3D MODELING METHODS – OVERVIEW AND COMPARISON

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***Abstract**: Nowadays, we are talking more and more about the objects three dimensional model (3D model). They are used in various fields like: Surveying, Architecture, Cultural Heritage Preservation, Medicine, Cinematography and many more. Why? Because they allow us to explore parts of the studied object that aren't reachable with a simple measurement such as fine details or high parts of certain structures. Three dimensional models can be obtained in different ways by using a laser scanner, or a digital camera due to the accuracy requirements.*

This paper aims to highlight a comparison of the 3D model of a Heritage object, from Arad City, obtained both by using a laser scanner and a digital camera, regarding technical requirements, advantages and efficiency.

***Keywords:** 3D model, laser scanning, close range Photogrammetry*

1. Introduction

The laser scanning method describes a surface sampling or scanning, using laser technology. It analyses a real life medium or an object having the porpoise of collecting information on its surface and appearance (i.e.: the objects colour). Collected information can be used for creating bidimensional representations, used in a variety of applications.

At first the laser scanning was used in the machine building industry and in the industrial design process, for facilitating the computer assisted design process (CAD). This helped the consumer goods large scale production. With the technology developing and the increasing advantages, the laser scanning extended its applications in fields like: geodesy, civil engineering, cultural heritage, architecture, urban planning, medicine and others.

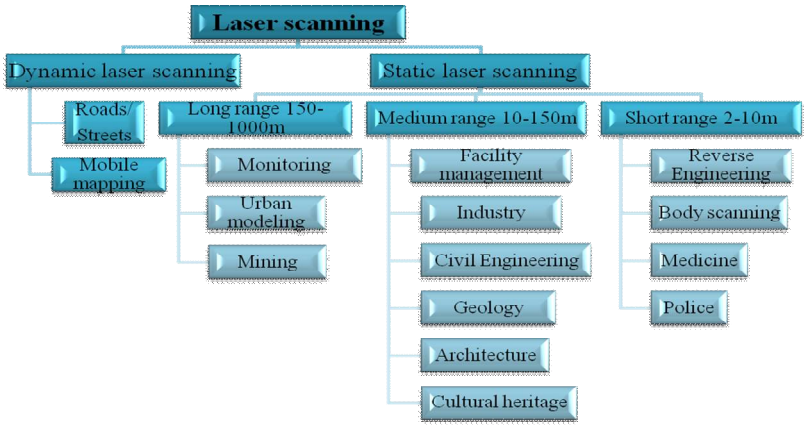

Figure 1. Laser scanning applications

Generally, Digital Photogrammetry is a well-established technique for acquiring dense 3D geometric information for real-world objects from stereoscopic image overlap and has been shown to have extensive applications in a variety of fields [1]. It implies one or two photos/photogramms analysis with specialized programs, for determining spatial relations.

Close Range Photogrammetry finds its application in various fields like medicine (plastic surgery), archaeology and historical and cultural heritage preservation because of its well known advantages: the measuring method is without direct contact with the studied object, the results are precise and reliable, the data collection is made in a short time with low costs and at any time the saved images can be remodelled [2].

This technique has become an efficient alternative at the classical façade topographical measurements, but an application accomplishment respects the steps of any Land Measurement project. So, for obtaining technical and scientific results it is necessary to plan and to recognize the field for the measuring campaign and to perform the measurement itself and also to process them.

2. Materials and Methods

The laser scanning technology consists in a laser beam deviation through a mirror (by rotation or scanning), reflecting it from the measured object surface and its receiving. In this situation the measurement precision depends by the intensity of the reflected laser beam (Figure 2).

Figure 2. The laser scanning principle [3]

The measurements result is represented by a multitude of points named in the scientific literature as "point cloud". During the scanning process along with the points 3D coordinates the instruments photo camera acquires the studied object photo.

It can be said that the terrestrial laser scanning is a conversion method of the high resolution spatial data in precise geometrical data models (2D or 3D).

Digital Photogrammetry implies one or two photos/photogramms analysis with specialized programs, for determining spatial relations.

