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3D MODELI OBJEKATA U PROCESU REKONSTRUKCIJE

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Apstrakt:

Poslednjih nekoliko godina terestričko i avionsko lasersko skeniranje je postala moćna tehnika za brzo i efikasno trodimenzionalno prikupljanje podataka za različite vrste objekata. Vazdušni laserski sistem (LiDAR) prikuplja tačne geometrijske podatke jako velikih područja za vrlo kratko vrijeme dok terestrički laserski skener prikuplja guste i geometrijski tačne podatke. Kombinacija ova dva segmenta laserskog skeniranja obezbjeđuje različite oblasti primene. Jedna od primena je i u procesu rekonstrukcije objekata. Objekti snimljeni tehnologijom laserskog skeniranja i pretočeni u konačni model predstavljaju osnovu za izgradnju objekta onakvog kakav je bio u svom prvobitnom obliku. U ovom radu će biti prikazane dvije studije slučaja zasnovane na upotrebi terestričkog i avionskog laserskog skeniranja i obrade podataka dobijenih istim.

Keywords: zgrade, lasersko skeniranje, rekonstrukcija,3D model

3D MODELS OF OBJECTS IN PROCESS OF RECONSTRUCTION

Abstract:

Within the last years terrestrial and airborne laser scanning has become a powerful technique for fast and efficient three-dimensional data acquisition of different kinds of objects. Airborne laser system (LiDAR) collects accurate georeferenced data of extremely large areas very quickly while the terrestrial laser scanner produces dense and geometrically accurate data. The combination of these two segments of laser scanning provides different areas of application. One of the applications is in the process of reconstruction of objects. Objects recorded with laser scanning technology and transferred into the final model represent the basis for building an object as it was original. In this paper, there will be shown two case studies based on usage of airborne and terrestrial laser scanning and processing of the data collected by them.

Keywords:buildings, laser scanning, reconstruction, 3D model

1. INTRODUCTION

Laser scanning is one of the leading data sources that can be used in different areas. By its wide application, laser scanning has found its place in the modern world of technologies. 3D model of the object presents the foundation of modern engineering. It can be used in construction, geodesy, architecture, mechanics... Nowadays, with new service development, there is increased need for automated, efficient extraction systems which produce data used in navigation systems, location based services, augmented reality and spatial infrastructure planning.

The results of this of methods of recording objects can be stored in databases, in different formats and different forms of the 3D models. Obtained data are also part of the advanced geographic information systems and various analyzes can be performed.

Formation of 3D models of objects is important in the process of documenting buildings, and is carried out for the purpose of reconstruction, restoration, analysis or visualization of the building. The model must therefore respond to requirements such as geometric accuracy, realistic display, precision, etc.

In this paper two case studies will be shown. The dataset of first case study was collected by using terrestrial laser. Area of interest is Monument to Victims of Raid located on the banks of the Danube. The goal was to display the monument to the tiniest details. Main software for processing is Geomagic Studio. It provides the industry's most powerful point cloud editing, mesh editing, and advanced surfacing functions [1].

The second case dataset was derived from integration of data that was collected by terrestrial scanner and the LiDAR system. Case study represents suburbs of Petrovaradin that abounds in the buildings of a longer life. Used processing software is also GeoMagicWrap combined with Leica Cyclone (LC). LC is a family of software modules that provides the widest set of work process options for 3D laser scanning projects in engineering, surveying, construction [2]. The data were processed in different software in order to display a different detail level of the 3d model.

2. RELATED WORK

Laser scanning is most commonly used for geometrical 3D object recording of complex objects and making 3D models. With their ability to scan a very large number of 3D points in seconds without signalization laser scanning offers high application potential, especially in construction, architecture and cultural heritage. There are many publications dealing with this topic. In this work, papers related to this will be highlighted. The Kersten case study was The Bismarck Monument in Hamburg. In his work a combination of triangle meshing and CAD was performed [3]. Jocea also used terrestrial technology and data as processes in GeoMagic software [4].

Specifically, on the subject modeling facades of objects, based on the cloud of points received from terrestrial laser scanning on one side, or cloud points created by a merged cloud of airplane and terrestrial laser scanning on the other, unfortunately there is still no match between them. The reason for the small number of papers is that the biggest problem is the fitting obtained models and their georeferencing due to different accuracy of sets aerospace and terrestrial laser scan data.

Some of the papers that dealt with the topic of cloud-based facade modeling are P. Babahajiani, L. Fan and S. Becker, N. Hall. Babahajiani and L. Fan used a complete scene parsing system which is devised and experimentally validated using 3D urban scenes point cloud that have been gathered by LiDAR acquisition devices. The steps such as segmentation, feature extraction, visualization is generic and adaptable to solve object class recognition problems in different streets with varying landscape [5].

