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Representation of a three-dimensional integrated survey of the Casa De Vidro by Lina Bo Bardi in São Paulo, Brazil

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Abstract - This paper describes the method and the process used for the representation of the integrated digital survey of the Casa De Vidro by Lina Bo Bardi in São Paulo (Brazil), carried out in 2017 by the DIAPReM (Development of Integrated Automatic Procedures for Restoration of Monuments) Department Center of the University of Ferrara. It is part of a Master's degree thesis which had as its objective the valorization of the site as a museum. After a brief description of the house and an introduction to the thesis work, the text describes the characteristics of the laser scanner survey and the method of extracting raster images as a support for architectural drawings. Subsequently, the strategy of representing the complex topography of the site is explored, aiming at the production of the situation plan. Given the importance of the tropical garden that surrounds the house, a further study concerns the representation of the vegetation on the vertical plane. The process that leads to the vectorization of the profiles of the landscape starting from the extractions from the point cloud is described in detail. Then it is exposed the treatment of the raster image with the visualization in false colors of the reflectance data through filters to bring the colors to shades of green. By assembling the trees together, it is possible to get drawings that best represent the vegetation and the insertion of the architecture in the tropical garden. It is noted that, due to the high density of trees, it would not be possible to create a representation corresponding to each one of them. These circumstances forced to choose specific specimens and to repeat them in the overall elaborates.

Keywords - survey, point cloud, representation, Casa de Vidro, garden, trees.

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INTRODUCTION

Casa de Vidro ("Glass House" in Portuguese) is the first built project (between 1949-1951) by the Brazilian architect Lina Bo Bardi. It was the private residence of her and her husband, Pietro Maria Bardi, the curator and founder of MASP (São Paulo Museum of Art). Located in the Morumbi district, São Paulo, it was not only a house, but also a meeting place for artists and intellectuals, and is considered one of the masterpieces of Brazilian modern architecture. As many observed, *Casa de Vidro* is an emblematic architecture in which the main themes that will characterize the later works of Lina Bo Bardi can be traced, like the relation between architecture and nature and the tension between modernity and tradition (Acayaba Milan, 2011; Lima and Bergdoll, 2013). In fact, the house, built on a plot with a complex topography, can be described as a hybrid architecture: public spaces are hosted in a transparent part sustained on steel *pilotis* while private rooms and services areas are located in an opaque one, with a Mediterranean language, well rooted on the ground.

Today it houses the *Instituto Lina Bo and P. M. Bardi*, which cares for the architect's archive and has started a process of converting the house into a museum. The objective of the thesis, from which this work is taken, is the study of a possible new use of the entire site, consisting of the villa and the tropical garden in which the atelier, the garage and the caretaker's house are immersed, aiming at preserving and opening to visitation all of the House's spaces. To achieve this goal, it has been proposed an addition to the rear of the property, designed to displace the offices and the archive of the institute currently located inside the house. It was fundamental to the project an accurate representation of the survey of the architecture and of the garden, the object of this paper.

In 2017, as part of the program financed by the Getty Foundation, an integrated diagnostic survey was

carried out on the site of the *Casa de Vidro* by the DIAPReM of the University of Ferrara, in order to evaluate the conservation conditions of the artefact and the possible insertion of a new museum architecture in the lot. Starting from this survey, drawings were produced in order to describe the conditions of the site with high precision.

METHODS AND RESULTS

The objective of the work exposed in this paper is to produce drawings of the Casa de Vidro inserted in the context. As reported by DIAPReM (2017), from the three-dimensional survey, a high-precision metric-morphological point cloud model was developed that can be used to investigate the formal, geometric and surface characteristics of the architecture. The survey was carried out by integrating time-of-flight laser scanner technologies, used to obtain a 3D metric model, in which each detected point is defined by the x, y, z coordinates and by the reflectance data, with a topographic one, used for the registration of scans and for the definition of a topographic net. Moreover, a macroscopic diagnostic survey was carried out for the definition of the conservative state of the surfaces integrated with the analysis of the reflectance data of the point cloud (DIAPReM, 2017).

In total, 197 scanner stations were performed, and 8,430,499,869 coordinates were acquired. The registration was done with the Leica Cyclone software. The point cloud model obtained, together with the photographic documentation, served as a basis for drawings. The representation methodology was based on the production of vector polylines starting from raster images extracted from the point cloud ("orthotiff"), both for horizontal and vertical sections. The extractions were generally two (slice and half-plane) and designated to each drawing. In addition to the extractions to draw plans, elevations and sections of the architectures existing in the lot, 14 overall vertical sections of the entire lot were made, in order to represent the elevations of the house and its relationship with the hill, along with 51 overall horizontal sections of the hill at regular intervals of 50cm for contour lines design, in order to represent garden's altimetry, and 26 horizontal extractions at different heights of the lot, aimed at displaying the garden in plan.

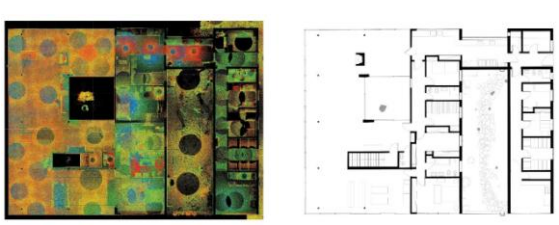

Figure 1: First floor plan of the *Casa de Vidro*, point cloud extraction and drawing. Author's elaboration, 2018.

