ANALYSIS OF THE APPLICABILITY OF LASER SCANNING TO MAKING AN INVENTORY OF SWIMMING POOL FACILITIES

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- upgrading,
- inventory swimming pool

Abstract:
3D scanning can be used in many branches of economy, e.g. reverse and prototype engineering, industrial design, quality control, prosthetics, orthodontics, archiving of historic objects and archeological findings, examination of a scene of crime, making films and computer games. The technology of terrestrial laser scanning has a bright future as we are living in the time of blooming measurement techniques, which can provide all needed data easily and in a complex fashion. Accuracy, ease of work, safety and non-invasiveness are the main advantages of the scanning technology, which make it increasingly popular in practice. This paper deals with the issue of measuring swimming pool facilities using the laser technique, and a procedure of making a three-dimensional model of a building. The authors also discuss possible applications of this modern technology for making an inventory of a swimming pool facility.

INTRODUCTION

Swimming pools are popular in Poland and across the world. Each larger town has swimming facilities: water parks, swimming pools, etc. Having a public swimming pool defines the town's status as a modern urban centre. Many schools and tourist resorts build their own pools so as to gain prestige. Technologically, constructing such facilities is extremely expensive and 'burdened' with a variety of technical and engineering difficulties. The architecture of a building itself, the complex structure and huge glazed wall surfaces are an immense challenge for building designers. Constructing a swimming pool is costly and calls for application of the state-of-the-art material and technological solutions, on which the building's visual quality, standard and perception by users will depend. It is not easy to fulfill high maintenance requirements when operating a swimming pool building. The omnipresent moisture, intensive use and great variety of facilities create a situation when frequent repairs and even major overhaul works are needed. Keeping a swimming pool in good condition also means its renovation and sometimes modernization. Whenever such a need arises, it is necessary to make an inventory of the building's assets, which is difficult to obtain with traditional measuring methods. Then, the 3-D laser scanning technique can come handy. Three-dimensional laser scanning is a measuring and modelling technology, which finds applications in many branches of science and economy. Results of measurements in the form of a huge number of points enable instant and precise imaging of scanned objects. [1, 2].

In this study, consisting of measurements of the University Swimming Pool in Olsztyn (fig. 1), a ScanStation C10 scanner made by Leica was used. Laser scanning is an exceptionally accurate and fast technique, for example the device used in out examination can record as many as 50 000 points per second. The results are highly attractive and easily processed. A model composed of a cloud of points is a faithful representation of the scanned environment, which can be manipulated with ease. In other words, we are able to transfer the reality onto computer monitors and fully interact with it.

Fig.1. The University Swimming Pool in Olsztyn (source: photo M. Druszkowski 2013)

Laser - (*Light Amplification by Stimulated Emission of Radiation*) is a generator of light radiation which takes advantage of the phenomenon known as stimulated emission. Light is a combination of many waves of different lengths, and when they are split, constituent waves of the whole spectrum of colours are obtained. [3, 4].

Two types of scanners are distinguished: pulsed and continuous ones. Pulsed lasers generate a laser beam in pulses, whereas in phase lasers the light beam is continuous. The ScanStation C10 scanner is a device emitting a pulse followed by a momentary break, after which another pulse is emitted. Pulsed lasers have low average power but high power of pulses. This enables a light pulse to reach further than the light beam generated by a continuous laser. [3, 4]. A pulsed laser is also a more economic solution: an expensive continuous laser with high power radiation can be substituted by a lower-power pulsed laser, yet reliable results can be attained. By definition, a pulsed laser is the one in which the time of emitting light is no more than ¼ second; any other laser is considered continuous (the Polish Norm PN-91/T-06700).

A 3-D LASER SCANNER

A 3-D laser scanner is a device which analyzes an object or a surface in real time and collects data about its shape, texture and consistency of the analyzed environment. Once all the data have been collected with a scanner, we are able to produce a fully digital, three-dimensional model of an object. Unfortunately, the laser technology is incapable of making precise measurements of light reflecting, light emitting or transparent surfaces. This is the reason why buildings with large glazed walls, such as swimming pools, are very difficult objects because a laser ray can be reflected by the surface of water or a glass wall (fig. 2).

