Application of 3D terrestrial laser scanning for measurements of buildings, situated in area, covered with bushes – technical difficulties, solutions and implementation

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Key words:3D terrestrial laser scanning, measurements, solutions, processing

SUMMARY

3D terrestrial laser scanning and its possibilities in data processing offer a number of various available solutions for each specific case in the geodetic practice when measurements are required. The aim of this case study is to give details about:

-the activities in the field, which were done for performing of geodetic measurements for buildings, situated in area, covered with bushes;

-the technical difficulties, which were met and the relevant solutions;

-the way of processing the raw data.

3D terrestrial laser scanning was chosen as a technology for performing of geodetic measurements due to the following main reasons:

-the time span for performing of the measurements could be chosen and set in the scanner;

-the object /buildings/ consists of a number of edges (detailed points) to be measured;

-the elimination of human-based errors;

-the possibility to obtain significant accuracy in the point determination in a reasonable time in the field;

-available photorealistic information in the data.

The paper studies the decisions, taken in the field in order to be created one point cloud of the object, taking in mind the specific terrain conditions. In this case study was described in details the procedure for creation of georeferenced point cloud, according to the existence of bushes.

Assessment of the accuracy of the geodetic measurements was done. Screenshots with the information, which describe the performed way of field work and data processing results are also given.

Conclusions and recommendations for future work are included in the paper.

АБСТРАКТ

3D наземното лазерно сканиране и неговите възможности при обработката на суровите данни предлагат огромен набор от възможни решения при всеки специфичен случай в геодезическата практика когато са необходими измервания. Целта на настоящото изследване е да бъде дадена детайлна информация за:

-дейностите на полето, които бяха извършени с цел провеждане на геодезически измервания за сгради, разположени в район, покрит с храстовидна растителност;

-техническите затруднения, които бяха срещнати по време на геодезическите дейности и съответните решения;

-начина на обработка на суровите данни.

Наземното лазерно сканиране беше избрано като технология за извършване на геодезически измервания поради следните основни причини:

-продължителността на измерванията може да бъде избрана и настроена в инструмента;

-обекта /сградите/ се състоят от много чупки (теренни точки) на контурите, които трябва да бъдат измерени;

-елиминиране на човешките грешки;

-възможност за постигане на висока точност при определяне на точките от контура на обекта в разумен времеви интервал за измервания на полето;

-налична фото реалистична информация в данните.

Този материал изучава решенията, взети на полето с цел създаване на общ облак от точки, имайки предвид специфичните теренни условия. В конкретния случай в детайли е описана процедурата по създаване на георефериран облак от точки, след вземане под внимание наличието на храсти.

Извършена е оценка на точността на геодезическите измервания. Дадени са извадки от данните с информация, описваща начина на:

-извършената полска работа;

-обработката на геодезическите измервания.

Препоръки и предложения за бъдеща работа също така са дадени.

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1. INTRODUCTION

Nowadays there are a number of technical possibilities to be obtained 3D coordinates of a terrain point. One of these is 3D terrestrial laser scanning – technology, by which could be determined the spatial coordinates of the contours of objects, subject of measurements. Applying this technology, it could be captured a huge amount of 3D data for the respective object. One known advantage of laser scanning is the possibility for measurement of the intensity of the returned in the scanner laser beam.

There are a number of literature sources on the topic for terrestrial laser scanning: https://mycoordinates.org/terrestrial-lidar-capabilities-for-cadastral-modelling/, http://www.diva-portal.org/smash/get/diva2:1362840/FULLTEXT01.pdf, https://www.e3s-conferences.org/articles/e3sconf/pdf/2020/24/e3sconf_tpacee2020_07012.pdf, etc.

Due to the existence of a number of brands terrestrial laser scanners, each one having its own technical specifications, the geodesist is the person to choose the most appropriate model for precise completion of the task.

