University Buildings Conservation Using Terrestrial Laser Scanning Technique

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ABSTRACT

Laser scanning is a new measurement technique through which can be recorded, fully automatic with high precision and speed. In documenting of existing buildings and facilities, knowing the geometry of the object is the most important. Old university buildings are icons from the past that exist in present time. In order to preserve this heritage for the future generation, recording and documenting of university buildings are required. With the development of information system and data collection technique, it is possible to create a 3D digital model. This 3D information plays an important role in recording and documenting old buildings. The purpose of this paper is to achieve the objective, namely, achieving 3D digital model of a university building located in the USAMV Bucharest campus. Examining the building, which has existed for over 80 years has a fairly high level of degradation, requiring investigation overall. Digital model has the role to graphically restore, as closely as possible the objective scanned, obtaining all the necessary information for this old building. Through this research, a proper database for storing and documenting the university buildings conservation data will be developed in order to attempt to register them in UNESCO patrimony.

Keywords: Educational building, Leica Scan Station, point clouds, terrestrial laser scanning, UNESCO patrimony.

INTRODUCTION

The definition of heritage conservation is to preserve, conserve and protect buildings, objects or other artifacts of historic significance.

Recording and documenting old university buildings are important in preserving information for future generations to learn about the past. There are many methods that are used in recording and documenting process of old buildings such as using surveying technique, digital photogrammetry technique (can produce high resolution textured 3D model based on their pictures), and the latest technology is active sensor – laser scanning (can create high resolution geometric model in 3D point cloud). During the generation of 3D models, requirements such as high geometric accuracy,

availability of all details, and efficiency in the model size and photo practicality have to be met by the different approaches used for data collection (Chellini *et al.*, 2014, Pellegrinelli *et al.*, 2014). One well-accepted technique frequently applied in the context of heritage site documentation is close range photogrammetry and laser scanning. Furthermore, laser scanning has become a standard tool for 3D data collection for the generation of high quality 3D models of cultural heritage sites and historical buildings (Basir *et al.*, 2013, Bednarz *et al.*, 2014, Herraiez *et al.*, 2014 Mario *et al.* 2008, Xu *et al.* 2014).

Laser scanning is a new measurement technique, through which can be recorded, fully automatic, the structure geometry without

reflector with high precision and speed. The measurements result is represented by a set of points, called points cloud (Chen *et al.*, 2014, Coșarcă, 2009, Yang *et al.*, 2014).

During data collection the information on edges and linear surface features like cracks is based on the analysis of the images, whereas information on object geometry is provided from the laser data. Computers provide us easier and faster storing, retrieving, and sorting information capabilities than traditional tools. By constructing a 3D model of a building, we are actually making a digital database of the building. Documentation must be able not only to qualify the geometric and formal characters of these architectures, but also to detect and to end up evaluating and present damages at the old buildings (Basir *et al.*, 2013, Calin *et al.*, 2014, Erghelegiu *et al.*, 2014).

The target of this paper is the chemistry laboratory building located on the campus of the University of Agronomic Sciences and Veterinary Medicine, 59 Mărăști Blvd, Bucharest (Fig 1.a).

The laboratory was initially a building with basement, 1E and attic, built between 1925 and 1927 (Fig.1.b). Because the building is a university laboratory fall into IInd Class of importance, respectively in “building whose seismic resistance is important.” For this building there is no technical book, also there is no other documentation regarding any changes or consolidation of the building (excluding the current 2nd floor built from 1964 to 1966), which have been made so far. In 2008 was made a technical expertise on the building, but the proposed consolidation works were not implemented.

Examining the building, which has existed for over 80 years, had a good behaviour over time, but currently has a level of degradation rather large (Fig.2), requiring an overall investigation. Romania has economic developments and for that require land obtained trough demolishing of old buildings, ignoring heritage preservation, resulting conflicts. Due to the increasing of student population and high demand on academic facilities, the university

Fig.1. a) Target site; b) Chemistry laboratory building, built between 1925 and 1927.

Fig.2. Main entrance of the building - damages.

Fig.3. a) Leica SR20; b) Leica TC407.

is undergoing a structural change. The university wants to preserve its structural history in digital form, which can be retrieved at any desired time and form for future generations.

MATERIALS AND METHODS

Data acquisition

In order to achieve laser scanner measurements, it was necessary to create a major control network.

Due to the configuration of the land we concluded that the best network is a closed traverse, which is why we started to create a database with GPS. The GPS used is Leica SR20 (Fig. 3a) with a wave length (L1), was stationed at the same time with a receptor in the point D1 and with another similar in the point D4. Measurement session lasted about 40 minutes, and the data thus obtained were reported to BUCU station with known coordinates, located approx. 4km away, and resulting errors in processing fits in tolerance.

In this way the points D1 and D4 were determined in 1970 Stereographic National System, then with Leica TC407 total station (Fig.3b) and using the points mentioned as starting points, was created a traverse with four

new stations denoted by S1, S2, S3, S4. Mention that Leica TC 407 total station, with accuracy 7", thus ensuring accuracy class necessary to perform measurements under optimal conditions.

Processing of GPS measurements was performed with GNSS Solutions software and ones made with the total station were downloaded using Leica Geo Office Tools program, obtaining coordinate file of measured points.