Collecting measurement data consists of measuring distances and the angle between the measuring device and the scanned object. A scanner sitting on a levelled and stable tripod collects data while rotating around its own axis. This is how a cloud of points evenly distant from one another and located in spaces corresponding to the surfaces of the analyzed building is created. Each point is defined with the coordinates X, Y and Z, orientated towards a local set of coordinates, which most often is the localization of the scanner. A point cloud gives realistic visualization of the scanned object. A disadvantageous effect with respect of the quality of achieved information is the so-called echo of a signal, which appears when some fragment of the laser's spot falls on the edge of the object. Some part of the signal returns to the emitting device but some of it is reflected back by an object located further away [5, 6].

Fig. 2. Deformation of a point cloud caused by the reflection of a laser beam from a glazed wall of the University Swimming Pool in Olsztyn. (source: authors)

The received set of data is also frequently polluted with the so-called information noises, that is scanned elements which incidentally appeared in the modelled space. A point cloud can be polluted with such items as human and animal figures, atmospheric precipitations or reflections of objects in glass or water surfaces (fig. 3). Such interferences are not uncommon when taking measurements of buildings like swimming pools.

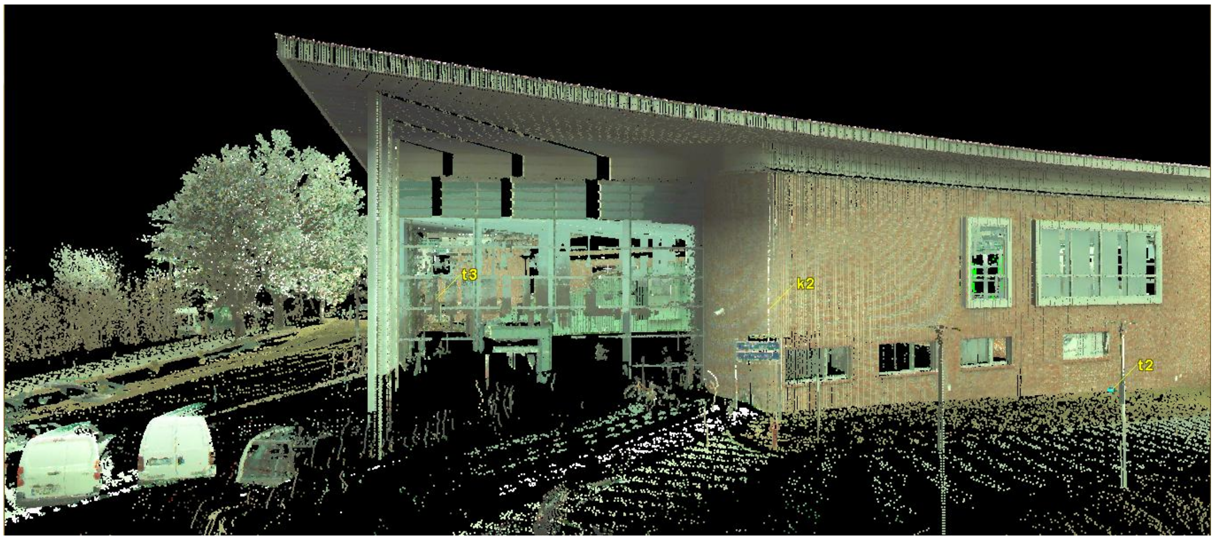

Fig. 3. Noises and interferences in an image of a swimming pool. (source: authors)

DATA ACQUISITION AND THEIR USE

The first step during preliminary field work is to make a field inspection and recognize the object. At that point, it is also possible to decide about the number of sites where the scanner will be placed and their location. Attention should be paid to ensure that the chosen sites enable the scanner operator to capture the whole scanned object. An erroneous localization of the scanner leads to the appearance of 'holes' in a cloud of points. The so-called dead spots are also created when another object, for example a tree or a car, appears on the way of a laser beam between the scanning device and the scanned object (fig. 4). Equally important is the correct setting of signals in the form of HDS 6 targets and spheres with the diameter of 10 cm, which constitute mutual references for the subsequent measuring sites of the scanner [6, 8].