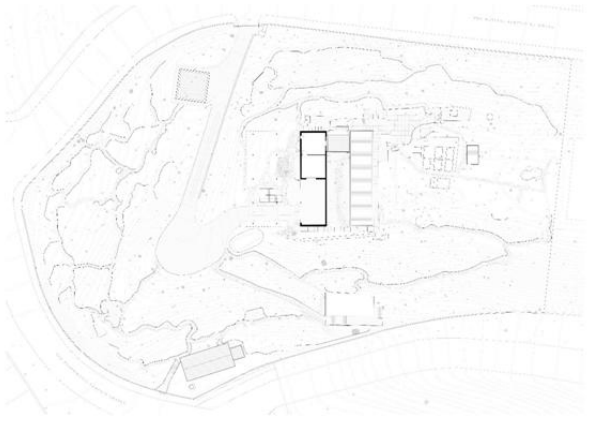

Figure 2: Plan of the site of *Casa de Vidro*. Author's elaboration, 2018.

Due to the steep elevation of the site, it is not possible to use a single horizontal section plane for the planimetric representation, because there would be the coexistence of (i) a part in which the projected foliage would be visible, hiding everything that is below it, (ii) a part where the garden with the lowest vegetation, the paths and the retaining walls would be visible and (iii) a part where the terrain of the hill would be cut and there would be no useful information. To produce a description of the entire garden it was necessary to do multiple extractions at different heights and consider only the most significant part, translating the section plane to proceed the drawing to the adjacent part. Thus, the situation plan was produced in which the vegetation trunks are all sectioned at the base, just above the root system, which sometimes emerges from the ground. In this way, the exact position of each tree was identified. Since many specimens of this garden have grown with the stem tilted, it would have been misleading to cut at a higher altitude, in relation to the scale of representation chosen (1:200).

Considering that the tropical garden in which these architectures are located is an element of great value, strongly characterizing the entire complex, the descriptive drawings of the *Casa de Vidro* would not be complete and sufficiently exhaustive without an adequate representation of the green component. The three-dimensional high- definition survey model has sufficiently precise data to know the morphological characteristics of the vegetation present. As seen before, regarding the planimetric representation, it is possible to identify the exact position of the tree trunks. On the contrary, in the elevations, the data is not so defined, especially regarding the foliage. In fact, due to the proximity between the various trees, there is a fairly in-depth detail regarding the trunks and branches in the lower part of the crown, especially if it is of substantial size; as for the fronds, often only the overall mass is appreciable and they are almost always confused with those of the adjacent trees.

To overcome this representation problem, significant specimens were identified, represented with both

vector and raster graphics taken from the point cloud, which were repeated to give the general sense of the green mass. From the three-dimensional model we moved on to the two-dimensional wireframe drawing, tracing in AutoCAD the outline of the tree trunks and branches with a polyline (Parrinello, 2009).

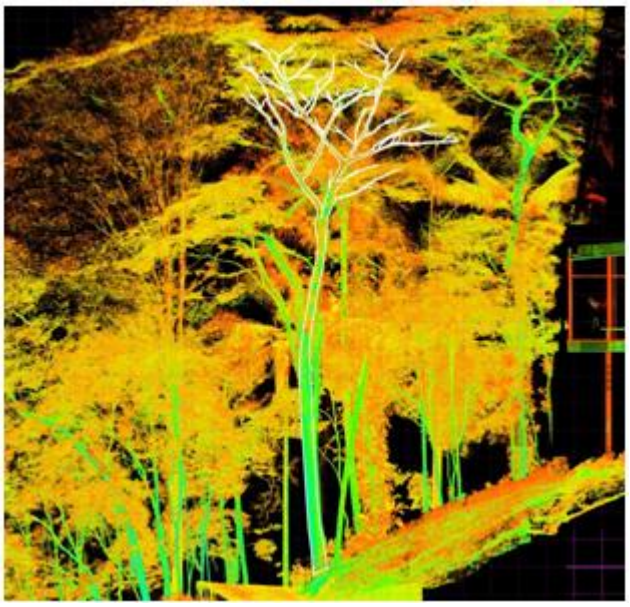

Figure 3: Process of tracing trunk and branches of a tree. Author's elaboration, 2018.

Both in terms of adding the bulk of the foliage and the chromatic data, which enriches the design of the green and helps to convey the atmosphere of the site, Photoshop was used. In the absence of the RGB photographic data of the point cloud, the colors were obtained by applying filters directly on the raster image of the cloud in false colors, one green for the yield of the foliage, one brown or gray for that of the trunk. To give three-dimensionality to the trees, points of light and shadow have been added. By assembling the trees in the sections and elevations, the effect of depth was obtained by simulating the aerial perspective, lowering the opacity of the plants in the background, which are lighter than those in the foreground.

Figure 4: Tree drawing process: adding the foliage and color filters in post-production. Author's elaboration, 2018.

Figure 5: Final image of the elevation of Casa de Vidro in its tropical garden. Author's elaboration, 2018.

CONCLUSION

Although nowadays it is possible to connect the point cloud model within some CAD software, in order to interrogate and dissect it directly in the same work environment in which the vectorization of the image takes place, the well-established method of representation described in this paper simplifies the relationship between vector drawing parts of raster material-environmental description. This method proved to get a better representation of the garden, so an attempt was made to extend a representation method applied to urban greenery, characterized by isolated specimens, to a garden left to grow deliberately uncontrolled, in a forest similar effect. Consequently, a way was sought to overcome the limit imposed by specific circumstances in order to obtain an effective communicative result, rather than scientifically correct in each phase. Thus, it was tested to where point cloud extractions can be manipulated for the representation of complex green spaces

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