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Original Research Article

TECHNICAL ASSESSMENT OF HISTORIC BUILDINGS ON THE BASIS OF INFORMATION OBTAINED FROM A THREE-DIMENSIONAL POINT CLOUDS

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Abstract

3D scanning is the most modern method of unlimited possibilities based on laser technology. Its main advantage is the speed of obtaining large amounts of data in a very short time, which gives a huge advantage over existing methods of the measuring. Scanning provides opportunities for use in engineering works, geodetic and the inventory of buildings and objects of a high complexity, as well as in studies of damage or deformation of the structure. 3D scanner is a device, which with high accuracy collects data about the shape and texture of the tested object and its surroundings in the form of a point cloud.

Keywords: 3D laser scanning, inventory of architecture and construction, damage to the building or structure, structures deformation

1. INTRODUCTION

The laser scanner is a tool that uses the latest technology, allowing for the acquisition of spatial information about objects and their environment. This measurement system allows for non-invasive and non-contact collection of data on spatial coordinates, so that it is possible to present three-dimensional buildings, engineering buildings and their visualizations.
ScanStation C10 laser scanner manufactured by Leica, can measure the elements at a distance of up to 300 m, with a rate of 50 000 points / sec. It is

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a tool using TLS method (Terrestrial Laser Scanning). As a result of the conducted scanning, one obtains a point cloud from each position of the instrument. Combining scans is made possible by the common points which are defined in the visual field of the scanner.
Thanks to scanner Leica ScanStation C10, which was used to make field measurements for presented objects in this report, it became possible to completely map their authentic shapes and textures and colours (Figure 1).

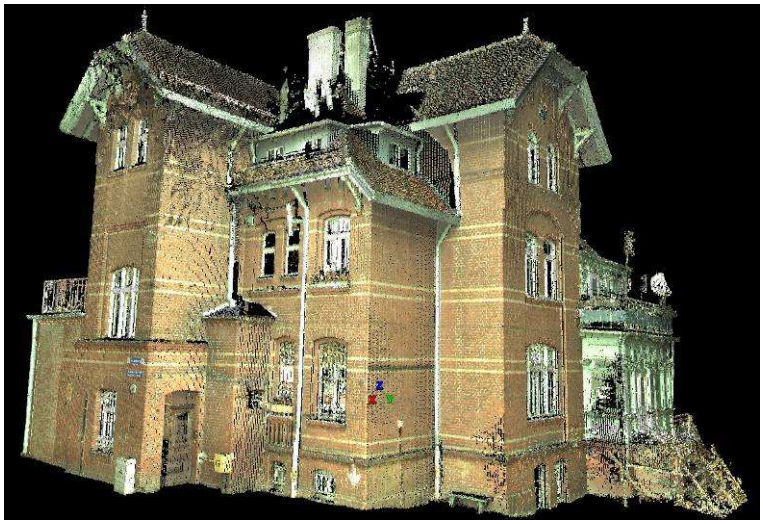

Fig. 1. Scanned building with superimposed images (source: own study)

2. OBTAINING AND PROCESSING OF POINT CLOUD

The result of the measurement with laser scanner on the given station is a set of points called a scan. These points have specific XYZ coordinates in the local coordinate system. In order to obtain complete data about the object, usually it is necessary to perform measurements at several measuring stations. One should, therefore, determine the amount and distribution of measuring stations that allow a good display of an interesting object and to choose resolution of measurement [2]. Scans from different positions are subjected to the orientation and filtration. Orientation is a process of spatial integration of a number of scans into one point cloud with tie points, which are special signals. These markers are arranged on the scanning area in the immediate vicinity of the instrument, so that to make it possible to connect the individual scans into one coherent whole. Filtration is the cleaning process of point clouds from all unnecessary elements (trees, people, vehicles) as a result of which we obtain a

set of data without unnecessary "noise". Data in the form of oriented and cleaned point cloud can be modelled and analysed.
Measuring with the scanner can replace the performance of architectural and building inventory using classical methods. There are many ways to inventory, enabling collection of accurate geometric data describing the object. In the traditional method, structural components are modelled by hand, and all documentation is developed on the basis of photographs and manual measurements. This way of inventory requires intensive amount of labour and time, and though it leaves many doubts regarding the accuracy of the made model.
Created from the point cloud object model can be used to determine the actual parameters and to show the current status of the tested building. Laser scanning technology is the most complete measurement method, which automatically collects vast amounts of information about the geometry and shape of an object of interest [1]. A multimillion point cloud covering the surfaces allows you to create a "near-continuous" spatial object, which in a later stage of processing allows to perform a complete architectural and building documentation [3], consisting of:

- 2D documentation - these are, e. g.: plans, views and sections created as a result of cutting and projection of the given object on an appropriately selected surfaces (Figure 2);
- 3D documentation - which consists of e. g.: framework and surface models, and models with superimposed textures created from cleaned point clouds through their modelling with TIN grid (composed of triangles), or by the so-called patch function (i. e. the surfaces superimposed on points) [2].