The data acquisition principle using the photogrammetric method aims obtaining information referring to physical objects and to the environment, from distance, without physical contact through photographic images recording, measuring and processing.

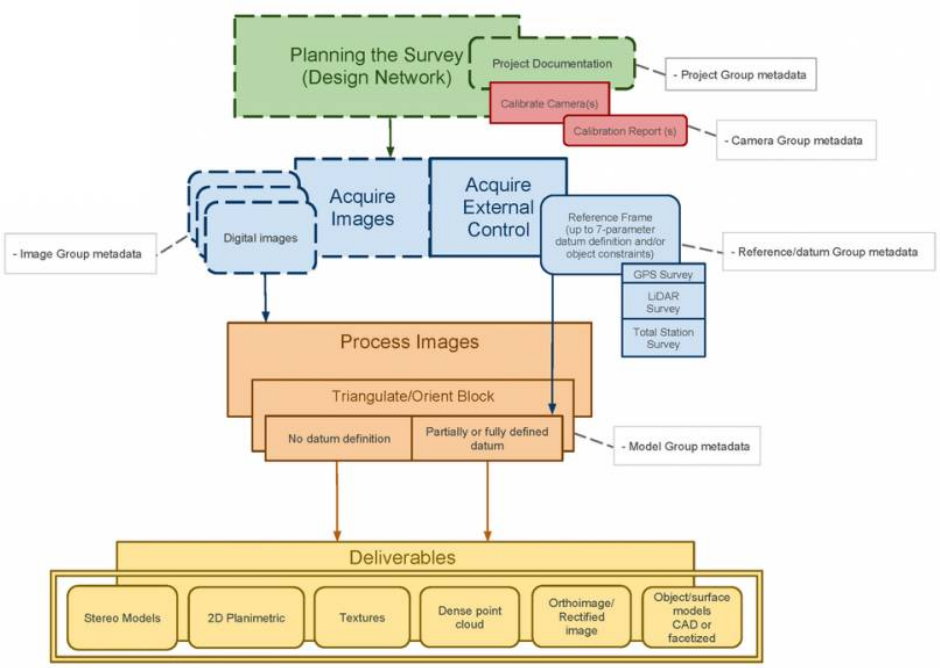

Figure 3. Close range Photogrammetry workflow [4]

The 3D model can be obtained:

- Stereoscopically – in this case two photo cameras are used. The distance between points can be obtained through the stereoscopic model analysis.
- Photogrammetric – this method uses only one photo camera which is used in acquiring multiple images in variable light conditions.
- Outline or silhouette obtaining – This method uses outlines obtained from photos made around an object, on a contrasting background.

3. Case Study

The Liberty Statue from Arad City is one of the most important touristic objectives from Crisana region of Romania. It was realized by Zala György and Huszár Adolf, as a tribute to the generals sentenced to death following the defeat of the revolution from 1948 - 1949.

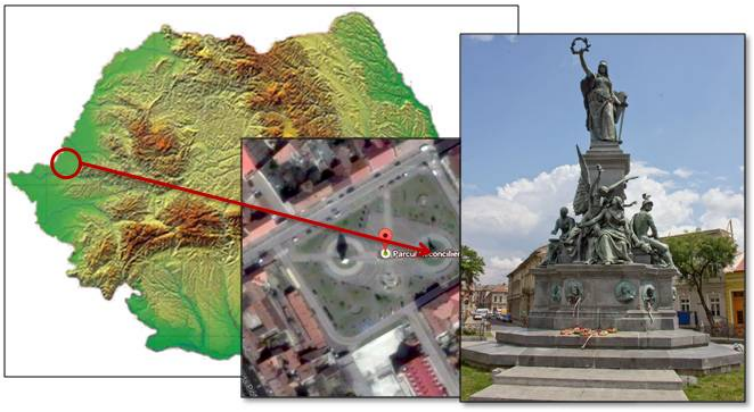

Figure 4. The Liberty Statue from Arad City

a. The 3D model obtained using terrestrial laser scanning technology

The first stage in obtaining the 3D model of the monument is the field measurements. It implies positioning the laser scanner in several station points around the monument, for realizing a complete scanning. For this application we used Trimble TX5 laser scanner and six spherical targets.