The object under study consists of several residential buildings, situated in area, which was covered with bushes and grass. The application of 3D terrestrial laser scanning, instead of any other surveying instrument was necessary and motivated by the following circumstances:
-existence of a number of edges of the buildings;
-short time available for field measurements;
-possibility to capture all cadastral information without any risk for human errors;
-created during the measurements photo realistic data.

This study aims:
-to perform contactless measurements of buildings, which were hard to access;
-to gain productivity in the field work;
-to assess and analyse the obtained quality of the conducted geodetic measurements;
-to use the created photo realistic information;
-to find solutions for the technical issues, caused by the bushes;
-to give the necessary recommendations, according to the specific geodetic activities, done in this case.

This study was focused on high-quality outdoor terrestrial laser scanning.

2. EXAMPLES FOR POSSIBLE APPLICATIONS OF 3D TERRESTRIAL LASER SCANNING FOR CADASTRAL PURPOSES

A lot of possible applications of the terrestrial laser scanning in the area of surveying could be found in various sources on the Internet: https://eprints.usq.edu.au/31409/1/Gann_N_Zhang.pdf, https://www.mdpi.com/2072-4292/12/10/1547/pdf, https://1library.net/title/visualisation-d-cadastre-using-terrestrial-laser-scanning, https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLII-2-W9/663/2019/isprs-archives-XLII-2-W9-663-2019.pdf, etc.

In surveying practice exists a number of specific cases to be solved. In this paper will be given one example for the implementation of terrestrial laser scanning for cadastral purposes, i.e., for measurements of contours of buildings. The issue, which should be overcome in this specific case was the existence of bushes all around the object. Also, the following key moments were taken into account in the field:
-setting the appropriate parameters in the laser scanner for outdoor scan and unstable (a bit foggy) weather;
-the artificial targets had to be placed in a safe, clear area to avoid the obstruction and damage, which might be caused by the bushes;
-choosing of appropriate places for each station of the scanner to avoid the bushes around the contour of the object.

3. NECESSITY FOR APPLICATION OF TERRESTRIAL LASER SCANNING IN THESE SPECIFIC TERRAIN CONDITIONS

As it was mentioned, there are a number of ways for determination of 3D coordinates of a point from a contour of a building. The choice of the exact surveying equipment might depend on various factors, like:
a) the terrain around the object;
b) the geometry of the object;
c) requirements for amount of captured 3D information;
d) required productivity;
e) existence of other objects nearby;
f) availability of photo realistic information, etc.

In this study the decision for application of terrestrial laser scanning as part of LIDAR was taken based mainly on the factors, given in points “b”, “c” and “f”. The technology allowed the buildings to be “stored” in the flash card as they were on the terrain [Kostov, 2015]. The geometry of the object was complex, with a number of terrain points, which had to be measured in a short time span in the field. The mentioned in this chapter circumstances imposed the usage of 3D terrestrial laser scanning for creation of the contours of the buildings, subject of measurements.

Also, during the field study of the object, it was decided, that for the creation of a complete digital model, containing all required terrain points it would be necessary to be created additional, redundant positions of the scanner due to the significant number of the edges of the buildings.

Taking in mind these facts the application of other surveying technology would be inappropriate and ill-founded from technical point of view.

4. PREPARATORY ACTIVITIES BEFORE SCANNING OF THE OBJECT

The buildings to be measured with terrestrial laser scanner were in rectangular shape, situated in an area with bushes in various height. The transport access was accomplished via streets with no durable coverage. These facts imposed detailed field recognition (before conducting of the geodetic measurements) in order to be chosen the appropriate places for both stations of the scanner and the artificial targets.

After completion of the field recognition a decision was taken to be used 3 “main” stations and one “redundant”, fig. 1. The last was created for capturing of some details of the buildings, which were hard (impossible) to access by the laser beam, due to the value of the angle of incidence.

