STUDY OF TERRESTRIAL LASER SCANNING INTENSITY DATA FOR THE BOSSCHA OBSERVATORY BUILDING'S MATERIAL CLASSIFICATION

Gusti Ayu Jessy Kartini[1,2] Sepki Utomo[2] and Hary Nugroho[1,2]
[1]Geodetics Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Nasional Bandung
Jln. PHH. Mustofa No. 23 Bandung, West Java 40124, Indonesia,
Email: ayujessy@itenas.ac.id

[2]Geodesy and Geomatics Engineering, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung
Jln. Ganesha No. 10 Bandung, West Java 40132, Indonesia

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ABSTRACT: In this study, the intensity value was derived from the results of data acquisition using TLS, which were then registered to determine which scanworlds overlapped as a criterion for selecting the intensity value sample. The obtained intensity values are influenced by geometrical factors and the material composition of the object. Because the intensity value is used to identify and classify the various materials that comprise an object, it is necessary to conduct research on the intensity value because it can support in detecting structural damage to buildings or in asset management. The identification process was carried out in this study using the windows scan method. The classification process relates to the intensity value that each material acquires, which is determined during the identification process. Materials with similar or identical intensity values will be classified together. The study's findings indicated that an intensity value within a specific classification range indicated the presence of material on the research object in the form of concrete walls, wooden doors, wooden windows, and glass lamps.

1. BACKGROUND

The Terrestrial Laser Scanner (TLS) is a mapping and spatial data acquisition technology that combines lasers and optical scanning to three-dimensionally map a piece of land or structure (Grussenmeyer et al ., 2011; Vidyan Y. et al., 2013). The point cloud data obtained from TLS measurements contains information about the positions of objects in the X, Y, and Z coordinate systems, as well as their intensity values (Vidyan Y. et al., 2013). The intensity of a wave is the amount of energy that the device receives back after the wave is reflected by an object (Coren & Sterzai , 2006). Additionally, intensity is referred to as the value of an object's reflection and the properties of the radiation emitted by a permuk aan object (Schmitz et al ., 2019).

The intensity value can be used to determine the material composition of an object. Different materials will have different reflection spectral properties, and thus will generate values for their varying intensities. Additionally, value intensity can be used to classify a variety of materials yes ng recorded during the scanning process (Kashani et al ., 2015). Classification is a term that refers to the value of the intensity that each material possesses during the identification process. Materials - materials with an intensity value equal to or close to will be classified in the same group. At the conclusion, the intensity value will provide information about the type of object detected during the TLS scanning process. With diketa huinya material, the use of the intensity of the acquisition result via TLS can aid in detecting structural damage to the building and Manaj Emen assets (Kashani et al ., 2015).

The value of the intensity obtained from TLS measurements is affected by the atmosphere's condition, the nature or characteristics of the object's surface (Soudarissanane et al., 2011), the process of transmitting a laser from the emitter to the object's surface and back to the tool (Fang et al., 2015), as well as distance measurement and the magnitude of the incidence angle that is set a priori (Wujanz et al ., 2017). However, this study focuses exclusively on the effect of the object's surface's nature or characteristics, the measurement distance, and the magnitude of the incidence angle. The intensity value is used to identify and classify building objects in this study. The building designated as a research object is the Kopel Observatory Bosscha, which is one of the cultural landmarks in West Java.

The purpose of this study is to determine how to identify and classify materials using intensity values (Kartini et al., 2018), as well as the effect of distance, incidence angle, color, and texture of the material on the intensity value during the material identification and classification process.

2. METHODS AND DATA

2.1 Data and Equipment

The data set for this investigation consists of a point cloud terrestrial laser scanner that was utilized to examine the intensity value. Wirnajaya et al. (2019) gathered the data. Additionally, utilised data includes photographs of buildings at the Kopel Observatory in Bosscha, which are the result of Maharani et al (2020) .'s data collecting and are employed in the material validation procedure.

Leica Cyclone 2020 software, and Leica Cyclone 3DR 2020 software are all used in this investigation. The registration of the data point cloud is performed using the Leica Cyclone 2020 software, and the intensity value is determined using the Leica Cyclone 3DR program.

2.2 Research Methodology

This research begins with a review of the literature on TLS and the intensity value associated with point cloud data acquired via TLS. Prior to conducting the research, you should conduct preparatory admisnitrasi and licensing for agencies-related research, data preparation, and equipment preparation. The first stage of research is data registration, specifically the insertion of scanworld into the stem reference public. The registration results will identify and classify known and selected research objects, which can then be identified, classed, validated, and evaluated to reach a conclusion.