Figure 5. Field measurements

For data processing we used Trimble RealWorks software. This point cloud modelling software allows the acquired data registration, visualization, exploring and manipulation. From the moment when the point cloud is created it can be manipulated very easy, in this way realizing the final work and in the end exploring the 3D model.

The data processing first step in creating the 3D model consists in importing the *.fls files and creating the point cloud by recording the stations (Target-Based Registration Tool).

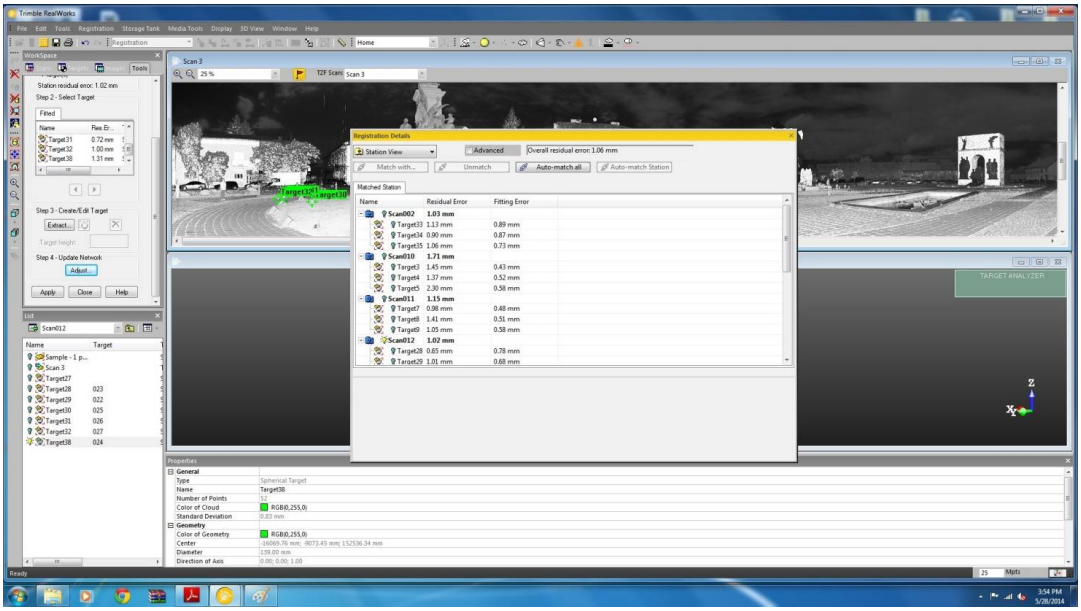

Figure 6. Registration details

The next step is the interest area delineation, which is made from the Tools menu.