Finally we use Leica ScanStation 2 laser scanner (Fig. 4) in all 6 points of the traverse, to scan the building, yielding six ScanWorld (Fig. 5). They have been processed using Cyclone 6.0 and 3DReashaper (Fig. 6 a) and b)).

As a data acquisition method, the stationed points were characteristic that were positioned such that the laser scanner to have visibility to common targets in the measuring process and also the measurement accuracy was set at 2 cm.

Data processing was performed in several steps using as contact points the ones determined from the major control network and also the targets fixed on building facades (Fig.7).

Data processing

This stage started with the basic tasks such as creating database project and imports the

Fig.4. Leica ScanStation 2.

Fig.5. Chemistry laboratory building – the 6 ScanWorlds.

a)

b)

Fig.6. a) Point cloud in Cyclone 6.0; b) Point cloud in 3DReashaper.

Fig.7. Targets used in scanning process.

ScanStation 2 Data. In this stage, point cloud data was checked and unnecessary point cloud will be deleted from database. Before the registration, is needed to verify the quality of the black & white and HDS targets. If the quality of target used is not good enough, the errors in registration process will become bigger. In this research, there were 6 ScanWorlds that have been registered to cover the whole laboratory building. All this 6 ScanWorlds were made at the exterior of the building. All the ScanWorlds have to register in one coordinate system to complete the visualization model of laboratory building. After the registration, data filtering process was carried out to remove the unnecessary point cloud that block the building.

Registration

Registration is the process of combining a project's ScanWorlds into a single coordinate

system as a registered ScanWorld. This integration needs pairs of equivalent tie-points or overlapping point cloud that exist in two ScanWorld. The function of Cyclone software was used to register the point cloud data (6 ScanWorld, around 6 million points) and produce a 3D visualization model. In this registration process, function of Auto-Add Constraints has been used (Fig.8).

By using this function, Cyclone will find all ScanWorlds' ControlSpace for objects with the same registration labels and it will be automatically pairs. The errors of the registration will be shown in Constraints tab menu (Fig.9). After the registration process success, this registration needs to be in freeze registration mode. This mode will not allow any further manipulation of the data that have been registered. After that, the ModelSpace must be carried out to view the

Fig. 8. Registration process - Auto-Add Constraints.

Fig.9. The errors of the registration shown in Constraints tab menu.

Fig. 10. a) The ModelSpace resulted after Registration; b) Complete 3D model of "Chemistry laboratory".

combination of all scan stations that have been registered in one coordinate system (Fig.10a).

Once the ModelSpace was created, complete 3D model of "Chemistry laboratory" building was loaded (Fig.10b). In this project, the result from registration process had 0.002 error value and this value is considered as acceptable.

RESULTS AND DISCUSSIONS

In documenting of existing buildings and facilities, as well the restoration of historical monuments, knowing the geometry of the object is very important. The purpose of this paper is to achieve the objective, namely, achieving three-dimensional digital model of the Laboratory of Chemistry. Digital model resulted from the point cloud modeling is a simple model, made using data collected on field. This model has the role to graphically restore, as closely as possible the objective scanned, obtaining all the necessary information for this old building.

3D model development

After the registration process is carried out, the next process is the development of 3D models of Laboratory of Chemistry. 3D building model of the building has been developed by using 3DReshaper software based on the point cloud

which has been registered in the Cyclone software. 3DReshaper software has been chosen to generate 3D model because this software provide tools to create simple 3D model to complex 3D model.

Each point data in the point cloud become a guideline for the construction of 3D model includes height, roof, walls, heritage design and others. Figure 11 show the example of point cloud that has been exported from Cyclone into 3DReshaper.

3D model for building conservation

For 3DReshaper software, the result from the construction of 3D models of Laboratory of Chemistry is as shown in Figure 12. It can produce a 3D building model along with the heritage design of the building. The building model has the proper structure and size because during generation of 3D building model process, measurement of the height and width is based on measurements that obtained from point cloud model.

The terrestrial laser scanning technique, besides the fact that it provides a fast solution for digitizing real world objects, provides a complete data set, easy to interpret, not only because of the points cloud, but also of recorded images. Thus, leads to a complete plan, with the radiation of all existing details from the field without any possibility of accidental omission of any detail.

Fig.11. The point cloud exported from Cyclone into 3DReshaper.

Fig.12. The construction of Laboratory of Chemistry 3D model.

In conclusion, laser scanning method is a modern technology successfully used in preserving old buildings.

CONCLUSIONS

Preserve or demolish? It is impossible to preserve all the old buildings and not having any developments. The work described in this paper was develop as a part of an ongoing research, which aims to underline the necessity to integrate image based and technology of laser scanner in order to optimize the geometric accuracy and the visual quality of 3D data captured in order to preserve, conserve and protect all buildings from U.S.A.M.V.B campus. By the combination technology of data collection and data documentation, the GIS database that plan to develop will meet the requirement for buildings conservation. In addition, we were seeking a better understanding of managing and integrating architectural and system for heritage recording purposes in the UNESCO patrimony. This includes exploring new concepts, tools and methods to streamline the digital recording and documentation process.

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