S. Becker and N. Hall used terrestrial LIDAR data, as well as facade imagery, to increase the quality and amount of detail for the respective 3D building models [6]. A publication with the topic of merging cloud points created by LIDAR and terrestrial laser scanning for modeling of objects and facades is A. Gruen, where Unmanned Aerial Vehicles (UAV) and Mobile Laser Scanners (MMS) were used as techniques for surveying and mapping. The building models have been created using the semi-automatic modeling software CyberCity Modeler [7].Also one of good examples of modeling building facade isPajic, who used Leica Cyclone as the main processing software [8].A. Iavarone and D. Vagners also used two technologies for acquisition, airborne LIDAR and tripod-mounted laser scanner [9]. Amovic used only LIDAR technology and created 3D model of the faculty building [10]. Popovic generated 3D model of Petrrovaradin Fortress and stored it in CityGML format. [11]

3. TECHNOLOGY OF AIRBORNE AND TERRESTRIAL LASER SCANNING

Technology of terrestrial laser scanning is widely used for reaching of detailed 3D models of any kind of urban objects. On the other side, airborne laser scanning is specialized for collecting a lot of data inthe shortestperiod of time, but is not so detailed. This is why these two techniques are so complementary.

Terrestrial laser scanner (TLS) cannot be called either a robotized total station or a digital camera but is widely accepted as a surveying method. TLS belongs to the family of so-called active sensors. The pulse carries are a laser and it cannot record a specific point but can provide a continuous scan of the object around the scanner. This method is also known as a ground-based laser scanner or a terrestrial LIDAR system. Laser scanning can be named as three-dimensional vector measuring system with radial component bases on electrooptical distance measurement [12].

To classify terrestrial laser scanners is a very difficult job. There are few options depending on which criteria we want to use. For example, measurement principle (pulse or phase method, triangulation) or technical specifications that are achieved [13]. No one scanner is universal for every single use, so the selection of the scanner depends on the type of object/area that has to be scanned and final accuracy of point cloud/model.

The hardware part is based on the tripod and the scanner mounted on it, which allows distance measurement, horizontal angle, vertical (zenith) angle.

Hardware is also enriched with polygonal mirrors, as well as encoders that register the orientation of the mirrors. 3D coordinates are the output result, instead of the measured length, horizontal and vertical angles. Airborne laser system is also called the LiDAR system and consists of air and terrestrial segment. In the aim of computing coordinates of laser scanning points aerial scanning system dispose of positioning and orientation system based on GNSS and inertial measurements for local position and previously mentioned orientation of laser scanning system at the moment of pulse emission.When it comes to precision and accuracy of this technology, most often corresponds to the conditions given by the user [14].

The main principle of airborne laser scanning is based on the use of phase differences and pulse echoes for measuring the distance from the air platform (plane, helicopter) to the point on the surface of the earth. The product of this surveying is a point cloud, just like terrestrial laser scanner.

4. CASE STUDY

As already stated at the beginning of the work, two case studies will be processed in this paper. Both locations are located in Novi Sad and they are the most recognizable elements of this city.

4.1. Petrovaradin Fortress (Donji Grad)

Donji Grad (lat.Suburbium) as a part of Petrovaradin fortress represents the baroque structure ofthe city. It is mostly preserved from damaging withthe exceptionthat some building has lost their previous appearance.The buildingsare mostly high with bulky roofs, small courtyards and narrow streets (Figure 1).

Figure 1. Petrovaradin fortress (Donji Grad)

The facades are decorative, with symbols of guard or statues of saints beneath the roof. Surveying of this part of Petrovaradin fortress was done with terrestrial laser scanner (Leica ScanStation P20) in three days and aerial laser scanner (Riegl LMS – q680i). At the end of scanning with terrestrial scanner, there were at total 30 stations and 40 positions of markers. The picture bellow shows sketch of marker positions as well as positions of laser scanner from which the acquisition was performed (Figure 2).

Figure 2. Positions of stations (TLS)

For final processing of model of fortress, both point clouds were combined into one, using Leica Cyclone software. There was used method of indirect registration by matching cloud to cloud. The reference cloud was cloud from terrestrial laser scanning due to higher accuracy of data. According to the data quality specification formulated by GSA (General Services Administration), which defines the required level of accuracy - LOA (Level of Accuracy) and level of detail - LOD (Level of Detail) laser points, in this project were used LOA 3 and LOD 3 (Table1). LOA requirements determine the tolerance of the positioning accuracy of the objects, which essentially rely on the accuracy of individual points in the point cloud. LOD requirements determine the minimum size of an object that can be pulled out of the cloud, which relies on density that can be captured [15].

Table 1. GSA accuracy level and level of details

GSA Level	LOA (Accuracy) mm (inch)	LOD (Detail) mm x mm (inch x inch)
1	± 51 (± 2)	152 x 152 (6 x 6)
2	± 13 (± 1/2)	25 x 25 (1 x 1)
3	± 6 (± 1/4)	13 x 13 (1/2 x 1/2)
4	± 3 (± 1/8)	13 x 13 (1/2 x 1/2)

The result of scanning is huge number of points, each with its X, Y and Z coordinates, as well as an additional attribute - value of the reflection of laser. Modern advanced scanners have also information in the form of RGB values. When points are colored with values of reflection or colors, the structure becomes more recognizable (Figure 3).

