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APPLICATION OF 3D TERRESTRIAL LASER SCANNING FOR CREATION OF PROJECT DOCUMENTATION FOR CADASTRAL OBJECTS

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Key words: 3D terrestrial laser scanning, documentation, measurements, cadastre

SUMMARY

3D terrestrial laser scanning provides geodesists, also the other connected specialists with a number of new technical opportunities. The technology could be applied in variety of specialized tasks and one of them is to conduct 3D measurements to obtain 3D and the respective 2D digital models of plans-situation, cross sections, etc. of various cadastral objects, where no documentation exists.

This study focuses on the technical implementation of the processes: 3D laser scanning, data processing, extraction and creation of 3D and 2D graphics if documentation for cadastral object should be created. The technical difficulties, which were met during the entire process are also discussed.

In the paper are given the relevant graphical examples in 3D and 2D space to illustrate the specifications of the carried work.

Conclusions and recommendations are also given in the paper.

РЕЗЮМЕ

3D наземното лазерно сканиране предлага на геодезистите и на други специалисти, основно от съседни на геодезията области, голям брой нови технически възможности. Технологията може да бъде приложена в различни специализирани задачи и една от тях е извършването на 3D геодезически измервания и създаване на тримерни, съответно двумерни цифрови модели на разпределения, сечения и др. за различни обекти на кадастъра, където липсва проектна документация. Изследването е фокусирано върху техническата реализация на дейностите: 3D лазерно сканиране, обработка на данните, извличане и създаване на тримерна и двумерна графика в случай, че трябва да бъде създадена документация за обекта. Дискутират се съпътстващите технически трудности при реализацията на задачата. Дадени са съответните примери от тримерното пространство и равнината, с които се илюстрира спецификата на извършената работа, заедно с заключение и препоръки.

1. INTRODUCTION

The technology of 3D terrestrial laser scanning offers excellent way for fast and accurate gathering of spatial information – the coordinates of each measured point, also the intensity of the returned laser signal in the scanner, see [Milev, 2012]. Information for the process of laser scanning could be found in several sources on the Internet, see [http://www.aftopo.org/download.php?matricule=412807] and [http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/15_Surveys.pdf]. On the geodetic market exists various types and brands of laser scanners and their usage in the practice depends on factors like: size of the object, accuracy requirements, etc.

In this paper are studied cadastral objects – both civil and industrial. In the scope of the article were included both exterior and interior parts of the objects as their spatial data were required also by the other connected specialists.

Here, 3D terrestrial laser scanning was used because of the existence of the following factors:
- absence of any documentation;
- impossible to access parts of the object;
- complexity of the object, incl. the interior;
- the conventional surveying instruments were not able to provide the spatial information in the required completeness with the necessary productivity.

The aims of this paper are:

- to study the technical requirements, which should be followed in the process of scanning complex (with existence of many details) cadastral objects – both civil and industrial;
- to prepare from the point cloud the ready-for-use data for other professionals;
- to propose recommendations, based on the practical activities.

This paper includes information from both outdoor and indoor 3D terrestrial laser scanning.

2. EXAMPLES FOR APPLICATIONS OF 3D TERRESTRIAL LASER SCANNING IN GEODESY, ESPECIALLY FOR CREATION OF DOCUMENTATION FOR CADASTRAL OBJECTS

There are a number of applications of 3D terrestrial laser scanning in the area of geodesy. Here are some examples, which illustrate the possible cases where is treated the creation of documentation:
[http://blog.lidarnews.com/preserving-the-nations-monuments-with-3d-laser-scanning/], [http://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XL-5-W7/179/2015/isprsarchives-XL-5-W7-179-2015.pdf], [http://www.researchgate.net/publication/224138298_Using_laser_scanners_for_modeling_and_analysis_in_architecture_engineering_and_construction], [http://tinyurl.com/qys7av2] and [http://tinyurl.com/pjnr4ep].

Other possible applications, which will be given in this study are:
- preparation of project documentation for cadastral objects;
- creation of cross-sections for each floor of a building.

The process is done in the light of current possibilities of the IT in geodesy and also uses the information, given in [Kostov, 2015].

The paper focuses on the following key moments:
- the necessary field procedures for capturing of the required spatial information;
- the extraction of the data from the point cloud to appropriate format for the 2D space;
- usage of the point cloud to export the digital information for other software products;
- application of AutoCAD, Trimble RealWorks, Trimble RealWorks Viewer and Internet Explorer for interpretation of the spatial information.

