Point cloud data; 3D laser scanner; Digitizing; Reality capture.*

1. INTRODUCTION

The continuous advance in the field of electronics allows us to increasingly access a wide range of solutions and tools that were once unimaginable.

The 3D laser scanner is a clear example of innovation and advancement, being a powerful and incomparable measurement tool that arises from the field of topography and it is more frequently present in the building, refurbishment and architectural heritage sector (Pukanská, 2012).

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It offers multiple advantages in measurement or data collection. These include precision, quality and speed, in addition to its versatility, simplicity and scope. It is a highly efficient tool as it reduces field work time.

As a result of the scan, a point cloud is obtained that represents a copy of reality at a 1:1 scale from which the most diverse information about the generated virtual model can be obtained, such as high resolution orthophotos, measurements in true magnitude, integration of the point cloud in BIM software, virtual tour of the model or even 3D printing (Mesároš & Mandičák, 2017).

Figure 1. 3D laser scanner and placement of spheres in the farmhouse.

The building under study is a farmhouse located in the Polytechnic University of Valencia, called "Mas del Noy". This house is from 1880, it was a farmhouse with two floors where the land was cultivated, it had a well, a doghouse and a small garden with a table under the trees. A ditch ran along the edge of the house and the orchards. This was how it remained until July 1998, when the University ceded the old farmhouse to the CEDAT Foundation. Nowadays it is the headquarters of the Foundation and the Special Employment Center. Its refurbishment, achieving total accesibility, was an arduous task, but currently it is a benchmark within the University (Azulay Ahuir, 2015).

2. METHODOLOGY OF LASER SCANNING

The scanning process can be divided into three stages: scan plan, data collection and data processing.

2.1. Scan plan

A scan plan is a set of information that describes the scope and approach that will be taken to capture the data at the site. A scan plan should be made after setting the project goals.

Many times a scan plan begins with a detailed analysis of what elements need to be captured. In the case of scanning a building for the first time, you will want to capture the position of all the elements. In the case of continuing with a work started previously, it is possible to set specific work areas on which more information needs to be collected.

Identifying the exact target of the items to be analyzed helps the field team to prioritize their efforts and reduce the time spent capturing unnecessary data. With a clear goal in mind, a document can be created that identifies the optimal location for each scanning station.

2.2. Data collection

Before starting the configuration it is important to check that there is a SD card inside the scanner to record the data.

Scan parameters can be changed from settings at any time during scanning. The main parameters include creating a scan project, selecting a scan profile indoor and outdoor and setting resolution and quality.

Figure 2. Data collection at the rear of the building.

It must be taken into account for the location of the reference points that mathematically three common references are needed between two consecutive scans. However, a higher

number of common references per scan will improve the registration results, making it easier and less likely to be error.

The scanner used is Faro Laser Scanner Focus 150. Scene, which is the software that Faro technology uses, allows the union of point clouds by points, by planes or by spheres (FARO Laser Scanner Focus3D, 2019). The spheres used as a markers should not be positioned symmetrically with the building. They must form a polygon around the scanner and have varying distances to it. The ideal thing is to place them at different heights, distances and planes.

The number of stations depends on the size and shape of the building. The scanning time depends on the number of stations, the quality and resolution, the complexity of the scanned building…

2.3. Data processing

The immediate result obtained from the laser scan is a series of point clouds. Each point is represented by coordinates (x,y,z). All point clouds are recorded together in a common coordinate system, resulting in a single point cloud.

Once the complete point cloud is obtained, unnecessary information is eliminated such as people, equipment, surrounding buildings, trees or noise, and then the color is applied (in the case of having scanned in color and not in black and white). Once all the previous steps have been carried out, the project documentation can be prepared by starting the preparation of plans (Tkáč et al., 2018).

3. CASE STUDY: A FARMHOUSE AT POLYTECHNIC UNIVERSITY OF VALENCIA

The main aim in this project is the preparation of ground floor plans to study a possible redistribution of space. The interior on the ground floor and the entire exterior perimeter are scanned. In this way, we can draw the thickness of the walls and the position of windows and doors on facades (Hrozek et al., 2012).

Regarding scan parameters, in our case we chose indoor to 10 meters, resolution 1/5 and quality 4x which took us an approximate scan time of 8 minutes; for outdoor more than 20 meters, resolution 1/4 and quality 4x with an approximate scan time of 12 minutes in color.