Fig. 1 The four stations, used to scan the object

In this way the following technical requirements were assured:
-the necessary short distances between the edges of the buildings and the scanner;
-value in the relevant bounds of the angle of incidence of the laser beam;
-the safety of the spheres on the ground within the bushes;
-the visibility scanner - artificial targets;
-the well-founded spatial geometry of the spheres;
-the required short distances scanner – spheres;

The relevant places of the scanner were chosen in a way, which guaranteed the direct visibility to the edges of the contours of the buildings.

Due to the unstable and bad weather conditions – existence of small amounts of fog and water drops in the air, the relevant settings for productive outdoor scans were set in the scanner. It was of essence for this specific case the scan to be done as fast as possible because of the high probability of rain.

5. 3D TERRESTRIAL LASER SCANNING OF THE BUILDINGS. TECHNICAL DIFFICULTIES

In the process of field recognition of the buildings was created plan for performing of the geodetic measurements. The last were done via phase 3D terrestrial laser scanner and the relevant artificial targets – spheres.

During the field measurements were used the already chosen positions of the stations of the scanner. The stations were chosen on suitable places, where existed visibility to the edges of the contours of the buildings. The scanning procedure was done sequentially from station to station until all edges of the buildings were captured.

During the field work one specific fact had to be observed – the presence of (tall) bushes all around the buildings, fig. N 2.

Fig. 2 The point cloud with a number of bushes around the buildings

The natural bushes – in various height and density, fig. 3 were one significant technical difficulty to be solved not only during the field work, but also in the data processing and handling.

Fig. 3 The spheres “hidden” in the bushes next to the buildings

The spheres had to be positioned over the stabilised control points (required for georeferencing). It was extremely hard the artificial targets to be placed on the ground, due to the terrain conditions - coverage of bushes and grass.

The issues, which arose in the process of conducting the terrestrial laser scanning were as follows:
-extremely difficult positioning of the spheres on the ground;
-safety risk for the artificial targets, due to the existence of branches;
-the visibility between the scanner and spheres was hard to be achieved;
-the spheres should be placed just next to the scanner in order to be “escaped” the obstruction, caused by the bushes, fig. 4;
- impossibility to be ensured the visibility of the artificial target in two adjacent stations.

