Stockpile Volume Estimation Calculation Based on Terrestrial Laser Scanner (TLS) Data Acquisition and 3D Surface Visualization

by Fenny Arafah

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Abstract

Stock taking is a series of activities to calculate the stock of goods that are still stored in the warehouse to be marketed. There are many activities covered in it, ranging from calculating the number of goods, conducting direct inspections, and structuring that will facilitate business operations when a certain product is needed. One of these activities is also carried out in the mining sector. Coal stock-taking is a survey activity carried out in the coal yard area to calculate the volume of the stockpile and coal tonnage after being multiplied by the density value. Large-dimensional coal stocking must be carried out quickly, accurately and in detail. The need for this can be obtained using laser scanner technology. Laser scanner is a tool designed to scan the surface of an object and represent it in 3D in the form of a height density point cloud. Based on this, in carrying out stock-taking calculation activities, measurements are needed which mainly aim to find out the stockpile volume and density in the fourth quarter of the Adipala PLTU Coal Yard. Stockpile measurement method using volumetric method. Measurement using a Laser Scanner tool to obtain the shape of the stockpile area is by seizing the entire surface of the Stockpile by setting the resolution of the density of coordinate points (x, y, z) as needed. Tool displacement when measurements are made on every detail of the Stockpile curve. Based on the calculation results, it is known that the volume value of the coal stockpile on the west side coal yard is 121,420,574 m3 and the east side coal yard is 88,230,355 m3 on. The total volume of coal amounted to 209,650,929 m3 then multiplied by the density of the bulk density survey results and obtained the tonnage of 180,384,417 MT

Keywords: Stockpile, TLS, Bulk Density, Volume

1. Introduction

Studies related to 3D models are very necessary because of the need for information and technological developments, from the previous one was only limited to 2D and developed towards 3D. where the information and appearance of the modeling results can be more detailed and represent the appearance of the original condition. As in the study conducted by Shimizu et all (2022) on the integration between TLS and UAV data as an approach to estimate tree height by utilizing poitcloud data from these two data, then calculating accuracy metrics from estimates using field survey data as a reference and then comparing their respective accuracy. In addition, the journal TLS for generating multi-LOD of 3D building model by Akmalia et all (2014) also discusses the need for 3D information, so that the journal tries to apply the results of TLS data in the formation of 3D modeling based on LOD. Based on some of these studies that use point clouds data as a reference in making 3D models, but different data sources sometimes have an impact on the quality of the model to be produced. The application of 3D modeling is increasingly being implemented in various fields, one of which is in the field of coal mining, and it is closely related to electrical energy

Electricity is the most vital source of energy in the world. The State Electricity Company (PLN) continues to strive to provide the best service in supplying electrical energy so that it can reach and be used by all Indonesian people. Currently, one of Indonesia's primary sources of electricity is coal-fired

steam power plants (PLTU). Indonesia is one of the world's top coal producers, and low coal costs are a major factor in the development of large-scale coal-fired power plants that use coal as fuel. Most of the power plants are built on the seashore. One of the reasons is to make it easier to supply the pltu fuel. Coal is distributed from coal producers to coal-fired power plants using barges. At the coal-fired power plant, part of the coal is temporarily accommodated in a large field called a coal yard, part of it is taken and accommodated in the coal feeder for use in the combustion process. Coal located at the coal yard location, periodically surveys / measurements are carried out to calculate its volume and tonnage. This survey is commonly referred to as stock-taking

Measurement of stock-taking aims to find out how much coal stock is left and also as a supervisory function. So far, the measurement of stock-taking is usually carried out using the Total Station (TS) tool (Adefan et all, 2016). Measurement of stock-taking with TS takes a relatively long time to get meticulous results. In fact, the coal in the coal yard also needs to be transported to fill the vacancy of the coal feeder so that the power plant can continue to operate. Therefore, measurements are needed using instruments and measurement methods that are faster and more efficient, and are able to produce accurate volume values. One of them is to use a Terrestrial Laser Scanner (TLS).

Volume is important in much of engineering work (Lechner & Baumann 2000). The accuracy of the shape and volume estimation of the meterial is important in many applications such as erosion studies, estimation of mining material retrieval and land assessment for construction (Yakara & Yilmazb 2008).