We decided that the first position of the scanner will be in the interior, actually it didn't matter if the first position was indoors or outdoors. We started in the old block (current meeting room), as we can see in the Figure 3 positions 1 and 2. We continued in the stairwell area towards the exit door (posititons 3 and 4). The connection of the interior with the exterior is very important and delicated. A mistake in this union will imply that the wall thicknesses will be wrong, among other things. Interconnection through the windows was very complicated only possible through the door. This was a very specific and very important step during scanning. In the exterior we continued around the building

(positions 5 to 14). The total scan time was three hours. This time consisted of installing the scanner, deployment of reference spheres and also changes in positions of the scanner and markers. The positions of the reference points were often different because we had available just five pieces of reference sphere. Due to this, in the union of point clouds we had to also use planes and not only spheres.

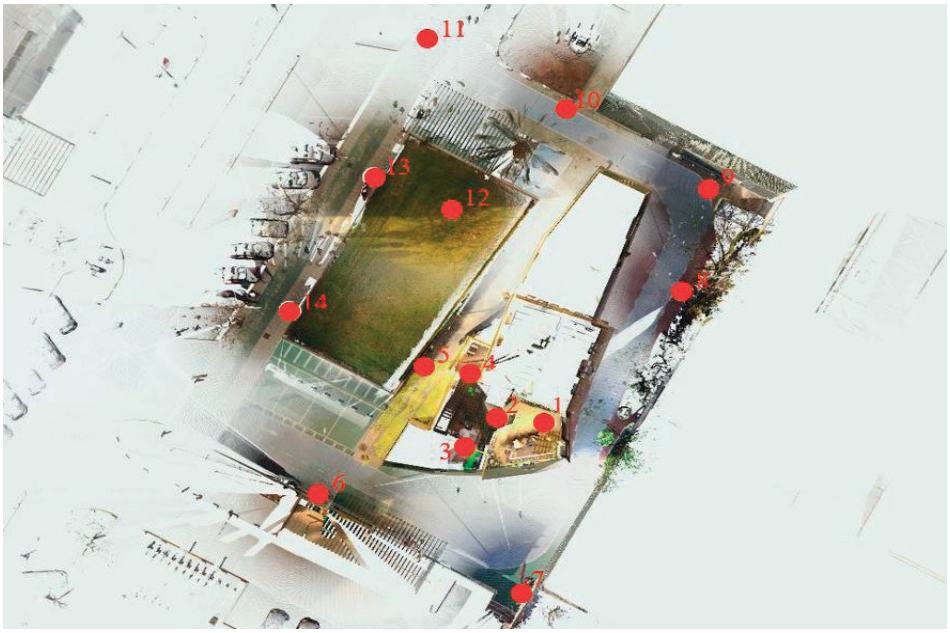

Figure 3. Fourteen positions of the laser scanner.

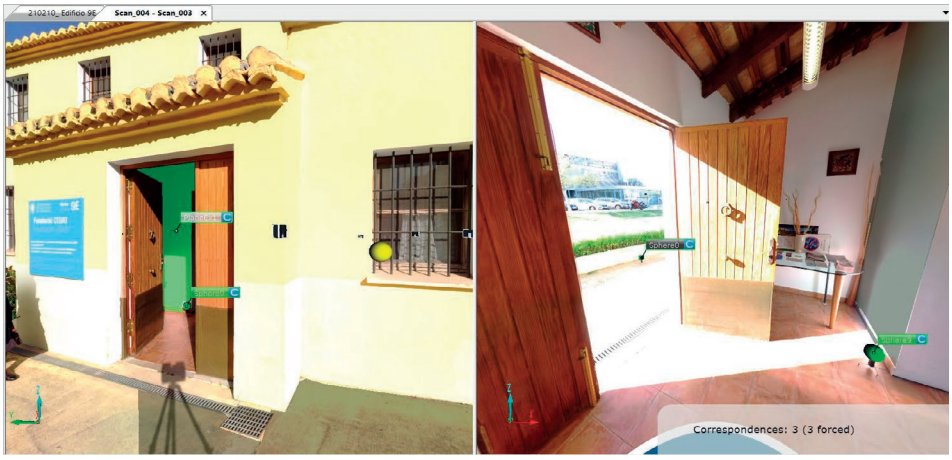

Figure 4. Interconnection between interior and exterior.

We must do the office work once the field work is finished. This work consists of the union of point clouds using Scene software. Each point cloud is joined with the next one by selecting common references that can be spheres, planes or points, as we can observe in Figure 4.

Figure 5. Complete cloud of the farmhouse and its surroundings.

This program offers simple measurements, coloring the point clouds, deleting unnecesari points and export the complete point cloud to various formats. We use the RCP format in order to import the point cloud into a CAD program, the program we work with is Autocad.