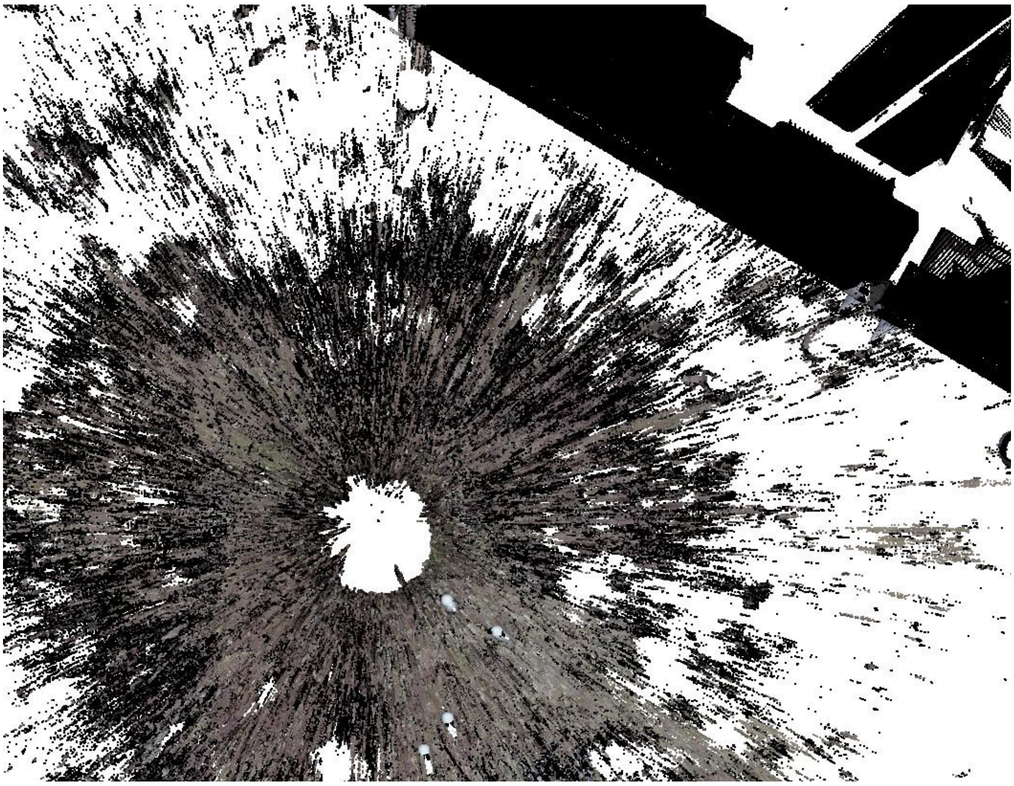


Fig. 4 The station of the scanner, the spheres next to it and the bushes – view from above

After finishing each scan no warning messages were observed. In this way it was guaranteed the quality of the data, even in the unstable weather conditions, described in details in chapter 4.

6. CREATION OF THE POINT CLOUD. SOLUTIONS OF THE TECHNICAL ISSUES

Due to the mentioned technical difficulties in the previous chapter the creation of the point cloud was done in a different, time and efforts consuming way. In this specific case the application of the spheres for their purpose, i.e. for the registration process was not possible. No matching spheres in the adjacent scans existed. The reasons for this fact were the obstruction, caused by the naturally existing bushes and differences in the terrain heights.

From the situation of the stations of the scanner, given on fig. 1 it could be given the following facts:
- in the north were created two stations, not far one from another. The chosen positions of the scanner were required due of the existence of specific form of the building to be measured;
- the southeast station of the scanner was necessary in order to overcome the existing bushes and branches, shown on fig. 2 just next to the edges of the object;
-the south-west and north-west positions of the scanner were chosen to capture the north and south facades of the buildings.

Taking in mind the huge amount of bushes the following technological availabilities and possibilities, given below were used for the creation of the full point cloud:
- “registration using planes” software option;
- the measurements from the redundant scan;
- the common situation, created from the measurements and later on involved.

It should be noted, that under the term “full” should be understood the point cloud, created from all four scans.

This “artificial” method for point cloud creation was necessary, because of the terrain conditions and geometry of the buildings subject of measurements. The technical issues were solved via:
- the existence of redundant information;
- software possibilities
- certain operator’s decisions.

Based on the listed above technical details, the raw data from the terrestrial laser scanning was processed and the full point cloud was created.

The point cloud was used for the following purposes: 3D interpretation of the buildings and extraction of the coordinates of the edges of the contours. Trimble RealWorks was used to create the point cloud, visualise the object and prepare the data for export to external geodetic software for further processing.

7. RESULTS FROM 3D TERRESTRIAL LASER SCANNING. ANALYSIS

In our specific case the creation of the full point cloud of the object was done via the manual unity of the relevant scans. The following procedure was followed:

7.1 Stations in the north

The created two adjacent stations of the scanner in the north part of the object were registered via “using plane” option. The information was processed and united in one object (point cloud). The accuracy results are given in fig. 5