2. Material and Methods

There are several methods of data registration point clouds that can be used, the registration technique chosen will affect the survey technique that will be carried out later so that it must be carefully selected based on the condition of the object and the area around the object (Quintero, Genechten, Heine, & Garcia, 2008).

a. Target to Target registration

This registration method is a commonly used registration method. The target used in this method is a target that has high reflectivity and can be recognized by the tool as a target. The target is used as a binding point

b. Cloud to Cloud registration

This registration uses a minimum of 3 allied points owned from both scans. This registration concept uses the iterative closest point (ICP) method. The point of this concept is to look for the offset or closest distance repeatedly from the two points that are closest between the two sets of point clouds. Although the minimum points required are 3 points, to get good accuracy, the calculation of point clouds must be above 60% so that it will increase the workload on the data retrieval process.

c. Traversing

Registration traversing uses the tool stand as an allied point and requires a single reference point as the starting point of the backsight. The advantage of this method is that it is faster to complete surveys

because the time for the preparation of tools and targets is not too long. However, this method usually provides lower measurement accuracy compared to other methods.

Data retrieval with a laser scanner for three-dimensional objects is impossible with just one data retrieval, so a technique is needed to combine data per one retrieval (ScanWorld) into a global data known as registration.

The following diagram illustrates the methodology used for the evaluation of the stockpile:
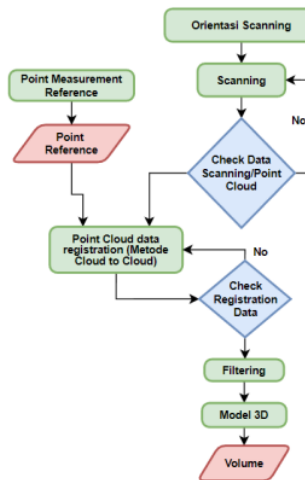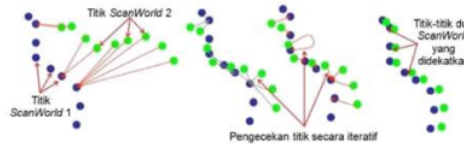

Fig 1. Research Flowchart

Fig 2. *Registrasi Cloud to Cloud*

In general, an object cannot be scanned from one point of view, due to obstacles and visual obstacles, the laser scanner must be positioned in a different location in order to perform the scan as a whole. The data that the laser scanner can get from any point of view refers to the local coordinate system. The goal is to perform a transformation that unites the coordinate reference of several data, commonly called registration. The transformation between two different coordinate systems $x\ddot{}g$ and $x\bar{}l$ can be described mathematically (Schluz, 2007).

Volumetric stockpile measurement technique. The stockpile area is measured using a laser scanner tool, namely by submerging the whole surface of the stockpile and adjusting the resolution of the density of coordinate points (x, y, and z). Tool displacement when the Stockpile curve's minute details are measured. The stockpile surface's output takes the form of XYZ coordinate points. This information is utilized to create a three-dimensional surface model

of the stockpile, with the stockpile's base surface serving as the reference point in this instance. The reference point can be a BM (Bench Mark) point or a permanent building according to the client's restrictions. In the calculation of volume by cutting the data from the calculation at the location where there is a coal base layer (Bedding). If there is coal that is only a spill from the stockpile then it is not included in the calculation

The base or bottom reference point used in the calculation will be considered flat. For a sketch of the calculation can be described as follows.
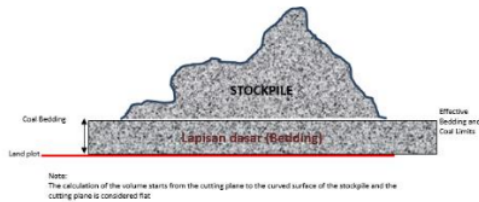
Fig 3. Overview of Stockpile Volume

In the process of measuring the volume of the stockpile stored in the coal yard, many methods can be used, for example by using a Total Station (TS) tool, Global Positioning System (GPS) or with 3D Laser Scanning / Terrestrial Laser Scanner (TLS) / High Definition Surveying (HDS) technology.
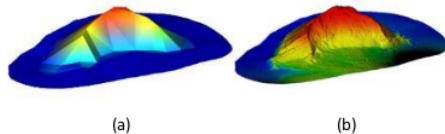
| (a) | (b) |

Fig 4. Perbandingan Pengukuran menggunakan TS/GPS dan TLS. (a) TS/GPS, (b) TLS

From figure 4, it can be concluded that one of the best and most accurate methods is to use Laser Scanner technology, by having high speed and accuracy in measuring until it reaches the size of millimeters between points with a distance of tens to thousands of meters to the object.

