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Construction of Indoor Spatial Information using Indoor Mobile Mapping System

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Abstract

As mobile devices and surveying techniques have developed and special information market has expanded in recent years, a scope that spatial information technique which was limited to outdoor space is expanding into indoor space. Information on indoor space can be served in various fields. Information on indoor space can be used in providing welfare and administration services. Conducting construction work effectively based on information on indoor space may lead to creation new industrial fields. However, research on a new method for construction of indoor spatial information is lacking. This study has built information on indoor space the study participants by using Indoor Mobile Mapping System which various sensors such as IMU(Inertial Measurement Unit), camera, 3D laser scanner, DMI(Distance Measurement Instrument) are combined. The method devised by this study can establish information on indoor space of targeted regions more efficiently than existing methods which used total station or 3D laser scanner. Established information on indoor space is related to 360 degree panorama image and point cloud and its accuracy were evaluated. Modeling the target was conducted effectively by using point cloud. It took 50 minutes to acquire information on 9 indoor spaces which lay in area of about 50m × 30m which was significantly shorter than time which took by using laser scanner only. It is expected that the bigger indoor space is, the higher such difference is. Indoor MMS(Mobile Mapping System) is expected to make a great contribution to improving productivity of establishing information on indoor space.

Keywords: *Indoor Spatial Information; Mobile Mapping System; Availability Evaluation; 3D Modeling; 3D Laser Scanner*

1. Introduction

Spatial information is closely related to everyday life of people beyond simple delivery of position information. Spatial information is considered to be essential in everyday life[1-2]. Spatial information technology has developed into technology that changes personal lifestyle beyond provision of various information[3-5]. In these days buildings have become large by development of construction technology and increase in population density in metropolitan cities, indoor space in which people spend over 80% of their time has been considered important[6-10]. Thus, scope of spatial information service has expanded into indoor space as well as outdoor space rapidly. It is expected that such change will create various service demand such as portal of information on indoor space, support for a person who is visually impaired, disaster response, subway use, indoor security making good use of development of high-technology for example IT and mobile

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devices[11-14]. Subway fire in Daegu which broke out in 2003 claimed 192 lives and injured 138 people[15-16]. At that time the accident broke out, information on the inside of Daegu subway station was not secured which caused massive causalities. Since then, Korean Government has established system to cope with various disasters that break out in public facilities making good use of information on indoor space[17-18]. In recent years, scope of special information service has expanded into indoor space as well as outdoor space rapidly and it is expected that such change will create various service demand making good use of development of high-technology for example IT and mobile devices[19-22]. However, research on a new method for construction of indoor spatial information is lacking. The purpose of this study is to establish information on indoor space in targets by using Indoor Mobile Mapping System in which various sensors such as IMU, camera, 3D laser scanner, DMI are combined and to evaluate its utilization. Figure 1 shows study flow.