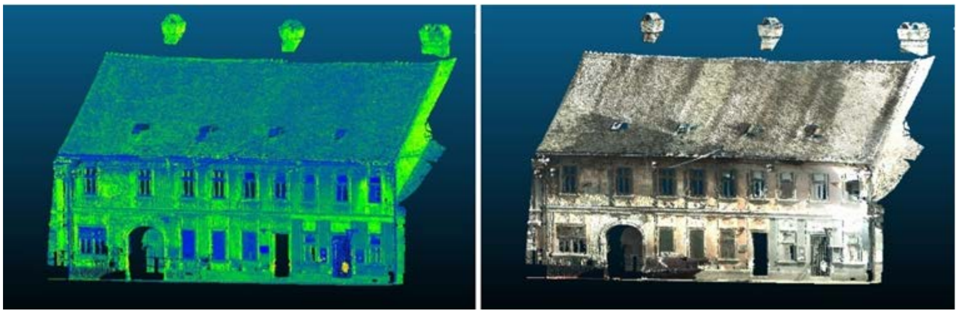

Figure 3. Segment of Petrovardin fortress presented with values of reflection (left) and RGB values (right)

There are few operations that we have to do on the merged point cloud such as: resampling, noise reduction, meshing, filling of holes on the model and reduction of number of triangles of the generated model. Final modeling made in Geomagic Studio is shown in the picture below (Figure 4).

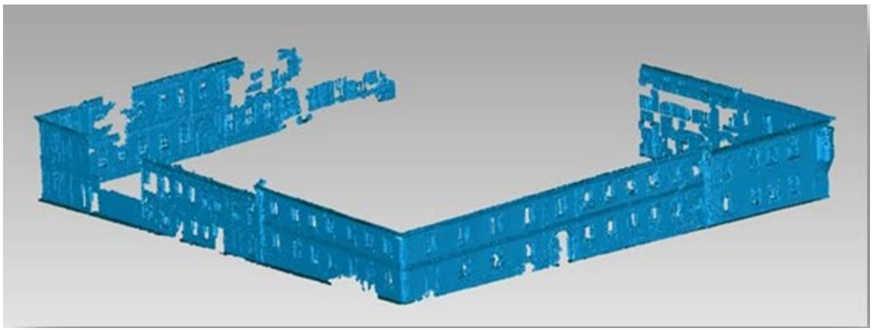

Figure 4. Final model of part of Petrovaradin fortress

Merged point clouds were published using internet-based application Potree [16]. The main advantage of Potree is that offers possibility to measure distances directly on the point cloud (Figure 5). Also, it has option to make different cross sections that is with previous option useful for possible reconstruction of object.

Figure 5. Measuring of distances on point cloud in Potree

4.2. MONUMENT TO THE VICTIMS OF THE RAIDS

The second case study was an important object of cultural heritage in Novi Sad, monument to the victims of raids. For scanning of this monument were used three markers. The resolution was set to 3.1mm/10m and scanning on each station lasted 7minutes. This is the indicator how long it takes to scan such an object. On the other side processing of the raw point cloud lasted a little bit longer. During processing of laser points, the main problem was points that were collected under the influence of the reflection of water in Danube river and the structure of material of monument.

Processing steps were the same as in the previous case with emphasis on the usage of algorithm that fills holes on the parts where points were not collected. Main holes were on the heads of humans what are represented on the monument. To solve this problem, we have used an algorithm for filling holes on the model based on points that surround specific hole. In the picture below there is an example of filled holes using algorithm provided by Geomagic software. Red dots represent corrected parts of the model and yellow dots are example of raw hole (without correction).

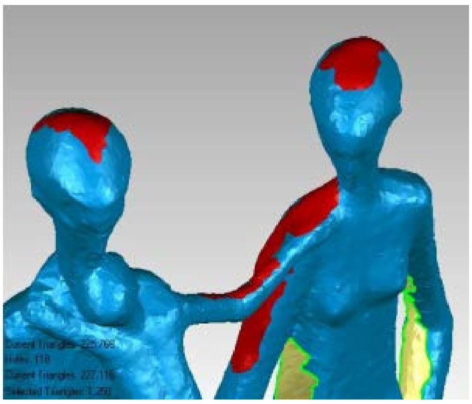

Figure 6. Holes on the model (red and yellow)

The holes were an obstacle in processing of the raw data, so by their elimination the final model was successfully generated. Figure 7 contains a Monument to the Victims of the Raids. On the left side, there is a photo of the real look of the monument. The right side of Figure 7 represents a model that was created in GeoMagic software.

Figure 7. Monument to the Victims of the Raids

5. DISCUSSION

The aimofthis work is to design a simple and fast method to reconstruct objects using laserscanningdata only, which can be useful in many applications.Automated methods for reliable and accurate 3D reconstruction of created models of objects are essentialformany users and providers of 3D city data, civil engineers, urban planners, architects, environmental engineers. A 3D city model captures the geometric description of all objects of interest in an urban area in computer supported form.The obtained 3D models can be used further in the construction or reconstruction of objects. Models satisfy certain precision, accuracy and level of detail. The GeoMagic software proved to be a good solution for creating models represented in this paper. The obtained processed data can be further used in the processing, analysis, mapping. They can be stored in various formats, databases and represented through certain web services.

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