3. SOME DETAILS FOR THE REQUIREMENTS AND ADVANTAGES OF 3D TERRESTRIAL LASER SCANNING OF ESSENTIAL IMPORTANCE FOR OUR SPECIFIC CASE

Here are given some of the requirements, which should be followed in the process of 3D terrestrial laser scanning. In order to be produced data with the relevant reliability, several environmental conditions should be carefully observed before the start of the process of laser scanning (for complete list, see the user manual [http://mep.trimble.com/sites/mep.trimble.com/files/Trimble%20TX5%20User%20Guide.pdf]):

- Surveying should not be conducted if the ambient temperature falls below 5 degrees Celsius;
- Measurements should not be conducted in dust, snow or rain;
- Scanning against direct sunlight should be also avoided;
- Highly reflective or absorbing objects' surfaces will increase the inaccuracy of the measurements.

The above mentioned requirements for the 3D terrestrial laser scanning required choosing of appropriate time period of the day for conducting of the measurements.

Here are listed some of the major advantages, if applying the terrestrial laser scanning for this specific case:

- 3D terrestrial laser scanning sealed the respective object as it is for the moment of the measurements. It was possible to obtain thorough spatial data for the object in a short time period at the field;
- Some of the parts of the objects (e.g. the roof), subject of measurements were located at practically impossible or dangerous for human access places. These circumstances required the usage of contactless technology for conducting of the geodetic measurements;

4. REQUIRED GEODETIC ACTIVITIES BEFORE CONDUCTING OF THE SCAN

The cadastral objects, subject of measurements were studied carefully, taking in mind the following requirements:

-the necessary distances between the parts of the object and the scanner;
-the required angle of incidence between the scanner and the targets [http://mep.trimble.com/sites/mep.trimble.com/files/Trimble%20TX5%20User%20Guide.pdf];
- the safety of the scanner and its accessories /placed in urban and industrial areas/;

- the necessary visibility between the scanner and the artificial targets;
- the visibility of the spheres between each two stations;
- the required spatial geometry between the spheres;
- the distances between the scanner and the spheres (in this case were used both two types of spheres);

The places for the stations of the scanner were carefully chosen, according to the complexity of the scanned object [Kostov, 2015].

According to the environmental conditions /outdoor and indoor scans/, the respective settings were applied in the scanner in order to be produced scans with the necessary quality.

5. PARTICULARITIES OF THE 3D TERRESTRIAL LASER SCANNING IN THE PROCESS OF CREATION OF DOCUMENTATION FOR CADASTRAL OBJECTS. PROCESSING OF THE RAW DATA. TECHNICAL ISSUES

The scanning was started after assuring, that the mentioned in the previous chapter requirements were met. For conducting of the measurements, Trimble TX5 was chosen amongst all other possibilities, due to its technology and technical possibility to deliver the required productivity and quality. In Trimble TX5, as it is known, there are colour settings - options for the exposure metering mode. In order to produce quality data from the laser scanning, the correct mode was chosen, according to the current environmental conditions. The usage of a certain scanner should be carefully considered, see [Alkan et al., 2012].

The mentioned above settings in the laser scanner assured, that the accuracy requirements of the project will be met and the quality of the panoramic photos will be enough for the extraction of the necessary spatial information. A balance between the quality of the scanning and productivity of the field work was assured.

The raw data was input in Trimble RealWorks and the necessary processing was done, using “spatial sampling” instead of sampling by step and adaptive sample. The used method created homogeneous point cloud.

In the process of creation of full 3D digital model from the raw data, some issues were encountered. Taking in mind the complexity of each cadastral object, the scanner was positioned on places, which ensured the direct visibility to each detail of the building.

Due to the specifics of the cadastral objects, the scanning was conducted from exterior to interior, not always with connection with artificial targets between the outer and inner space. The registration was planned to be conducted with the usage of the existing cadastral details.

These technical circumstances imposed the usage of different approach for the registration of some stations in the point cloud. One of the used ways was the so called “cloud-based registration tool”. It should be noted, that this method required much more efforts by the operator and was time consuming. In case there were no artificial targets, also the cadastral information was too complex, etc., the tool could be useful for creation of complete 3D digital model, especially in our case.

6. USAGE OF THE POINT CLOUD FOR CREATION OF 3D AND 2D DIGITAL MODELS FOR PROJECT DOCUMENTATION OF CADASTRAL OBJECTS. SOFTWARE

The created point cloud was used for several purposes, including and not limited to: full 3D visualization, creation of vector model of polylines, extraction of cross-sections, etc.

