MONITORING THE HISTORICAL MONUMENT "CURTEA VECHE" USING TERRESTRIAL LASER SCANNING

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ABSTRACT

Throughout time, a series of methods have been developed for space point upheaval, commencing with the tahimetric methods, where the upheaval was created point by point, with attributes for each point, up to the mass upheaval of the object points through photogrammetric methods and through laser scanning. The timing for the punctual quantization of the objects and for inserting attributes to each point of the tahimetric methods, is very large comparing to the photogrammetric methods and to the laser scanning, which secure a rapid take over, but without attributes. Laser Scanning is a new geodetic technique, through which the geometry of a structure can be measured completely automatic (more or less), without the aid of the reflecting methods, with a high speed and a high accuracy. The result of the measures is represented by a (considerable) multitude of points, which in the specialized literature are called point cloud.

MATHERIAL AND METHOD

The present paper presents a practical way of creating a 3D visualization of a historical monument, more precisely of the Historical Complex “Curtea Veche” in Bucharest. For the realization of this paper two G.P.S receptors on a tripod were required, a total station and a laser terrestrial chair with a fix position to which the reference points, or the targets have been added. The laser used was of type TOPCON. The precision of the point of determination is ±3 centimeters, absolute position. The coordinate system used is the national one, precisely the 1970 Stereographic.

The following steps have been covered in the realization of the archaeological site:

- Establishing the object (objects) to scan;
- Establishing the optimal distance towards the object in order to obtain the best precision according to the proposed scope;
- Establishing the stations from which the object will be scanned so that no areas would remain un scanned and that they can be calculated as a position;
- Marking the references on the scanning zone;
- Scanning the object from each single station;
- Measurements to determine the geodetic and the reference network; calculating the geodetic and reference network.
- Calculating the coordinates for the cloud of points. Processing the data with special programs in order to obtain the scanned object.
- Interpreting the results.

RESULTS AND DISCUSSIONS

The case study has been focused on the following points:

1.Establishing the object to scan. In order to create the whole digital model of the building, the need to scan both the exterior and the interior of the historical monument “Curtea Veche” in Bucharest has been determined.

2.Establishing the optimal distance towards the object in order to obtain the best precision according to the set purpose. It was decided that the exterior will be scanned at a distance of maximum 10 meters, and the interior according to each room, but for no more than 10 meters. Where the rooms were very big, it was established to increase the number of stations.

3.Establishing the stations from which to scan the object so that no areas will remain un scanned and they could be calculated as a position. As it has been mentioned, the scanner projects a beam of laser rays that perfectly outlines the shape of the studied object.

In order to establish the stations the following has been taken into account:

-each single station has to be connected to the coordinate system in which the work will be carried out;

- the object will be fully scanned, both on the exterior and the interior, including the superior part, and under each station, where it will be necessary to supplement them.

In this case, the stations have been established according to the below image (Figure 1). The stations marked in red are outside the perimeter, the ones marked in green are within the perimeter.

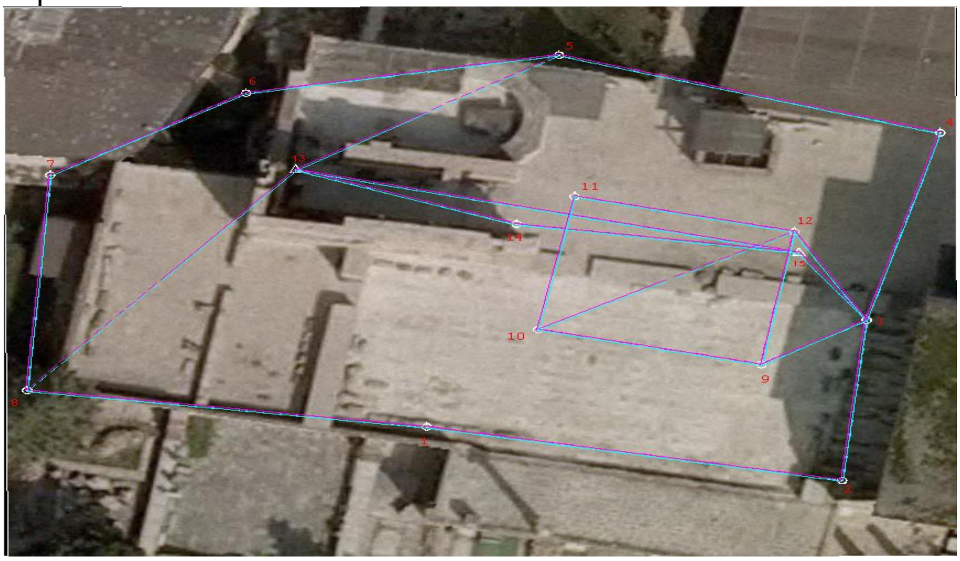

Figure 1. The blueprint of the scanning and the thickening network

After this has been realized, the positions of the stations have been materialized with metallic bolts according to the standards in force.