2.3 Registration Process

The study's data set consists of ten scans per planet, which were gathered through the use of free scans. Additionally, the data that do register with the cloud to cloud approach overlap 30%-40% of each scan globe. The outcomes of the registration procedure are diketa hui, which scans the world for ATP4_SCN0001, ATP5_SCN0001, ATP7_SCN0001, ATP8_SCN0001, and ATP9_SCN00011. The registration results are depicted in Figure 1.

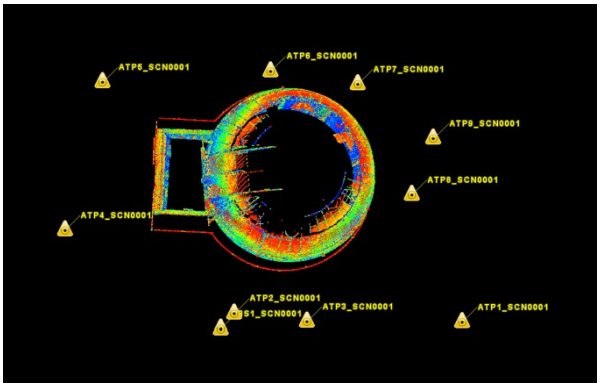
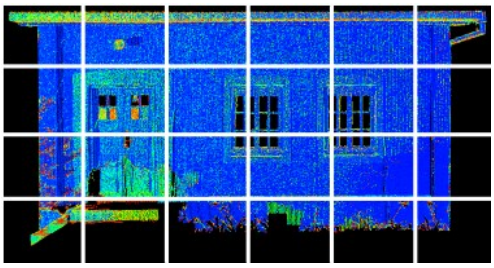


Figure 1. Point Cloud Data

2.4 Identify the Intensity Value

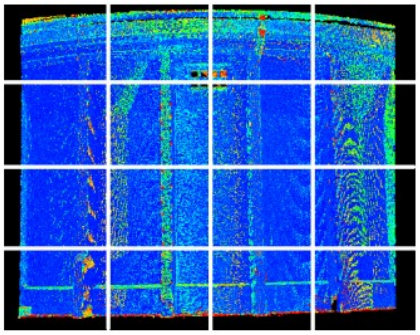
At this stage, two parts were determined to be analyzed , namely the front and the back of the Bosscha Coupling. Part front of the building is a result of the acquisition of the scan World ATP4_SCN0001 and ATP5_SCN0001. Scan the world are selected for having the overlap of 40%, with that can do the analysis of the value of intensity at the position of the same based on the distance and incidence angle are different . In the identification process of the front of the Bosscha Kopel building , 24 points were selected to be identified. Points which are in the process of identification is divided into six columns and four rows can be seen in Figure 2.



1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24

Figure 2. Distribution and Numbering of Front Identification Points

The back of the selected Bosscha is the result of data acquisition on scan world ATP7_SCN0001, ATP8_SCN0001, and ATP9_SCN0001. The scan world was chosen because it has three different distances and incidence angles, so that a comprehensive analysis can be performed. In the process of identification is determined 16 points that would be identified. The point spread is divided into four columns and four rows which can be seen in Figure 3.



1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

Figure 3. Distribution and Numbering of Rear Identification Points

2.5 Material Classification

The intensity value identification points that inform the distance and incidence angle are classified into five groups of value ranges with each group having a difference of 0.2. Of vulnerable g value of intensity from 0.000 to 0.200 , the range of values from 0.201 to 0.400, the range of values from 0.401 to 0.600, the range of values from 0.601 to 0.800 to the range of values from 0.801 to 1.000.

After that, to determine the type of material at each point of the sample do validation object by using a photograph of the building Kopel Bosscha were obtained from the data Maharani et al (2020). The process of validation that also provide information regarding the color of the object with the unit of hexadecimal and texture of the object.

2.6 T-Test

T test is done by using software SmartPLS to determine whether factors geometric effect on the value of the intensity that is generated on the object with the material timber and the wall of the concrete de ngan hypothesis is as follows .

H0a: Geometric factors do not affect the intensity value on objects made of wood
H0b: Geometric factors do not affect the intensity values on objects made of concrete walls
H1a: Geometric factors affect the intensity values on objects made of wood
H1b: Geometric factors affect the intensity values on objects made of concrete walls

The results of T-test of this will result in the value of T and the value of α. If the value of T indicates the results of more than 1.96 and the value of α menunjukka n results in under 0.05, then the hypothesis H1 is accepted.