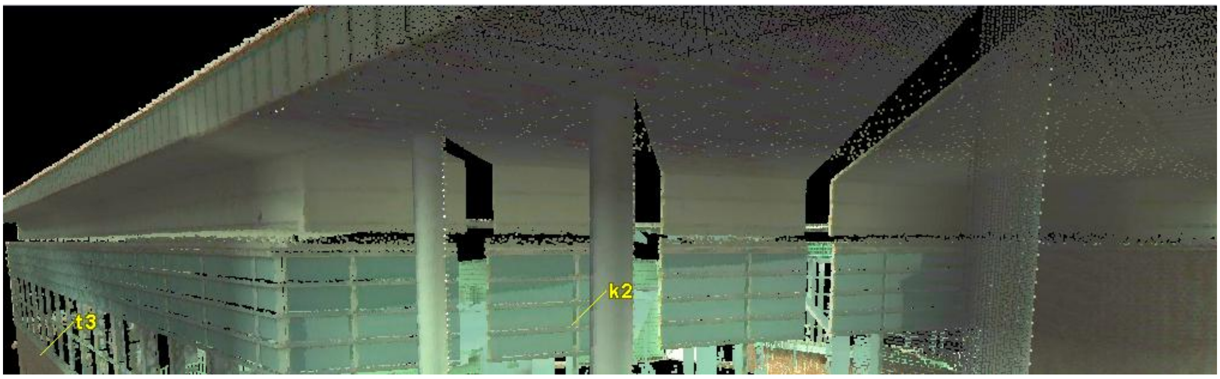

Fig. 4. Dead spots (source: authors)

A three-dimensional set of points achieved from laser scanning, known as a point cloud, as well as photographs taken by the scanning device served as the basis for determination of the structure of the building, that is the way its form was shaped and what construction materials were used to raise it. Our further work on the data involved their computer processing with the Cyclone 7 software, when scans from individual sites were integrated so that a uniform, three-dimensional model of the building was created. The 3D image thus obtained was filtered to remove unwanted information noises, after which it was overlaid with photographs to give the model its colour and texture (fig. 5).

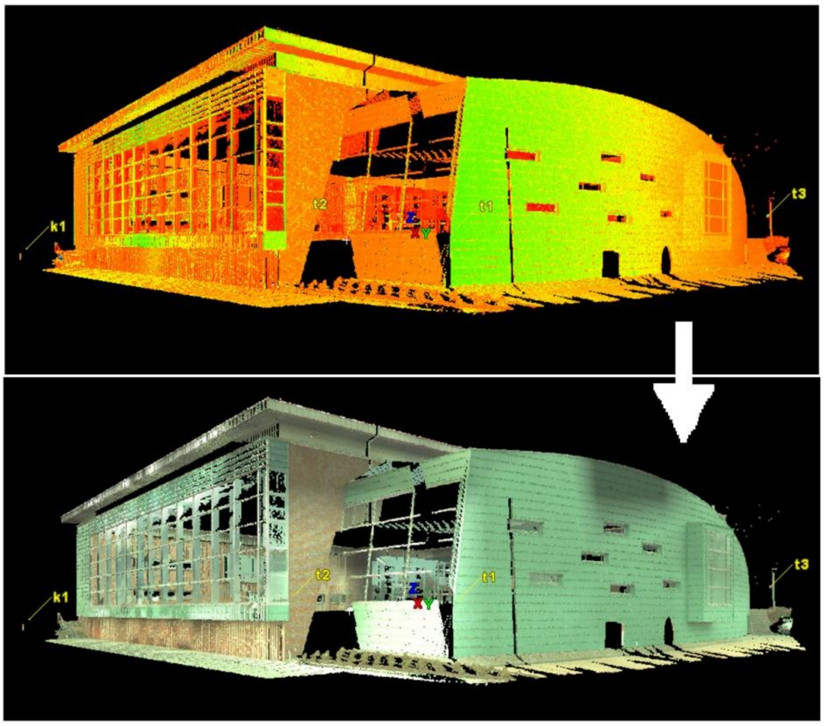

Fig.5. The UWM Swimming Pool – a three-dimensional image of the building in the form of a cloud of points and after photo overlay. (source: suthors)

For making inventory documentation, needed for example to renovate a building, data from three-dimensional scanning of an object can be highly useful. Data from measurements with a scanner, owing to the dedicated software and its functions which enable selection of groups of points, can be used to create vertical and horizontal cross-sections in any plane (fig. 6). This way it is possible to work out technical documentation, which is necessary for example to make a costs analysis or to define the extent of construction works. In addition, the software programme enables the user to create visualizations and to view a full image of the scanned building in three dimensions.