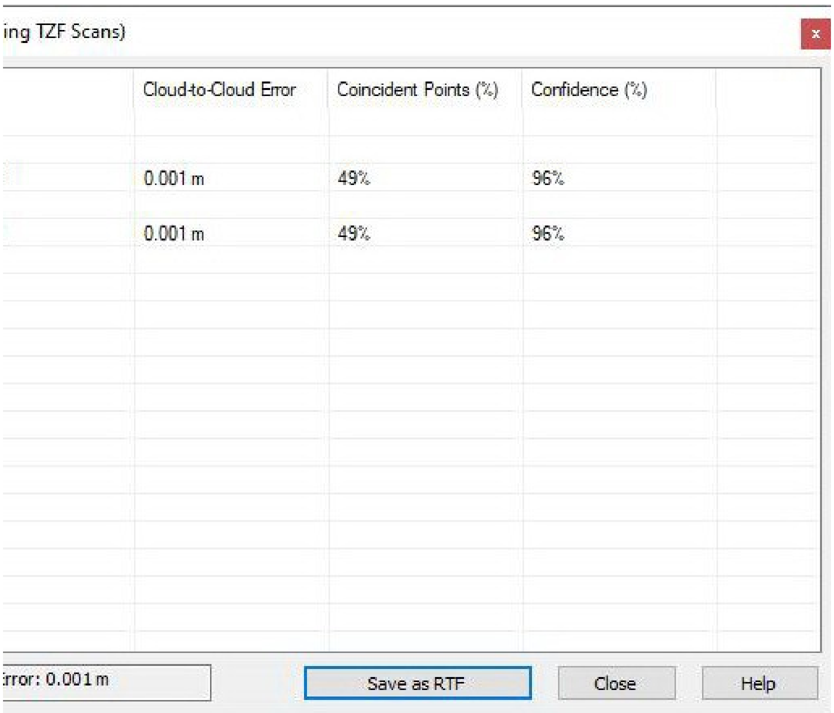
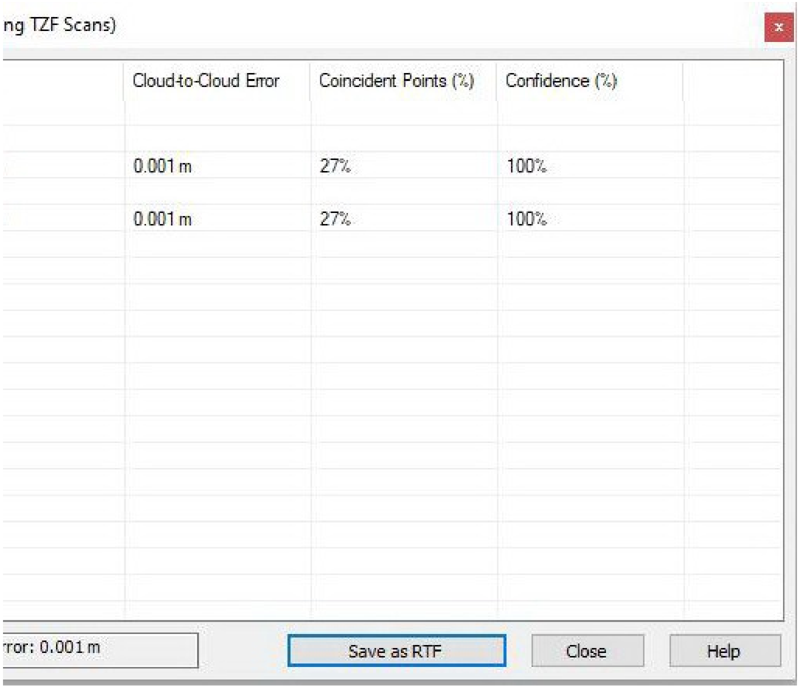


Fig. 5 Registration using planes, of two stations with 96 % confidence

7.2 Stations in the south

The next adjacent stations of the scanner were registered using the same software option, due to the impossibility for application of spheres. The raw data was processed and the accuracy results from the registration are given in fig. 6.



ng TZF Scans)

	Cloud-to-Cloud Error	Coincident Points (%)	Confidence (%)
	0.001 m	27%	100%
	0.001 m	27%	100%