3. RESULTS AND CONCLUSIONS

3.1 Results of the Identification Process

The identification results provide information about the object's position, intensity value, distance, and the magnitude of the incidence angle. The results identification of the data point cloud on the part of the front of the building Kopel Observatory Bosscha record objects that are on scanworld ATP4_SCN001 and ATP5_SCN0001. While the identification results part of the rear of the building Kopel Observatory Bosscha record objects that are on scanworld ATP7_SCN001, ATP8_SCN0001, and ATP9_SCN000.

3.2 Results of the Classification Process

After the identification process is complete, the intensity values are grouped into groups with predefined intensity value ranges. According to the results of the classification of the intensity value of the front of the Bosscha Kopel building on the ATP4_SCN0001 scan world, the glass lamp has an intensity value in the range of 0.401-0.600, while the ATP5_SCN0001 scan world classifies this glass lamp as having an intensity value in the range of 0.000-0.200. Thus, glass lamps have a low intensity value. This is because the lamp's glass material has specular reflectance characteristics, which means that the laser light energy received by the lamp is not completely reflected back to the instrument, with the majority of the laser energy being absorbed by the glass material.

Windows and doors made of wood have an intensity value in the range of 0.800-1.000 in the scan world ATP4_SCN0001. In this scan world, wooden windows are scanned at a distance of 12.017m and 11.188m with an incidence angle of 256º01'52" and 264 º 42'07", respectively. Meanwhile, wooden doors were scanned at 14.093m and 13.818m, respectively, using incidence angles of 243º41'17" and 244º55'34". The wooden window then has an intensity value classified as 0.201-0.400 and 0.401-0.600 in the ATP5_SCN0001 world scan, with each being scanned at a distance and incidence angle of 12.650m; 337o23'10" and 14,235m; 342o29'06". While the wooden door has an intensity value classified in the range of 0.601-0.800, at a distance of 10.166m and an incidence angle of 325º23'10" and classified in a range of values of 0.801-1.000, at a distance of 10,430m and an incidence angle of 327º10'48'. This shows that the beige-colored wood material with the code #C7C2AC and smooth texture has high reflectance properties. In addition, it also shows that if the distance between the object and the tool is getting closer, the intensity value will be higher. Similarly, when the incidence angle is small, higher intensity values are obtained.

Walls made of concrete have more points in the range of intensity values from 0.801-1.000. This indicates that although the intensity value is influenced by the characteristics of the target surface including color, texture, and material and is influenced by the acquisition of geometric data including distance and incidence angle, the surface characteristics of the object have a greater influence on concrete walls. This is in line with the research conducted by Kaasalainen et al. (2011) who found that concrete wall objects do not follow the cosine rule which says that the greater the incidence angle, the smaller the intensity value obtained. Additionally, the object of the concrete wall in this study is white with the color code #FFFFFF, giving it a high reflectance or reflectance property.

Similar classification results were also found in the classification results of the back of the Bosscha Kopel building which provided information that the world scans ATP7_SCN0001, ATP8_SCN0001, and ATP9_SCN0001 had scanned concrete wall objects with the code #FFFFF and produced various intensity values classified in the entire value range. The two classification results on white concrete walls with the code #FFFFFF explain that at different distances and incidence angles, the intensity value produced will remain in the same or close range.

3.3 T-Test

The T-test is carried out as the basis for accepting or rejecting the proposed hypothesis. As for this study, the results of the T test are shown in Table 1.

Table 1. Statistic Test Result

Material	T Value	α Value
Wood	4,094	0,000
Concrete Wall	1,107	0,269

As illustrated in Table 1, geometric factors such as distance and incidence angle on objects made of wood materials have an effect on the intensity value. This is indicated by the obtained T value of 4.094, which is greater than the specified minimum value of 1.96. Additionally, the value of on wood is 0.000 below the predetermined significance level of 0.05. As a result, H1a is accepted. This is consistent with the classification process results, which indicate that

when windows and doors are made of wood, the intensity value is influenced by geometric factors.

Additionally, Table 1 indicates that for objects with concrete wall materials, the T value is 1.107 and the α value is 0.269. Thus, geometric factors such as distance and incidence angle have no effect on the intensity value associated with objects made of concrete wall materials. As a result, the H1b hypothesis is rejected. This is consistent with the classification process findings, which indicate that the intensity values in concrete wall materials are spread across the same range of values regardless of the distances and incidence angles. Thus, it is established that distance and incidence angle have no discernible effect on the intensity value of objects made of concrete.

3.4 Conclusions

Based on research, it can be concluded that the intensity value can be determined by selecting points divided into multiple columns and rows, or what is referred to as the window scan method. The classification stage is then performed by grouping the intensity values obtained during the identification stage into five value range groups. According to the results of the classification process analysis, it can be concluded that the characteristics and material of the object have a greater influence on the intensity value than distance and incidence angle.

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