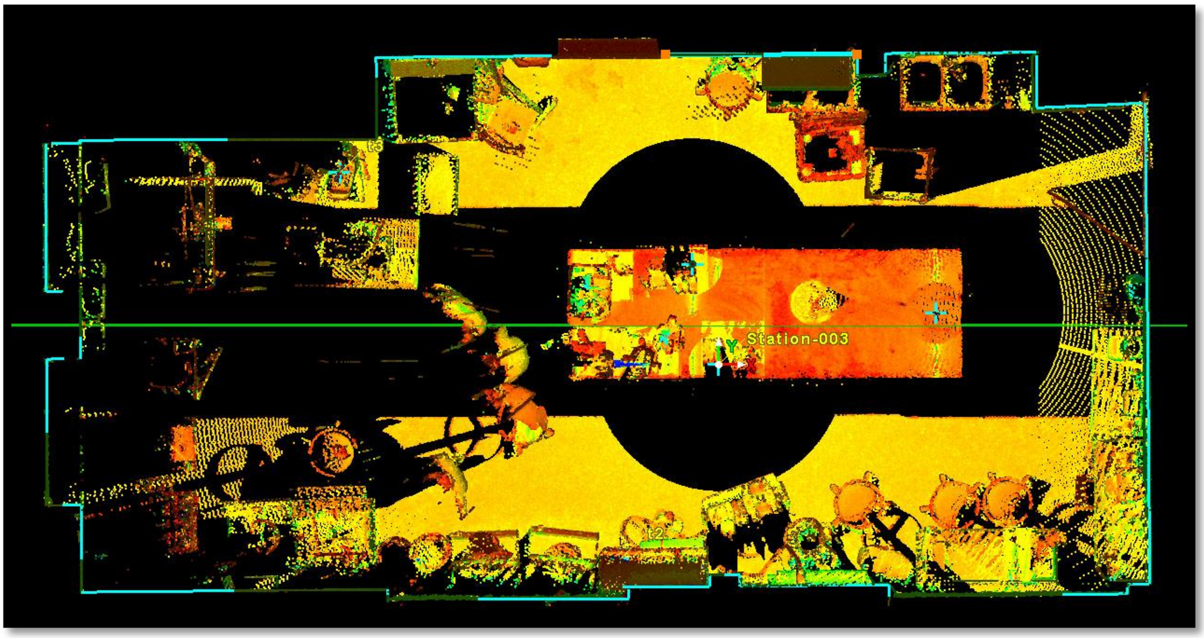

Fig.6. A horizontal cross-section of a scanned room. (source: authors)

Precision of the execution is necessary in any construction works, which gives laser 3D scanning an undisputable advantage of enabling an overview of the existing condition of a swimming pool building, especially by diagnosing construction elements exposed to intensive effect of humidity. The accuracy with which such elements of a building construction are made and joined together influences the work of the whole construction. In some constructions, e.g. metal ones, it is essential to assemble and bind all elements with great precision, as this will affect immensely the work and resistance of the whole construction. With laser 3D scanning we obtain a faithful model of a building, which can be compared to the technical documentation so as to assess the quality, precision and correctness of the execution of a given element. These problems very often concern large buildings with glazed walls, of which swimming pools are a good example.

SUMMARY

Making an inventory of a swimming pool building with a laser 3D scanner is of great assistance to architects, building designers and developers. Irrespective of the large amount of work required to make a three-dimensional model of a building, this method is becoming more and more popular. Having a precise model of a real building, its is easy to review and assess the condition of the building. At the same time, it is possible to monitor whether the construction functions properly. The possibilities created by the 3D scanning technology include easy inventory making and modelling of buildings with complicated structures.

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