The millions of points (or the could of points, as this is called in the specialized literature), which projects the shape of the object, are defined by the space coordinates in a reference system. Independently from the chosen system of coordinates, the clouds of points needs to be defined in the same system. For this to be carried out, it is necessary that the station point above which the scanner is set to have a position defined in that system of coordinates.

4.Marking the references on the scanning area. Similar to aerial photogrammetry and classical terrestrial photogrammetry, points of landmarks are needed in order to scale the scanned object, points of reference (control) are necessary, or fix points as they are called in the specialized literature.

Three points of reference are necessary for any cloud of points obtained from a station.The points of reference are determined with the help of the total stations based on the points where the scanner was positioned (Figure 2). The coordinates of the points of reference have to be in the same system as the coordinates used to create the support network or the traversing.

Figure 2 Photogrammetric landmarks. Red – landmarks on a wall; blue - landmarks on another wall of the same room

Figure 3 Methods to mark the landmarks

The landmarks can be certain details from the scanned object or they can be proper markings (Figure 3). If details are chosen from the scanned object, these have to be point like and unmistakable (perfectly defined). The smaller the dimensions of the bench, the smaller the error with which the object is presented. Normally, if we want to obtain 3 millimeters of error, the landmark has to be 1-2 millimeters and its determination error from the base station also for about 2 millimeters. It is more indicated that the landmarks be planted on the object before the scanning, in order to have them determined after in coordinates.

The landmarks have been determined simultaneously with the conducted measurements in order to determine the position of the support points (of the station) through radiation.

5.Scanning the object from each single station. After establishing the position of the stations and marking (establishing) the landmarks, each point of the station is being stationed with the scanner.

This is programmed to scan the interest area. Practically the position from which the scanning starts is being established as well as the one where the scanning stops, so that the whole building is being covered.

For each station, the scanner is connected to a laptop. The operator can select the area for which the necessary data has to be captured. The scanning is started immediately, the remaining time until the finalization of the scanning is indicated by the program. It only takes a few minutes in order to collect the desired image. The scanning stops when all the projected points have been stationed and when the correct data has been collected from each point. It has to be considered that the area underneath the tripod cannot be scanned on a radius equal to the height of the device. Due to this, complementary stations have to be projected in order to scan the mentioned area.

The scanning has been conducted from the stations in Figure 4.1 and they have entirely covered the historical complex both on the internal as well as on the external part.

6.Measurements to determine the geodetic network and the landmarks; calculation of the geodetic network and that of the landmarks. After the scanning, the network of stationed points and its landmarks has been determined. The measurements have been conducted with total stations. Three series have been measured, in order to secure the necessary precision to determine the landmarks, while all the directions have been measured, as well as the determinable distances.

Through the GNSS technology, the ROMPOS method, two points sent on the terrace of the historical monument, respectively points 13 and 15. Considering that a very good precision is necessary, precisely of millimeters, it has been recommended that the ROMPOS determinations on a single point be repeated so that the necessary precision could be achieved. The coordinates have been directly determined being registered in the memory of the receiver. From these points a geodetic network was developed which had a number of 13 new points, respectively 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, and 14.

The measurements of directions and distances have been centralized in tables that have not been included in the table due to lack of space, also the compensation through the method of the least squares, indirect measurements.

The average precision for determining the network was of ± 5 millimeters. This precision is very good and constitutes the base for determining the landmarks. The landmarks have a more reduced precision than that of the base network.

GNSS bases have been measured, as it emerges from the above discussion, which have brought the coordinates of the geodetic network in the interest area, along with it the total station directions and distances have been measured in order to determine the coordinates for the points of the geodetic network for supporting the landmarks.

The calculation of the station points has been made through the method of the least squares, in discrete measurements.

7.Calculation of the coordinates of the points cloud. Processing the data with special programs in order to obtain the scanned object. Having the coordinates of the station points and those of the landmark points, the coordinates have been determined (three-dimensional position) of each point from the cloud of points for each single station.

After calculating the last station, each point from the cloud of points has been placed on its real position. In this way, the scanned object has been recomposed. The end of the paper is presented in the movie resulted after finalizing all the calculations. It has been take account of the so-called “noises” which can induct errors in the final result, (objects that are not part of the actual building, persons caught in movement during the scanning, etc.).

CONCLUSIONS

The results of such a paper have to be correct. Technology seems very simple in a first instance, the programs are very well made, but the results can be spoiled.

There is also necessary to have the certainty that the result is correct and fits with the required precision. The controls are available to those that execute the work.

A work is not finalized if the necessary controls have not been conducted. Firstly photos have been taken which confirm the real situation, following, the points of control have been verified through probing through measuring the distance among them with a measuring cord and then compared with the length from the cloud of points.

The result of the measurements processed and finished is the 3D image of the objective, presented also in the movie of the attached file.

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