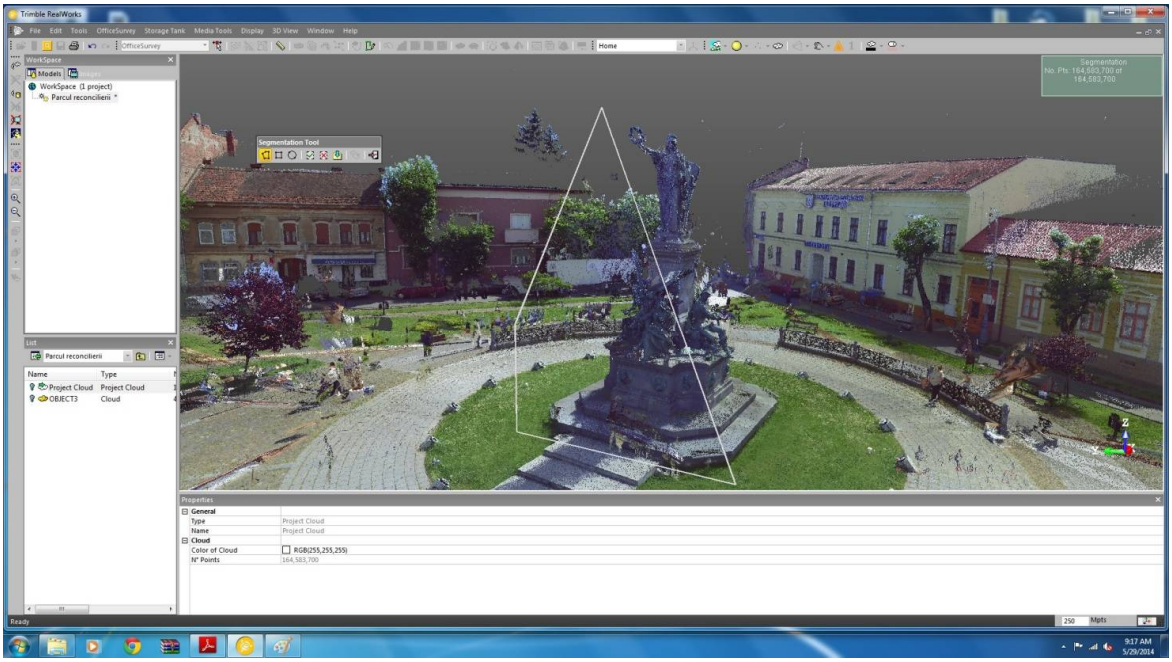

Figure 7. The interest area delineation

Next, from Office Survey using Mesh-Creation Tool command and selecting the interest area, we create its mesh. In the figure below the mesh created for the soldier head can be observed.

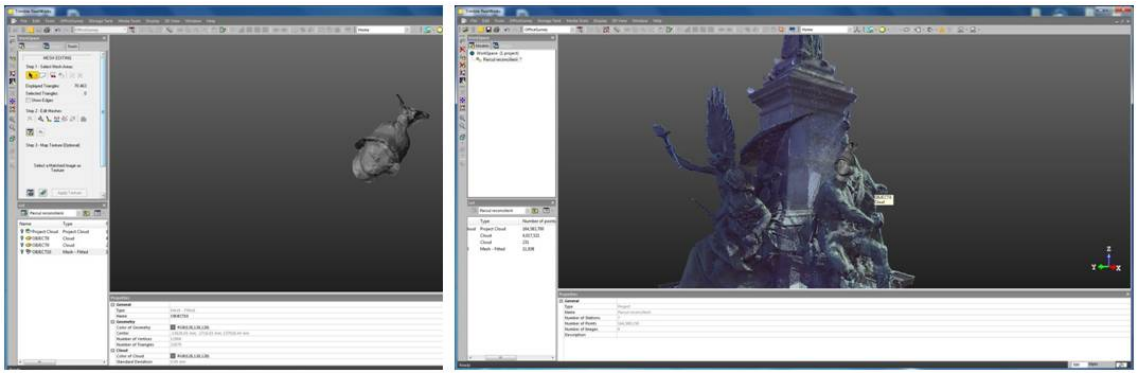

Figure 8. Mesh editing

3.2. The 3D model, obtained using close range Photogrammetry

For this project the images were acquired with a Nikon D3100 and the processing software was 123D Catch from Autodesk. This software creates 3D models from series of photographs taken at various angles using Photogrammetry principles. 123D Catch is freeware software that can either be downloaded onto the PC or it can also be used online.

The starting point for creating a 3D model from 2D images is to photograph the studied object from different angles (Figure 9). About sixty photos were taken.