3. CHOSEN RECONSTRUCTION METHODS OF TECHNICAL CONDITION OF AN OBJECT FROM THREE-DIMENSIONAL POINT CLOUD

Leica proposes to use the Cyclone program, which is helpful in connecting the individual scans and in modelling removed objects. The software gives the ability to "create" from a cloud a three-dimensional point model using various ways. The two most popular are modelling the building using the "Patch" function and using the TIN grid.

3.1. Modelling using the "Patch" function

It involves crafting three-dimensional model of the object by creating surfaces. They are manually fitted into the point cloud that defines developed building element, for example a wall. Unfortunately, the "superimposed" surface

"covers" all irregularities occurring on the object. The problem of covering also relates to all kinds of openings, for example windows, which are located on the wall. Therefore, they require manual separation. Elements that are not flat (e. g. rainwater pipes) can be modelled by using e. g. the cubes or cylinders, which are given a proper thickness and "are pulled" along the designated axis. Working with the "patch" command is quite tedious because it requires manual creation virtually any of the necessary components (Fig. 2).

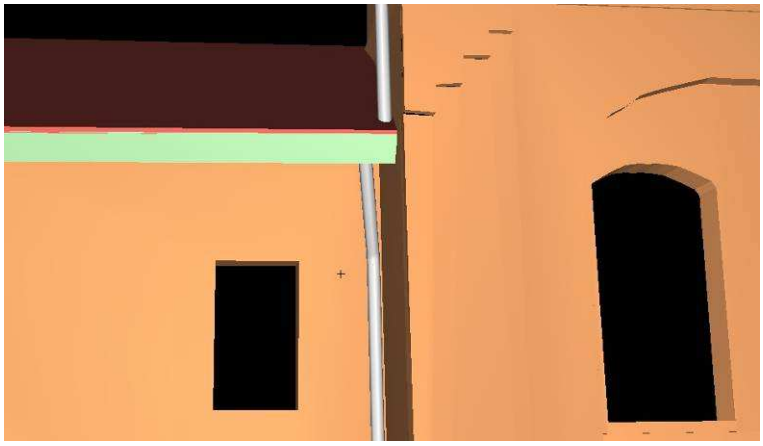

Fig. 2. Modelled fragment of the facade using the surfaces (source: own study)

3.2. Modelling with TIN grid

Fig. 3. The same fragment of the facade (see Figure 2) modelled using TIN grid (source: own study)

The TIN grid (Triangulated Irregular Network) is a network composed solely of the triangles. Their tops are the closest adjacent three points from the point cloud.
Modelling object using the TIN grid leads to obtaining a three-dimensional mapping of the studies object of a high-quality (Figure 3**Błąd! Nie można odnaleźć źródła odwołania.**).

3.3. Analysis of suitability of non-modelled point cloud

High accuracy of measurement guarantees high-quality point cloud, which is also an accurate representation of the given object (Fig. 4). The three-dimensional data obtained by the instrument, enable inventory and description of the loss or damage to the facade of the building, as well as deformation in a structure [4, 6]. Having the cleaned point cloud itself we are able to observe where on the object occur such abnormalities and perform their measurement on the computer screen (Fig. 5).

Fig. 4. Destroyed facade of a historic building (source: own study)