Trimble RealWorks was used for processing of the raw data, also to export the required information (in *.dwg, *.dxf, etc. formats) from the point cloud.

6.1 Extraction of the necessary data for the creation of digital models of plans for each level of a cadastral object

One of the major advantages of Trimble Realworks is its ability to create cross sections at user-defined level see – fig. 2 and fig. 4. The “raw” view of the cross-section is given in fig. 6. In this way the surveyor could create digital models in the plane in *.dwg format, at the relevant level of the building, ready for further usage by other professionals. Fig. 1 below shows a screenshot from Trimble RealWorks, which gives the surveyor spatial information for the objects /the rooms/. The data were used furthermore for creation of the relevant cross-section in *.dwg.

Fig. 5 is a window, taken from above of an industrial object. It could be seen the upper part of the roof with the interior. The 3D information was applied for creation of cross-sections of the interior in *.dwg format.

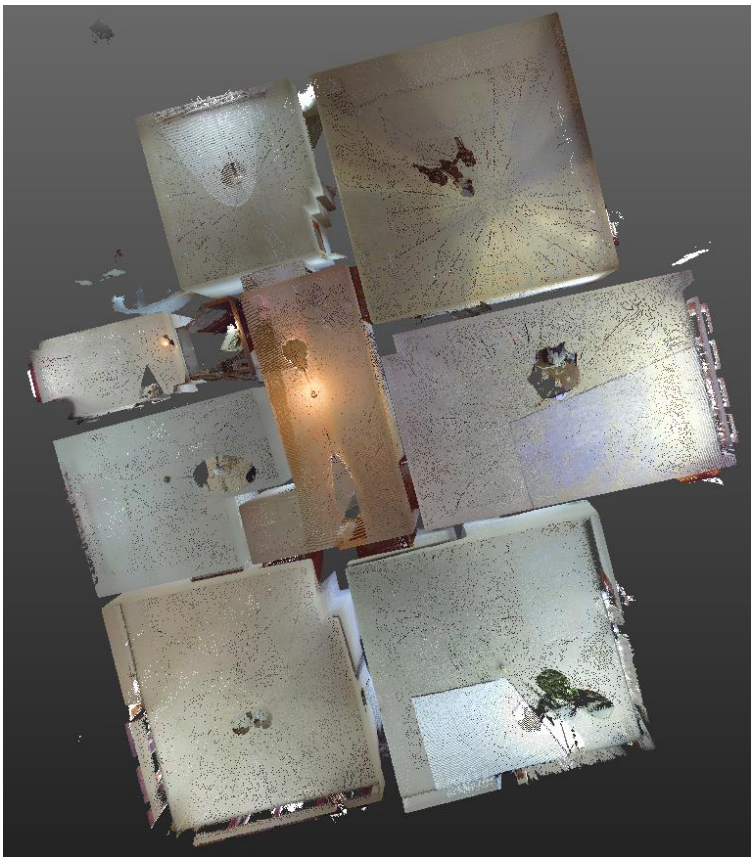

Fig. 1 Rooms in a house /view from above/

Fig. 2 The under-roof space
(*.dwg model - point cloud and situation)

6.2 Extraction of the necessary data for creation of digital model of a roof

The roof could be one of the most difficult and dangerous for human access part of a building. In some of the cases it might be difficult or even impossible from technical point of view the roof to be scanned from outside of the building. In this specific case, the scan of the roof was done from the last floor.

Fig. 3 shows a roof, viewed from aside in the virtual environment of Trimble RealWorks. The visual information, along with dimensions and cross-sections were useful information for the relevant specialists in the process of creation of the documentation.