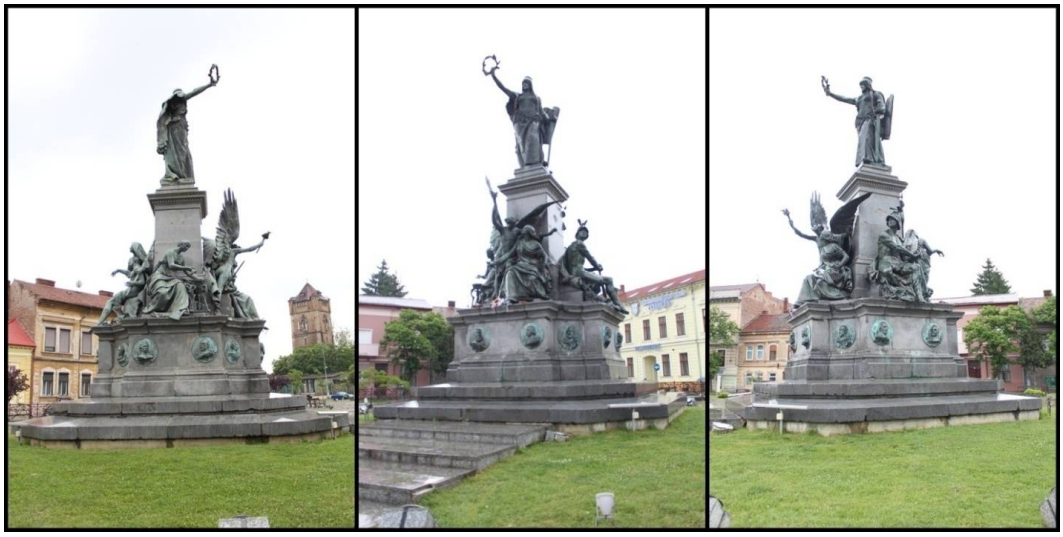

Figure 9. The monuments photo taken from different angles

The next step was to download these photos from the digital camera on the computer and to launch 123D Catch software. Then we created a new capture and uploaded the photos on the memory cloud (Figure 10). The capture is created online on the memory cloud and then it can be downloaded into the software (if the software is installed on the computer – Figure 10); otherwise (if the software is used online) the capture is displayed on the computer screen.

In the figure below we can observe the animation path of the camera and also the unprocessed 3D model.

Figure 10. Data processing using 123D Catch software

The mesh type (Texture Only, Wireframe Only and Wireframe and Texture) and texture (mobile, standard and high) can be selected from Display Setting menu and also, from this menu, settings for the software workspace visualization elements can be made. For facilitating the 3D model processing we choose the Wireframe only mesh type and standard mesh resolution. The unwanted details were eliminated by using the Lasso Selection option, for selecting them and the Delete command from the keyboard, for deleting them.

After cleaning and healing the mesh we obtain the final result presented in the figure below:

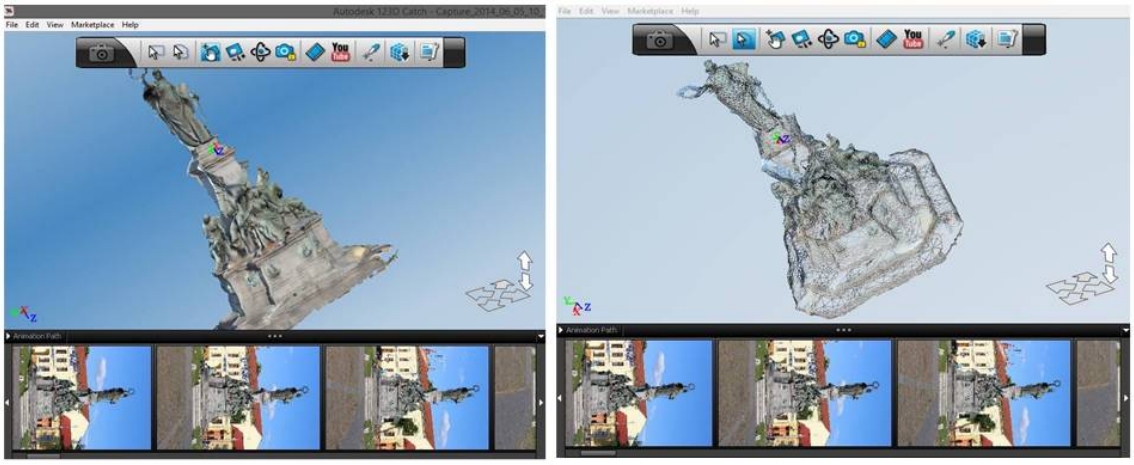

Figure 11. The monuments 3D model with Texture Only and Wireframe Only meshes

4. Conclusions

Laser scanning is a versatile technology that offers ultra fast, high density and remotely captured 3D digital images of objects and surfaces [10]. From its numerous advantages the following can be highlighted:

- the data captures speed;
- the high-density, accurate data using direct measurements which ensures a complete and accurate survey;
- the remote acquisition and measurement that increases efficiency and safety of surveys;
- the 3D visualization provides added confidence that the studied objects correspond to reality.