3. Result and Discussion

3.1 Stockpile Volume

The results of the implementation of the stock-taking calculation in determining the quantity of coal stockpiles located in the coal yard, so that the final result of the data acquisition is then modeled into a Digital Terrain Model (DTM) of the stockpile area, which can then be calculated with area boundaries and with reference points. By using the tools available in the software used, so that the volume value can be calculated

Fig 5. Stockpile Volume Calculation Results

3.2 Bulk Density

The results of the calculation of the average bulk density of the survey results so that they are obtained as follows.

Table 1. Bulk Density sisi barat
West Side

| No | Point Sampling/Location | BD (Tonnes/M3) | | |
		Loose	Compact	Average
	Upper	0,789	0,931	0,860
	Middle	0,847	0,938	0,893
	Lower	0,835	0,944	0,889
	Ground	0,857	0,923	0,894

Table 2. Bulk Density sisi Timur
East Side

| No | Point Sampling/Location | BD (Tonnes/M3) | | |
		Loose	Compact	Average
	Upper	0,756	0,830	0,780
	Middle	0,732	0,843	0,787
	Lower	0,874	0,961	0,918
	Ground	0,852	0,945	0,898

Tables 1 and 2 show the Bulk Density values on the west and east sides, the average values are calculated using 40 sampling data on each side. Each sampling side is categorized into four picking positions, namely upper, middle, lower and ground. The results showed that the average value of each point did not show significant differences.

3.3 Stockpile Quantity

With known results of the calculation of stockpile volume and the results of calculating the period of commodity types. Tonnage is obtained by multiplying the result of the volume by the value of the bulk density of the stockpile area. The results of the volume calculation can be seen in the table below.

Table 3. Stockpile Quantity

	Location	Volume (m³)	BD Average	weight(MT)
Stock Coal	West Side	116975,349	0,881	103055,282
Efektif	East Side	83999,804	0,828	69551,838
Total Coal Efektif(A)		200975,153		172607,12
Volume	West Side	4445,225	0,894	3974,031
Bedding	East Side	4230,551	0,899	3803,265
Total Coal Bedding (B)		8675,776		7777,296
Total Coal	West Side	121420,574		107029,314
Efektif(A) Dan Bedding (B)	East Side	88230,355		73355,103
Grand Total		209650,929		180384,417

Based on table 3, the results of the stockpile quantity calculation show that the total effective volume of coal on both sides is 200975,153 m3 with a tonnage weight of 172607.12 MT. The yield of Bedding Volume on both sides is 8675.776 m3 and the total weight is 7777.296 MT. So that the overall effective total result is 209650.929 m3, the overall weight is 180384.417 MT.

3.4 Point Cloud

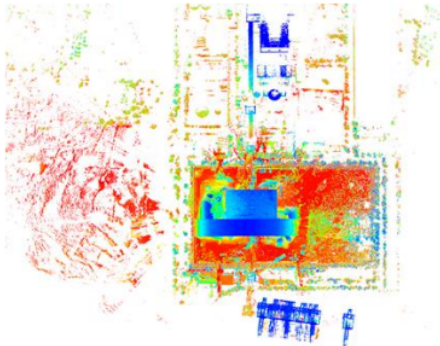The results of point cloud plotting can be seen in the following figure