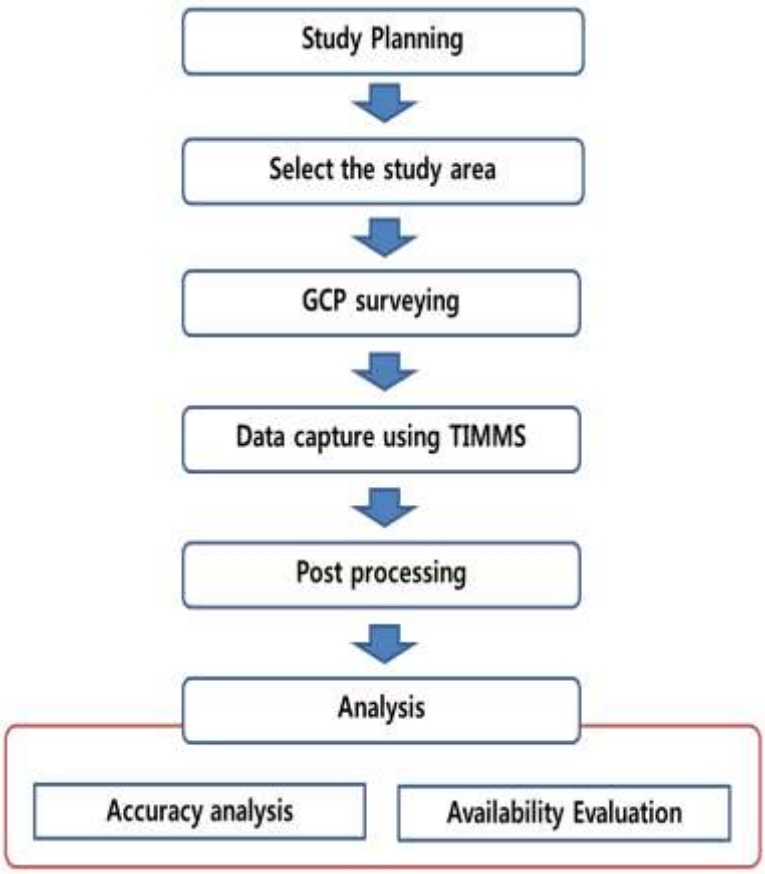

Figure 1. Study Flow

2. Study Area and Acquisition of Spatial Information

A building which was under construction and located in Incheon was selected in order to establish information on indoor space. The building was selected for this study because it did not have any things such as furniture that may obstruct acquisition of information on indoor space. Figure 2 shows the building selected for this study.

Figure 2. Study Area

TIMMS(Trimble Indoor Mobile Mapping Solution) was used to acquire data in this study. TIMMS was developed to acquire information on indoor space with MMS in which various sensors such as IMU, DMI, 3D laser scanner and camera are combined.

The greatest difference between TIMMS and MMS which is based on vehicle that is used in outdoors is that there is no GNSS(Global Navigation Satellite System). It is difficult to receive satellite signal indoor. Positioning is performed by using highly efficient IMU and DMI.

TIMMS is the optimal fusion of technologies for capturing spatial data of indoor and other GNSS does not matter areas of all sizes and locations. It provides both LiDAR and spherical video of a facility, enabling the creation of accurate, real-life representations of interior spaces and all of its contents. Figure 3 shows TIMMS[23].

Figure 3. TIMMS

This study set up five GCPs(Ground Control Point) and three check points to establish information on indoor space. GCPs were used to initialize TIMMS and correct position. Check point was used to evaluate accuracy of established spatial information. Table 1 shows coordinate of GCP and check point.

Table 1. Coordinate of GCP and Check Point

Point	X(m)	Y(m)	H(m)
GCP1	4147408.443	292476.584	58.343
GCP2	4147424.746	282485.990	58.345
GCP3	4147434.857	292491.633	58.368
GCP4	4147444.184	292496.884	58.355
GCP5	4147458.527	292505.193	58.349
Check1	4147425.451	292492.025	60.174
Check2	4147436.973	292486.068	29.945
Check3	4147451.708	292496.884	60.224

Spatial information was acquired by initializing TIMMS in GCP 1. GCPs 2~5 were used to correct a position while acquiring data. Spatial information was acquired by using 360 degree panorama camera 3D laser scanner. Spatial information was synchronized with path information which was acquired in IMU and DMI. Data acquisition was conducted for 9 indoor spaces which lay in area of about 50m × 30m. Figure 4 shows a scene that data are acquired.

Figure 4. Data Capturing

Data acquired in TIMMS is post processed by using POSPac software. Post processing is conducted in order of import of IMU and DMI data, input of GCPs, creation of path information, creation of point cloud and creation of panorama image. Figure 5 shows post processing screen.

Figure 5. Post Processing Screen

Post processed data are created to las format point cloud and jpg format panorama images. Figure 6 shows point cloud. Figure 7 shows panorama image.