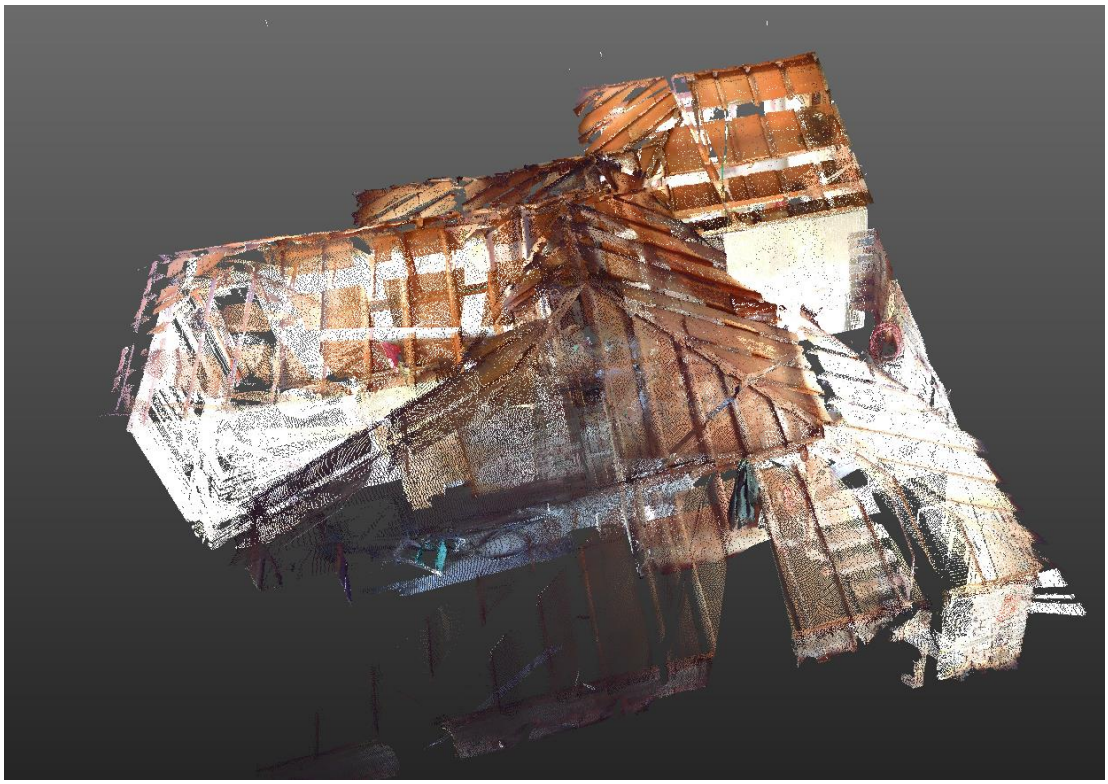

Fig. 3 The roof – view from aside

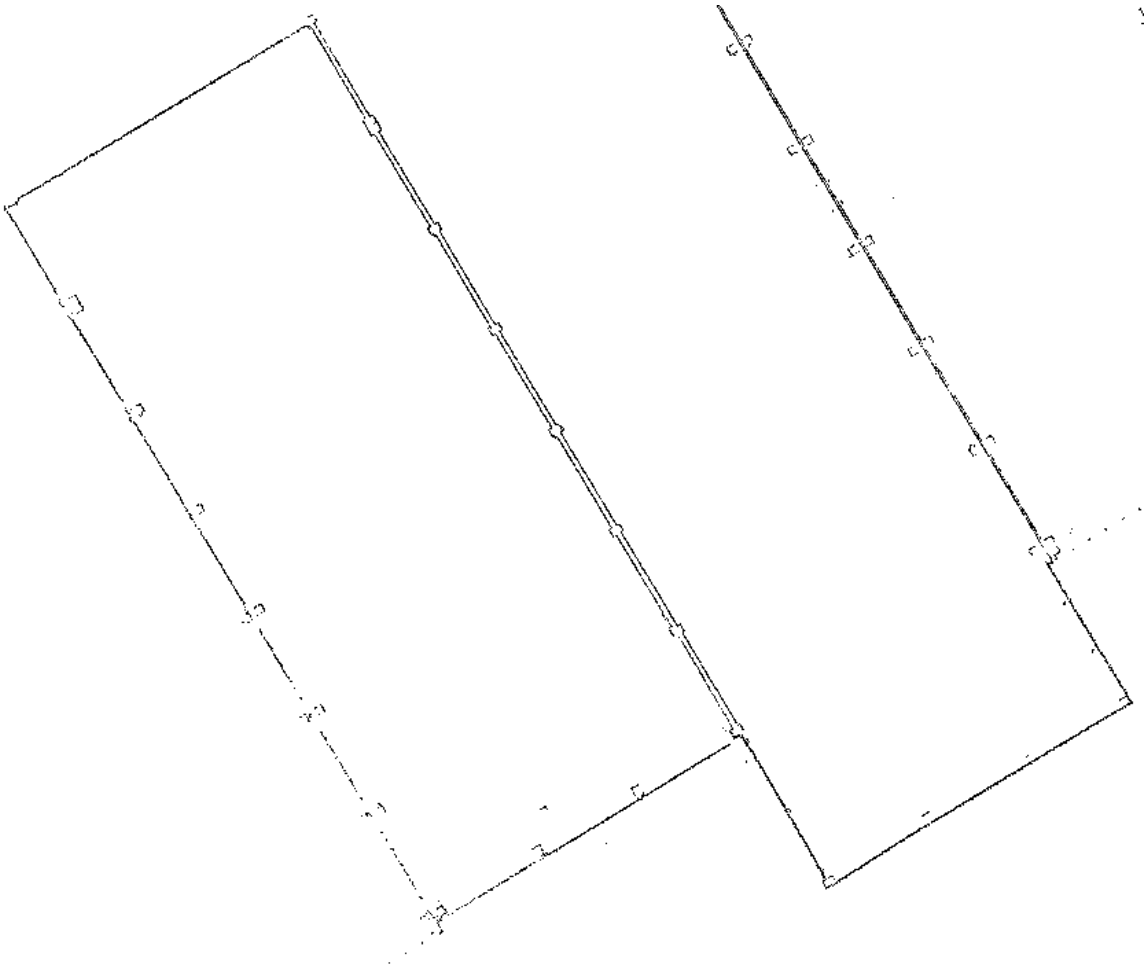

Fig. 4 A cross-section in *.dwg format, extracted from the point cloud

Fig. 5 Industrial object – view from above

Fig. 6 Industrial object with “raw” cross-section

6.3 Software aspects

There are several software products, which could be used to process and visualize the information from the 3D terrestrial scanning in this specific case: Trimble RealWorks, Trimble RealWorks Viewer, AutoCad, and Internet Explorer. Note, that this listing is not a complete one.

The final products from the 3D terrestrial laser scanning in our specific case could be and not limited to:
- *.dwg files containing plans for the respective level of the object;
- *.dwg digital model of a vertical cross section of the facades of the object;
- Vector models with information containing the schemes of the separated objects at each floor of the building;
- Created dimensions in the 3D space.

Many more examples also could be listed here, depending on the current assignment.

7. RESULTS AND ANALYSIS

It should be noted that the work load from the entire process could be divided into two major parts:
a) Creation of a complete digital model of the point cloud for the object;
b) Extraction, processing and preparation in the appropriate format of the required information in 3D and 2D space.

In the common case, creation of a complete model might require specialised human intervention for the process of the usage of the “cloud-based registration tool”. If applying the last, then the overall error for this study was about several centimetres, depending on the fitting between the reference and moving clouds. For the purposes of our specific case, this accuracy could be treated as acceptable. Note, that the procedure might require time, based on the used hardware and amount of data to be processed.

The accuracy, which was achieved for the point cloud, created using artificial targets varied from 2 mm. up to 5 mm.

For the next step – extraction and processing of the data in the relevant space, the surveyor should create the vector model based on the point cloud. Depending on the existing obstructions around the object, it might be necessary to be paid more attention and virtual walks to be performed in the environment of Trimble RealWorks or Trimble RealWorks Viewer.