ror: 0.001 m

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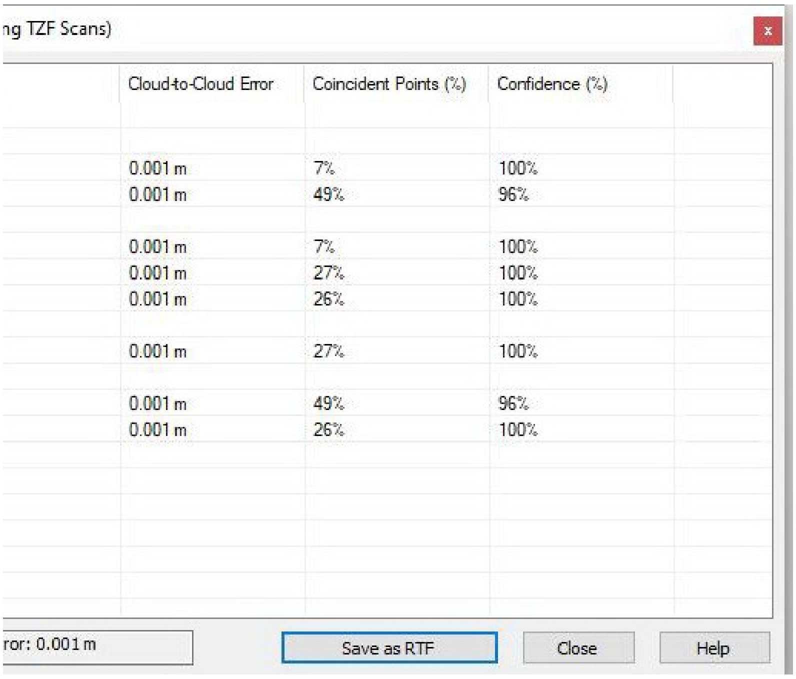
Fig. 6 Registration using planes, of two stations – 100 % confidence

7.3 Creation of the full model. Results

Based on the processed laser scanning data, the full model was created via the registration of already created point clouds (see points 7.1 and 7.2). The registration results are shown in fig. 7.



ng TZF Scans)

	Cloud-to-Cloud Error	Coincident Points (%)	Confidence (%)
	0.001 m	7%	100%
	0.001 m	49%	96%
	0.001 m	7%	100%
	0.001 m	27%	100%
	0.001 m	26%	100%
	0.001 m	27%	100%
	0.001 m	49%	96%
	0.001 m	26%	100%

ror: 0.001 m

Save as RTF | Close | Help

Fig. 7 Registration using planes, of all stations

The completion of above-described parts eliminated the technical difficulties, which were met by the existence of bushes and were described in details in chapter 6.

From the processing of the raw laser scanning data in our specific case, the following results were achieved:
-cloud-to-cloud error 1mm for all registrations;
-confidence 96% and 100%.
-overall cloud-to-cloud error 1mm.

The above-mentioned quality results proved the obtained extremely high accuracy of the point cloud, created even in such hard terrain conditions. The results from the next step of data processing – georeferencing of the point cloud are given in fig. 8. The georeferencing was done with created for the case network of control points. Some of them were excluded from the calculations in order to be obtained better quality results. The error - calculated with the best determined control points was 9 mm.