As drawbacks of laser scanning the following can be noted:

- its price;
- the complex processing of the dense datasets;
- the atmospheric conditions and the seasons can influence the data acquisition on the field;
- the difficulty of getting shots in tight areas or from very close range.

3D modelling technique based on 2D images highlights the Digital Photogrammetry useful character of real life objects 3D visualization and modelling. The obtained 3D models have a precision that can make Close Range Photogrammetry an alternative to classical measuring techniques.

Close Range Photogrammetry as a research method has many advantages, like:

- it has low expenses on one area surface;
- the images can be processed for free online or on the downloaded application;
- image processing is made on a computer cloud;
- using it you can print a 3D model of the studied object at different scales;
- the final result can be exported as a file in *.dwg, *.fbx, *.obj extensions which allow an accurate further processing in other programs;
- the beneficiary can use the studied object animation;
- it is the fastest solution in case of a large data volume, creating the research possibility for vast and/or inaccessible areas.

As disadvantage we can note:

- the atmospheric conditions and the seasons can influence the photo acquisition on the field;

- in general, land measurements are made for a higher precision.

The conclusions can be structured following several aspects like:

✓ **The working time**

The time spent for obtaining the 3D model, with the laser scanner, was about three hours (about one hour for the field measurements and two hours for data processing) and for the 3D model from 2D images was obtained in about an hour (20 minutes for image acquiring and about 40 minutes for the image processing). So, it may be concluded that for obtaining a 3D model in a short time, 2D images will be the most probably used.

✓ **Working equipment**

About the working equipment it can be concluded that the one used in the laser scanning technology is a complex one and only a specialist with geodetic skills can handle it.

✓ **Costs**

Comparing the costs for obtaining the 3D models, it can be highlighted that the 3D model obtained using the laser scanning technology have higher costs than the one obtained from 2D images.

✓ **Software**

From this aspect the difference from the two ways of obtaining the 3D model are significant: Trimble RealWorks has the possibility to be downloaded on a View only version (if it wasn't bought), meanwhile 123D Catch can be used free online or to be downloaded full version on the computer. Another important fact that must be highlighted when using 123D Catch is that a part of data processing is made online on the memory cloud and when Trimble RealWorks is used the data processing is made only on the computer. Taking all this into account it could be concluded that an online data processing is faster and it saves computer resources.

✓ **The 3D models precision and aspect**

Regarding the precision and aspect when we have a 3D model of a large object the laser scanning technology has a higher precision and a better aspect (Figure 12) than the one obtained using 2D images.

a) b)

Figure 12. The monument 3D model realized with: a) 123D Catch, b) Trimble RealWorks

But, if an object at a smaller scale is studied it can be concluded that we obtain a higher precision and a better aspect when using 2D images (Figure 13).

a) Trimble RealWorks b) 123D Catch c) Reality

Figure 13. Monument detail

✓ **Errors**

In both cases errors can occur. For example when the laser scanning is used is very important that the space around the studied object to be undisturbed because otherwise the data cannot be used furthermore. When acquiring a 2D image, is very important that the photo is clear and not blurred or moved, because a blurred photo cannot be used.

✓ **Operators point of view**

A comparison can be made from this point of view too: anyone can take photos and obtain a 3D model using a freeware (which can be learned from web tutorials), but only a specialized person like a geodesic engineer with certain professionals skills can learn to use a complex technology like the laser scanning.

In the end we can conclude that if the beneficiary requests a precise 3D model of a large scale object always the laser scanning technology it is most likely to be chosen, on the other hand, when a 3D model of a small scale object is requested the one obtained from 2D images is the one that probably will be used.

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