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IMPACT OF PHYSICAL PROPERTIES OF DIFFERENT MATERIALS ON THE QUALITY OF DATA OBTAINED BY MEANS OF 3D LASER SCANNING☆

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Abstract

This paper discusses the impact of a laser beam deformation during 3D laser scanning of different objects. Based on a point cloud obtained for selected examples, the paper addresses the issue of the quality of data dependant on the intensity of laser beam reflection and the type of material. The knowledge of these issues allows obtaining valuable data necessary to develop a digital and visual model of practically any building structure made of any given material.

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Keywords: building material; laser scanning, reflection intensity, point cloud

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1. Introduction

A building structure subjected to laser scanning takes the form of the so-called point cloud comprised of thousands of measured coordinates. The cloud not only shows a lot of information about the shape and dimensions of the target object, but, by means of measuring the intensity of a laser beam reflection, it also receives data related to its structure and colours. The laser beam reflection intensity is the value of the energy returning to the receiver following it being sent from the transmitter and reflected form the surface at which the laser beam was directed. It provides valuable information about the structure and colours of the examined object [1], which is then transferred into the computer memory, where, by means of a special software and processing a realistic, spatial representation of the measured object is obtained. . By superimposing a digital image taken by the scanner during measurements over a cloud point, a realistic image of the examined object can be obtained, irrespective of the material it is made of [2].

2. Reflective properties of an object

Measurements performed by means of laser scanners depend largely on the quality of the beam reflected from the surface of the target object and returning toward the receiver. The strength of a returning beam is influenced by the reflective properties of the surface of the target object, including its colour, texture, temperature and the moisture content. These properties may result in certain, sometimes even serious errors during scanning of different surfaces. One way to avoid this is to apply a temporary cover in the form of a special cloth or substance. This, however, is not a universal method [3].

It has been proven that an increase in the scanning density does not impact the value of the mean squared error. Increasing the angle at which the laser beam hits a flat surface causes a decrease in the intensity of diffused radiation which reaches the receiver. Whereas in the case of a rough or uneven surface, the power of the returning laser beam is almost constant. The issue of the moisture content in the scanned object has also a documented impact on the measured intensity. This is connected with the content of water in the materials, which may cause changes to the behaviour of the wave [4].

3. Examination and analysis of surfaces made of different materials

The material of which the examined object is made has a significant impact on the laser bean reflection intensity during scanning. The surface (examined object) chosen for the test purposes made from different materials: wood, stone, brick, plaster and glass. In order to enhance the contrast of the intensity of reflection of particular surfaces made of different materials, a laser scan was taken, where the angle of incidence of the laser beam on the surface and the distance from the measuring post was constant. The examination did not evaluate the impact of moisture and ambient temperature. The data obtained allowed preparation in the Leica Cycon programme of intensity maps presenting the numerical values of this parameter using a full colour scale. By selecting appropriate shades for particular values a rich and clear contrast was arrived at, visible with the naked eye. Fig. 1 presents the scope of colours selected for creating the images, ranging from blue to green to creamy to brown to purple and white.

The numerical values of the intensity represented by particular colours range between the minimum and maximum values set. This suggests occurrence of areas of intensity values ranging from minimum to maximum ones. The parameters are presented in the scale ranging from 0.0. to 1.0, where 0.0 means no reflection whatsoever, whereas 1.0 indicates a full reflection of laser beam. In the researched case there are no areas featuring extreme parameters. The values fall within the range between 0.0828 and 0.9973 (Fig. 1).

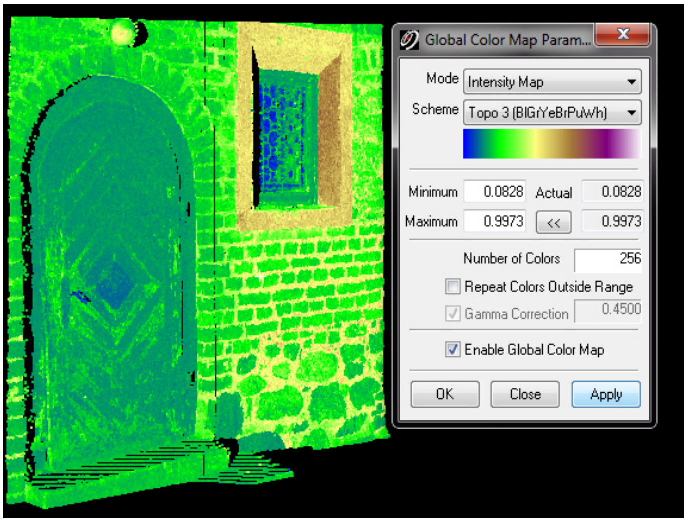

Fig. 1 Map of intensity of the researched surface

Using the histogram in a simple way, the empirical distribution of this intensity was determined by means of the three primary colour channels: blue, green and red (Fig. 2). The empirical distribution was performed along the horizontal axis of the selected surface.