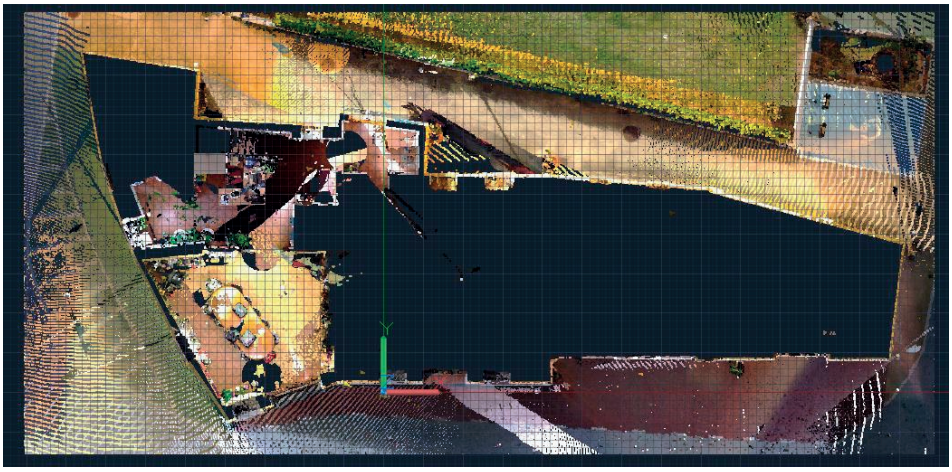

Figure 6. Elimination of redundant points.

This software allows us to make countless sections in the complete point cloud and draw the 2D plans that interest us generating them in a short period of time. Façade, floor plans, sections and details can be elaborated simply by making cuts to the complete cloud and drawing on top of them using them as a template.

Figure 7. Main façade of the building.

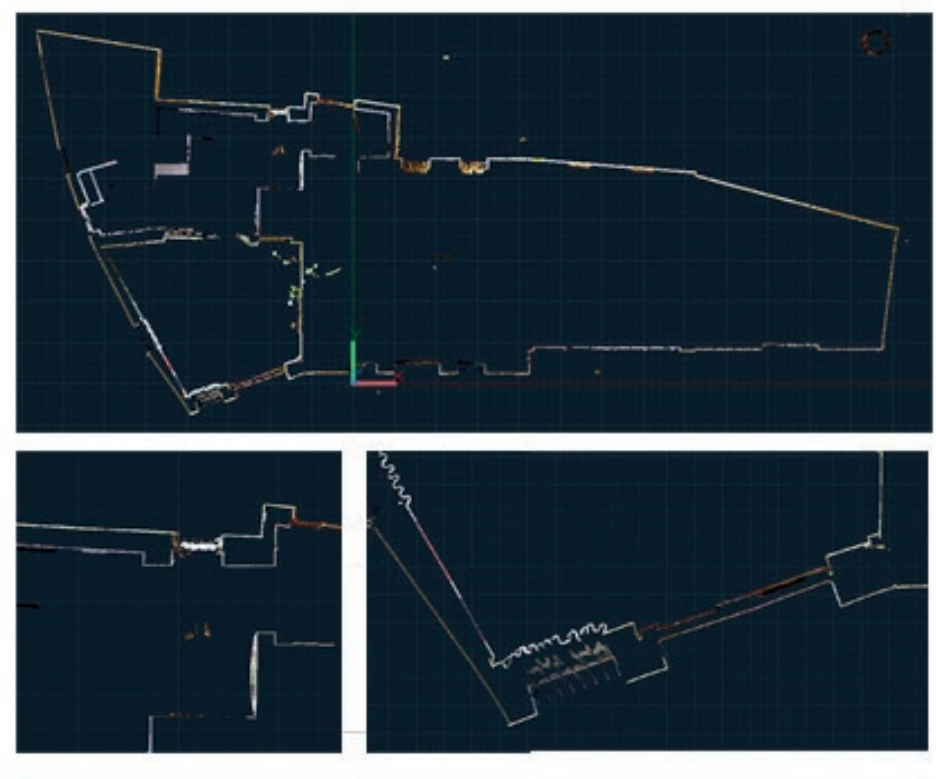

Figure 8. Preparation of floor plan and details.

4. CONCLUSION

This paper shows 3D laser technology as a state-of-the-art tool for drawing with great precision plans of traditional buildings. It has been described step by step how to prepare the graphic documentation of the farmhouse located at the Polytechnic University of Valencia. There is no doubt that the 3D laser scanner is a very effective tool to carry out graphic surveys of the current state of historic buildings.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

AUTHOR CONTRIBUTIONS

M-P.J: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Visualization. **A-C.A**: Conceptualization, Validation, Investigation, Funding acquisition, Writing - review & editing, Visualization, Supervision. **M.A.**: Formal analysis, Methodology, Software; Supervision; Validation. **F.H.M.**: Formal analysis, Methodology, Software; Supervision; Validation.

All authors have read and agreed to the published version of the manuscript.

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