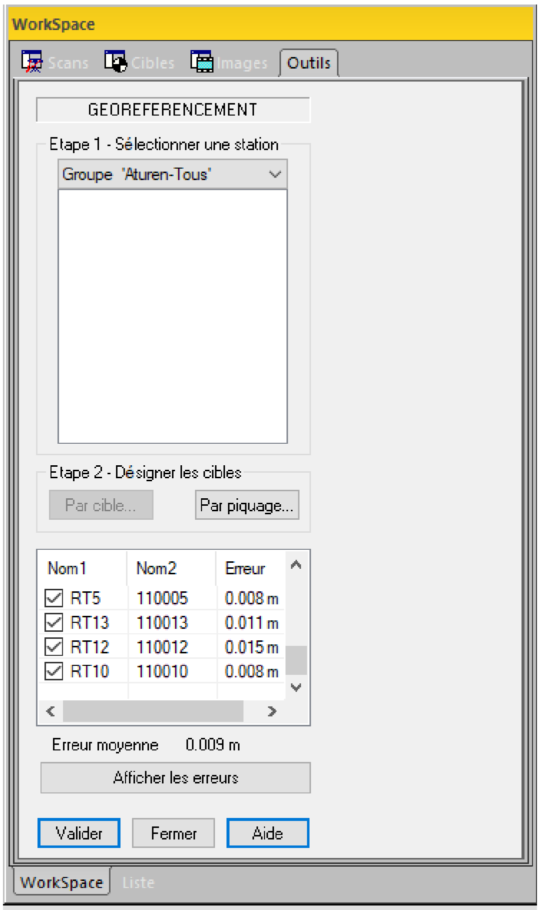


Fig. 8 Quality results from georeferencing of the point cloud

8. CONCLUSION. RECOMMENDATIONS

This study explored:
-the technical implementation;
-issues, which were met;
-the solutions
in the process of 3D terrestrial laser scanning and raw data processing of buildings situated in area, covered with bushes.

The point cloud, subject of assessment in this specific case was used to deliver information, necessary for the creation of the contours of several buildings.

The full digital model of the object was not created in the “classical”, fast and convenient way (using artificial targets). The presence of bushes all around the object imposed:
-replacement of target-based registration with registration using planes;
-three registrations using planes instead of application of target-based one;
-usage of powerful contemporary laptop;
-more computational time, required for registration using planes process.
-human decisions/intervention for the specific way of measurements and data processing.

In spite of the existing issues in this case study, the required amount of data was captured via contemporary, precise and very productive surveying technology. In this study were used the current possibilities of the IT.

The measured 3D information was analysed and it could be noted the high accuracy, which was obtained and given in chapter 7:
a) 1 mm in the registration process;
b) 9 mm in the georeferencing of the point cloud.

The mentioned quality results satisfied the requirements for accuracy of the terrain points of the object. The extracted data from this terrestrial laser scanning was represented in the plane. The information was used for further geodetic activities in the area of cadastre.

Based on:
-the geometry of the object;
-the closed area where the buildings were situated in;
-the technical difficulties (solved during the data processing);
-the hardware, used in this study;
-the taken decisions in the area of terrestrial laser scanning
it could be noted, that the geodetic measurements were done in a reasonable time (due to the bad weather conditions) and excellent quality results were obtained.

Proposal for future activity before performing of outdoor laser scanning. In order to avoid the described technical issues, caused by the existence of bushes around the object it could be recommended their removal in advance in the appropriate way by the owner or representative.

REFERENCES

Kostov, G., 2015, Application, specifics and technical implementation of the 3D terrestrial laser scanning for measurement and analysis of the spatial geometry of a steel construction. FIG Working week 2015. From the Wisdom of the Ages to the Challenges of the Modern World. Sofia, Bulgaria. ISBN 978-87-92853-35-6. ISSN 2307-4086. pp4. Sofia, FIG

WEB

https://1library.net/title/visualisation-d-cadastre-using-terrestrial-laser-scanning
https://eprints.usq.edu.au/31409/1/Gann_N_Zhang.pdf
https://mycoordinates.org/terrestrial-lidar-capabilities-for-cadastral-modelling/
http://www.diva-portal.org/smash/get/diva2:1362840/FULLTEXT01.pdf
https://www.e3s-conferences.org/articles/e3sconf/pdf/2020/24/e3sconf_tpacee2020_07012.pdf
https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLII-2-W9/663/2019/isprs-archives-XLII-2-W9-663-2019.pdf
https://www.mdpi.com/2072-4292/12/10/1547/pdf

USED SOFTWARE

Trimble RealWorks (http://www.trimble.com/3d-laser-scanning/realworks.aspx);

BIOGRAPHICAL NOTES

Gintcho Kostov graduated in UACEG, Sofia in 1998. He is chief assist. prof. Dr.-eng. at University of Forestry, Sofia. In TU Wien, Austria he completed and defended a scientific project, entitled “Assessment of the Quality of Geodetic Networks Using Fuzzy Logic”. Dr. Kostov holds the following licenses: for performing of activities in the area of geodesy, cadastre and investment design. He is a member of: Union of Surveyors and land Managers in Bulgaria, Union in Scientists in Bulgaria Chamber of Engineers in Investment Design and Council of Experts in Municipality Opan.

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