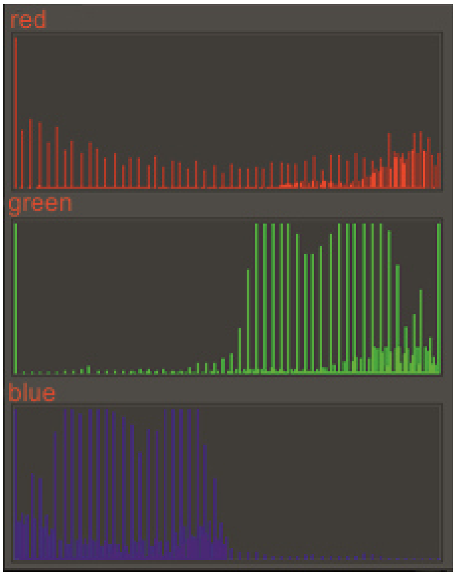

Fig. 2 Histogram of intensity divided into particular colour channels

The analysis also included measuring and calculating the mean, minimum and maximum values, and the difference between the extreme intensity values, using the Leica Cyclone Programme. These values were presented in a table, showing also the general characteristics of the material samples used: red brick, wood, stone, brass, plaster and stained glass (Table 1).

The results in table 1 confirm the graphical representation of the intensity map. Both the map and the numerical values indicate that only the plaster displays a significant difference, compared to the other samples, in all values, mean, minimum or maximum. It is also characterised by the highest results in all respects, compared to the other materials. These high values ranging from 0.4347 to 0.7130 are represented on the map by colours ranging from light beige to dark brown.

Table 1 Material samples data

Material	Colour and texture	Surface	Mean value	Min. value	Max. value	Difference
Red brick	uniform, red, matt,	slightly rough	0.2887	0.2000	0.3773	0.1773
Wood	uniform, medium-brown, matt,	smooth	0.2171	0.0922	0.3420	0.2498
Stone	uniform, grey, matt,	slightly rough	0.2942	0.1800	0.4083	0.2283
Plaster	uniform, white matt,	smooth	0.5739	0.4347	0.7130	0.2783
Stained glass	varied, yellow and green, transparent	smooth	0.1905	0.0832	0.2978	0.2146

In the case of the stained glass, its lowest value results from the transparent pale yellow areas, which reflected the beam very poorly. Additional scans show than many particles went through the material and settled on the elements right behind it, resulting in a low minimum value.

The results for wood fall between the results for the red brick and the stained glass. The mean and minimum results showing the following values - 0.2171 and 0.0922, respectively, are closer to the results for the stained glass, ranging from 0.1905 and 0.0832, than to the results for the red brick, whose mean value was 0.2887 and the minimum value was 0.2000.

The stone and the red brick show very similar results. The difference between their mean results is only 0.0055. This may suggest the existence of common material features, e.g. the type of structure, its porosity or roughness.

4. Summary and conclusions.

Measurements performed by means of laser scanners depend largely on the quality of the beam reflected from the surface of the target object and returning toward the receiver. The power of a returning beam is influenced by the reflective properties of the surface of the target object, including its colour, texture, temperature and the moisture content. These properties may result in certain, sometimes serious errors during scanning and interpretation of different surfaces. In some cases, the shape of the target object is critical for the the intensity of reflection of a laser beam from such surface.

Laser scanning is one of the latest technologies used mostly for land survey measurements, but it is becoming increasing useful over a large a number of new areas. Laser scanning is developing dynamically, contributing to an increased efficiency and accuracy of the devices and that of the examination itself. By transferring data to a specialist computer software and processing it therein one can obtain a realistic, spatial representation of the measured object. By superimposing a digital image taken by a scanner over a cloud point, one can generate a realistic view of the researched object, which, through the application of reverse engineering, allows creation of a model of the original object, reflecting its colours and details. The cloud created by means of this technology, comprised of thousands of measured points, shows much more than just a lot of information about the geometry and the dimensions of an object. The test performed showed an interdependence between the types of the scanned material and the laser beam reflection intensity. A more thorough research into these interdependencies could result in the determination of a constant range of the intensity parameter for a given material in its appropriate position. To this effect, a greater number of samples would have to be examined, taking into account many more factors. A good idea would be to examine as many different samples as possible, made of different materials, taking into account the activity of external factors. This type of research is already carried out today.

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