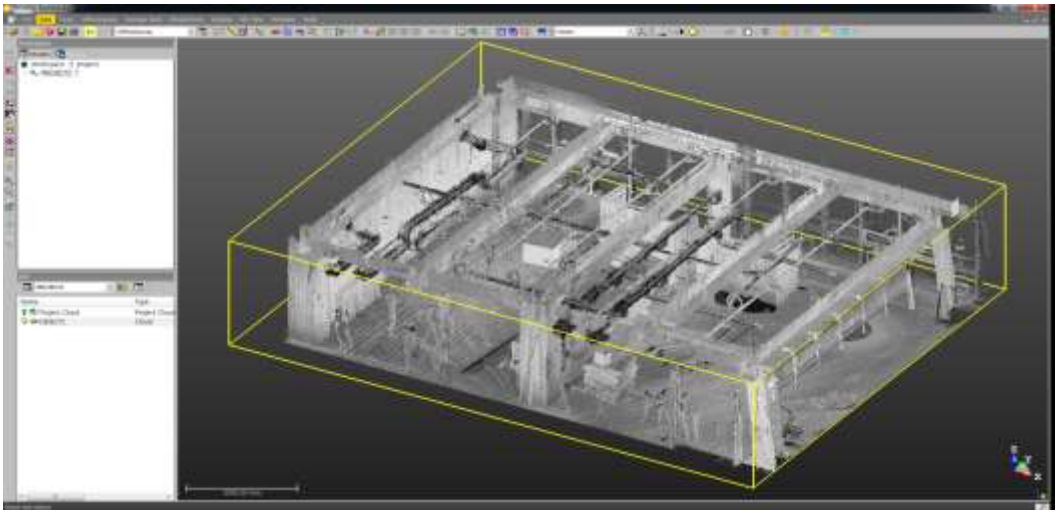

Figure 6. Point Cloud

Figure 7. Panorama Image

3. Data Processing

This study evaluated utilization of information on indoor space which was acquired by using TIMMS. Accuracy was analyzed to evaluate utilization of information on indoor space which was acquired by using TIMMS. Modeling and creation of sectional view of the building were conducted by using acquired spatial information.

Coordinates of check points in data which were acquired from TIMMS were obtained and they were compared with coordinates which were surveyed with total station to evaluate accuracy. Table 2 shows a result of accuracy evaluation.

Table 2. Result of Accuracy Evaluation

Point	dX(m)	dY(m)	dH(m)
Check1	0.014	0.009	0.018
Check2	0.007	0.008	0.012
Check3	0.019	0.013	0.015

A difference between coordinates which were acquired with TIMMS and total station was found to be no more than 2cm. Spatial information on the building of this study was acquired by using existing method and a method which was devised in this study and time that it took when using the methods was compared. Only 3D laser scanner was used in acquiring data and the other conditions in the methods were same. Scanner was installed eleven times to acquire data. Sphere target was installed for registration. It took 3 hours to work in total. When using TIMMS, it took 45 minutes which included 30 minutes that was required for initialization to acquire data. The larger area of the building, the more difference in time that takes to acquire information is. Such result shows efficiency of TIMMS. Acquired point cloud and panorama image can be used in producing data with high utilization. This study created a floor plan of the building by using point cloud. Figure 8 shows a floor plan.