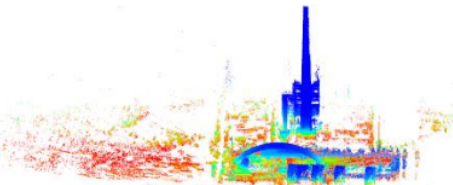**Fig 6.** All Point Cloud Top View of Adipala PLTU Coal Yard
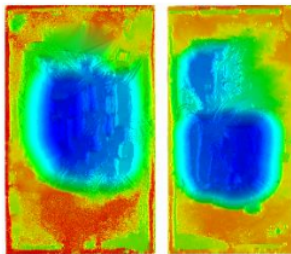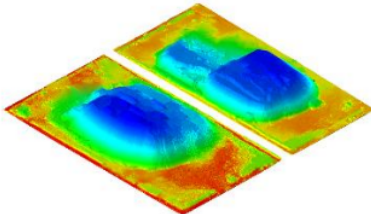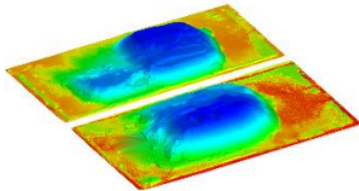

Fig 7. All Point Cloud Front View Adipala PLTU Coal Yard

(a)

(b)

(c)

Fig 8. a. top view, b. west side, c. east side 3d surface coal yard side

Figure 8 shows a visualization of the 3D coal results on the stockpile, according to the results in the calculation table which shows the west side stockpile has a larger value.

4. Conclusion

The utilization of TLS provides several advantages that are able to take measurements more quickly and effectively. It can be seen that the pointcloud results can be used as a reference in the calculation of stockpile volume, so that it can provide exsisting and planning data estimates. In order for stock-taking calculations to be more effective and efficient, use a calculation system that is truly accurate and capable to ensure that there are no errors during recording.

5. References

Adefan, A. A., Andaru., R., & Istarno. (2016). Pembuatan Peta Dari Ekstraksi Data Point Clouds 3d Hasil Pengukuran Terrestrial Laser Scanning Dalam Penyediaan Data Spasial Kadaster 3d. Yogyakarta: Universitas Gadjah Mada.

Akmalia, R., Setan, H., Majid, Z., Suwardhi, D., & Chong, A. (2014). Tls For Generating Multi-Lod Of 3d Building Model. 8th International Symposium Of The Digital Earth (Isde8), 1-7.

Ashawabkeh, Y. (2006). Integration Of Laser Scanning And Photogrammetry For Heritage. Stuttgart: Institut Fur Photogrammetry Der Universitat Stuttgart.

Barnes, A. (2012). Pengunaan Metode Fotogrametri Rentang Dekat Dan Laser Scanning Dalam Pembuatan Dense Pointcloud (Studi Kasus: Candi Cangkuang) . Departement Of Geodetic Engineering, Institut Teknologi Bandung.

Bict, T. (2012). Footprint Decomposition Combined With Point Cloud Segmentation For . Delft University Of Technology, .

Boehler, W., & Marbs, A. (2005). Investigating Laser Scanner Accuracy. I3mainz, Fh Mainz, University Of Applied Sciences, 47-60.

Haala, N., & Kada, M. (2010). An Update On Automatic 3d Building Reconstruction. Isprs Journal Of Photogrammetry And Remote Sensing, 570-580 .

Lechner W. dan *Baumann* S. (*2000*). Global Navigation Satellite System. Computers and Electronics in Agriculture 25 (*2000*) 67–85, Elsevier.

Pu, S., & Vosselman, G. (2009). Automatic Extraction Of Building Features From Terrestrial Laser Scanning. Isprs Journal Of Photogrammetry And Remote Sensing.

Quintero, M. S., Genechten, B. V., Heine, E., & Garcia, J. L. (2008). Tools For Advanced Three-Dimensional Surveying In Risk Awarness Project (3driskmapping). Leonardo Da Vinci Programme Of The European Union.

Radosevic, G. (2010). Laser Scanning Versus Photogrammetry Combined With Manual Post Modelling In Stecak Digitization. The 14th European Seminar On Computer Graphics.

Reshetyuk, Y. (2009). Self-Calibration And Direct Georeferencing In Terrestrial Laser Scanning. Stockholm: Royal Institute Of Technology.

Schulz, T. (2007). Calibration Of A Terrestrial Laser Scanner For Engineering Geodesy. Diss. Eth.

Yakara, M. and Yilmazb, H.M. 2008.Using In Volume Computing Of Digital Close Range Photogrammetry. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. PartB3b. Beijing.

Zakaria, A., & Handayani, H. H. (2016). Studi Pemodelan 3d Menggunakan Terrestrial Laser Scanner Berdasarkan Proses Registrasi Target To Target. Jurnal Teknik Its, 1-6.

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