8. CONCLUSION. RECOMMENDATIONS

This paper studied the procedures, which should be followed in the process of creation of a project documentation for objects of cadastre /civil and industrial buildings/ with information derived from the created point cloud of the 3D terrestrial laser scanning. Issues, which might appear during the processing of the data were also discussed.

One contemporary and very productive way for gathering of large amounts of spatial information was used for measurements and further interpretation of the data.

The final results from the measurements – both 3D and 2D digital models in the relevant format were used for creation of the plans of the respective floors and various cross-sections of the cadastral objects.

Based on the data from the extracted digital models in *.dwg format it could be summarised, that for the needs of creation of documentation for cadastral objects, 3D terrestrial laser scanning could be applied as fast, reliable and contemporary technology in the surveying practice. Current survey methods may be outdated for this specific case, if completeness of the data and productivity of the process are of essence.

Taking in mind the structure and the size of each object, it could be noted that the used technology successfully fulfilled the requirements for: data delivery in the relevant digital format and the overall quality.

Based on the described technical details in the paper, it could be recommended the usage of 3D terrestrial laser scanning and its results for specific tasks in geodesy and connected professional areas for creation of project documentation.

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7. http://tinyurl.com/pjnr4ep
8. http://tinyurl.com/pttjzxh – in French
9. http://tinyurl.com/o4tttly
10. http://tinyurl.com/o7gm5vw

USED SOFTWARE

1. Trimble RealWorks (http://tinyurl.com/pdckrlr);
2. Trimble RealWorks Viewer (http://tinyurl.com/qhwj92w);
3. Autodesk Autocad (http://tinyurl.com/nma4923);
4. Microsoft Internet Explorer (http://tinyurl.com/ocxn2by).