Research on Geo-Referencing Methodology of Point Cloud Data

HyungSig Cho[1], HongGyoo Sohn*[2], Soohee Han[3], and Il Suk Park[4]

[1,2,3,4] GRS Lab., Yonsei University, Seoul (120-749),
South Korea; Tel: + 82-2-2123-2809; Fax: +82-2-2123-8209
[1]Ph.D student, E-mail: f15kdaum@yonsei.ac.kr
[*2] Professor, E-mail: sohn1@yonsei.ac.kr
[3]Post-doctoral research fellow, E-mail: sciviler@yonsei.ac.kr
[3]Master's course, E-mail: mon_cher@naver.com

KEY WORDS: geo-referencing, terrestrial LiDAR, point cloud, GPS

ABSTRACT: The Terrestrial Laser Scanner (TLS) has been widely used in many engineering fields because it provides us with direct measurement of 3D information of objects with high resolution and reliable accuracy. The TLS measures distances and angles from the sensor to the reflecting target, and only the relative positions are recorded. Thus, geo-referencing of point cloud data is required to provide the products with their absolute position in the real world. In the past, geo-referencing of point cloud data was achieved by using a total station. Firstly, the surveyor conducted a control survey by using a GPS, and set up the total station at the control point. The surveyor attached the special target on the surface of the object, and measured the absolute position of it. Then, the geo-referencing was conducted through post-processing. However, this conventional process requires too much time, and errors in total station are propagated to the coordinates of the point cloud data. In the current study, we suggest a new methodology which simplifies the geo-referencing process by integrating the GPS and targets. It is expected that a great deal of time and cost can be saved by implementing our suggested methodology.

1. INTRODUCTION AND METHODOLOGY

Terrestrial LiDAR is a system that can quickly and precisely produce 3D images of objects, and it is increasingly being used in fields such as civil engineering, architecture, and in restoration projects involving cultural assets. Because terrestrial LiDAR data is obtained from a machine in the form of relative-coordinate point cloud data, a geo-referencing process is needed to change that data into spatial coordinates. Regular geo-referencing is carried out by first conducting a control survey using a GPS, and then by observing the control points (CPs) using a total station. This study carried out point cloud data geo-referencing using only static GPS and RTK (real time kinematic). To assess the efficiency of the proposed method, the subject area was equipped with a checkpoint target and then scanned. During scanning, the checkpoint target and the geo-referencing target were identified and the absolute coordinates of the point cloud data were changed to 3D conformal transformation. The point cloud data that had been geo-referenced were evaluated for work efficiency and accuracy by obtaining 3D coordinates of the checkpoint using a non-target total station.

2. TEST AND RESULTS

Terrestrial LiDAR was installed in the athletic field of Yonsei University with easy viewing of open air and favorable observation distances, and a checkpoint for evaluating work efficiency and accuracy was established. The checkpoint used a target for the terrestrial LiDAR and, to minimize the effect of the observation direction, a firm topography was chosen and the terrestrial LiDAR was installed with a minimum angle of incidence (Figure 1).

Once the installation of the checkpoint was completed, the terrestrial LiDAR was used to scan the checkpoint and install additional CPs for geo-referencing.

The 3D absolute coordinates of the CPs were observed using the static and RTK methods by combining one GPS receiver and a scanner target used for a checkpoint. The static method involved hourly observations and network adjustments through its connection to a permanent GPS station. The 3D coordinates of the target obtained from these two methods were used to carry out geo-referencing of the checkpoint target. Figure 2 shows the locations of the terrestrial LiDAR installations in the research subject area, the CPs and the checkpoint target.

To geo-reference the point cloud from the GPS measurement, a minimum of four CPs are needed for safety considerations. When the geo-referencing method proposed in this paper is applied, and moving time and target installation time are considered independently from the subject area and the observation size, the static method requires a total of five hours of observation time, and the RTK method requires three minutes per CP for a total of 12 minutes of observation time. The latter method also requires 30 minutes of observation time when moving time is considered.

(a) T3 (b) T5 (c) T7

Figure 1. checkpoints

Table 1. Comparison of checkpoint coordinate acquired from TS, Static GPS and RTK GPS data

CP	Checkpoint (m) using total station			Checkpoint (m) using Static			ΔD(㎜)	Checkpoint (m) using RTK			ΔD(㎜)
	X	Y	Z	X	Y	Z		X	Y	Z	
T1	451435.202	194234.476	42.600	451,435.220	194,234.440	42.598	39.971	451435.194	194234.464	42.604	265.80
T2	451494.209	194154.444	35.834	451,494.196	194,154.422	35.813	32.477	451494.207	194154.435	35.838	245.96
T3	451483.035	194123.131	36.748	451,483.036	194,123.106	36.727	32.833	451483.034	194123.122	36.752	245.54
T4	451495.610	194113.224	35.976	451,495.601	194,113.208	35.956	26.991	451495.611	194113.216	35.981	245.75
T5	451467.572	194102.977	35.747	451,467.568	194,102.966	35.738	14.403	451467.573	194102.967	35.751	257.25
T6	451450.645	194080.829	36.735	451,450.641	194,080.839	36.743	13.659	451450.648	194080.818	36.739	275.29
T7	451450.699	194054.606	34.826	451,450.693	194,054.628	34.827	22.619	451450.703	194054.595	34.83	268.79
T8	451445.172	194042.363	36.888	451,445.161	194,042.376	36.891	17.847	451445.177	194042.351	36.892	270.69
RMSE							±9.584				±12.38

To assess the accuracy of geo-referencing using a GPS, the checkpoint was directly observed with the total station and used a reference value, and the geo-referenced checkpoint coordinates using the GPS were as shown in Table 1. Using the checkpoint coordinates from the total station as references, the results of comparing the values using the method proposed in this paper show that the static method produced a maximum of 39.9 ㎜ and a minimum of 14.4 ㎜ location error with RMSE ±9.58 ㎜, whereas the RTK method produced a maximum of 275.2 ㎜ and a minimum of 245.7 ㎜ location error with RMSE ±12.38 ㎜(Table 1).

3. DISCUSSIONS AND CONCLUSIONS

This paper proposed an efficient geo-referencing method for terrestrial LiDAR data. To improve on the regular method of first measuring a GPS reference point and then obtaining absolute CP coordinates using a total station, the process was simplified by using only a GPS and the accuracy was tested to confirm that this process was more economical than the regular method. However, in terms of having a degree of precision, the existing method was the highest, followed by the static and RTK methods, and it is judged that additional further research is needed regarding ways to analyze causes and to enhance precision.

Acknowledgement

This research was supported by a grant (07KLSGC04) from Cutting-edge Urban Development - Korean Land Spatialization Research Project funded by Ministry of Land, Transport and Maritime Affairs.

References

Leica Geosystems, 2010. Webpage accessible from http://hds.leica-geosystems.com/en/ Leica-Cyclone_6515.htm

Lichti, D.D., and S.J. Gordon, 2004. Error Propagation in Directly Georeferenced Terrestrial Laser Scanner Point Clouds for Cultural Heritage Recording. In Proc. of FIG Working Week, Athens, Greece, May 22-27, pp. 16.

Yuriy Reshetyuk, 2009. Self-calibration and direct georeferencing in terrestrial laser scanning. Stockholm, Sweden. pp. 114-142