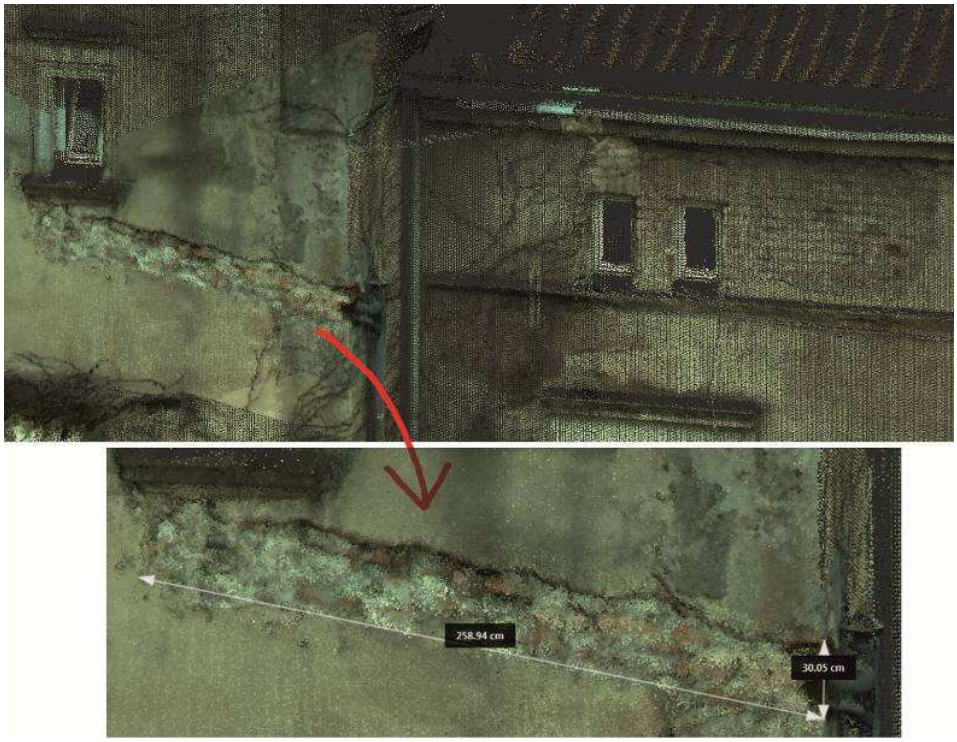

Fig. 5. Measured damage and losses (source: own study)

4. SUMMARY AND CONCLUSIONS

The conducted analysis leads to the conclusion that the technical condition of the building can best be assessed without performing tedious work to model object. As one can see from the above, the method of surfaces is not at all useful in the records of damage, and the TIN grid method is labour-intensive and also little useful process of collecting data about the technical condition of the object. However, the usefulness itself of the objects modelling is useful, for example, when one needs a visualized form of the object.

Historic buildings and structures can thus be archived and preserved for future generations, even when there is no original documentation of the object, or if it must be demolished for some reason. With the creation of its digital documentation in the form of point cloud, it can survive for generations.

Bearing in mind the continuous efforts to modernize and accelerate construction works, the proposed method using data from 3D laser scanning is accurate, although works on the object modelling can be considered pointless in this case.

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OCENA STANU TECHNICZNEGO BUDYNKÓW ZABYTKOWYCH W OPARCIU O DANE UZYSKANE Z TRÓJWYMIAROWEJ CHMURY PUNKTÓW

Streszczenie

Skanowanie 3D jest to najnowocześniejsza metoda o nieograniczonych możliwościach oparta na technologii laserowej. Jej podstawową zaletą jest szybkość pozyskiwania dużej ilości danych w bardzo krótkim czasie, co daje ogromną przewagę nad dotychczasowymi metodami pomiarowymi. Skanowanie daje możliwości wykorzystania w pracach inżynieryjnych, geodezyjnych, przy inwentaryzacji budynków i obiektów o dużym skomplikowaniu (np. zabytkowych), a także w badaniach ich uszkodzeń i odkształceń konstrukcji. Skaner 3D jest to urządzenie, które z dużą dokładnością analizuje w czasie rzeczywistym mierzoną budowlę oraz zbiera dane o kształcie, fakturze oraz teksturze badanego przedmiotu i jego otoczeniu. Prawidłowo przeprowadzone pomiary dają zbiór punktów o znanych współrzędnych X,Y,Z w formie chmury punktów, które można obrabiać, w efekcie czego stworzony zostaje w pełni cyfrowy, trójwymiarowy model obiektu. Często w czasie inwentaryzacji wykonywanej metodami klasycznymi nie ma możliwości, aby zauważyć wszystkie uszkodzenia występujące na badanym obiekcie. Również trudno jest ocenić i zmierzyć np.

zniekształcenia elementów konstrukcyjnych. Analiza obrazu uzyskanego z trójwymiarowej chmury punktów, pozwala na zidentyfikowanie ubytków, określenie wielkości pęknięć i innych odkształceń (np. ugięć belek) we wszelkiego rodzaju budynkach i budowlach.

Słowa kluczowe: skaning laserowy 3D, inwentaryzacja architektoniczno-budowlana, uszkodzenia budynku lub budowli, odkształcenie konstrukcji

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