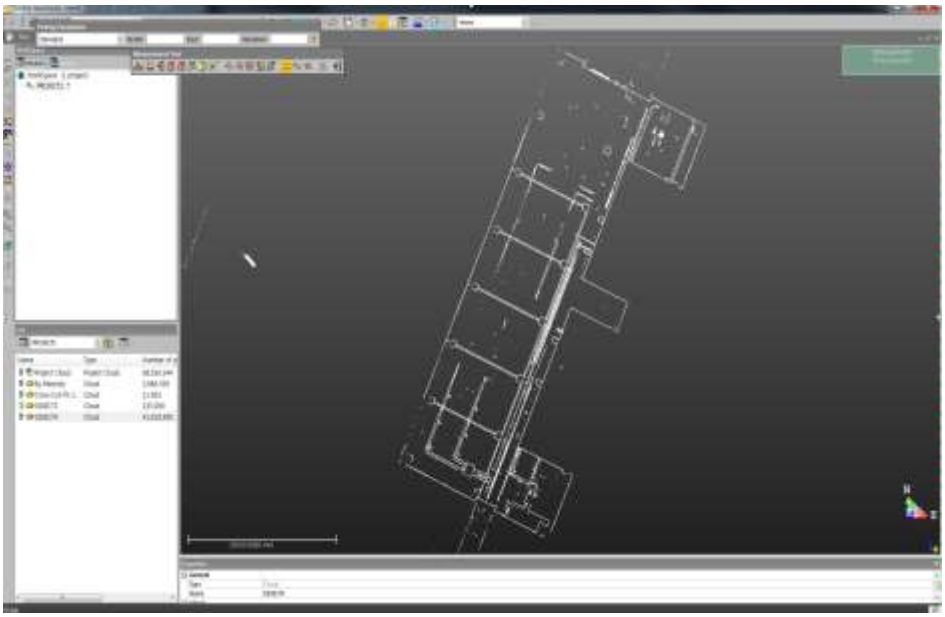

Figure 8. Floor Plan

A floor plan was created by using sectional view in point cloud easily. Data such as sectional view can be used widely in construction and civil engineering. This study

conducted modeling of indoor space by using Realworks software. Modeling was conducted for some of 9 indoor spaces. Figure 9 shows modeling process and Figure 10 shows modeling result.

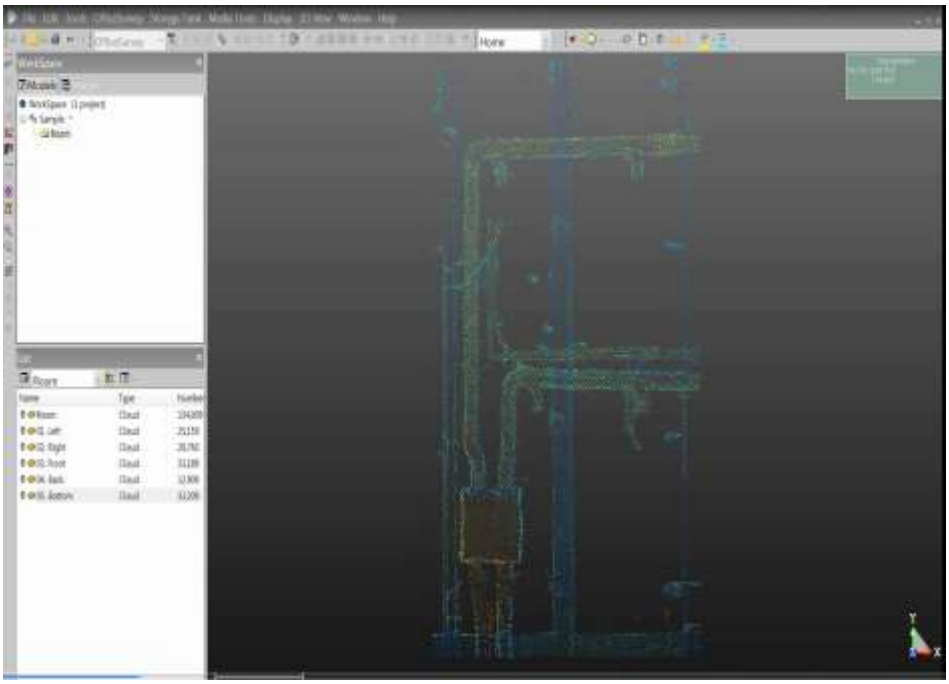

Figure 9. Modeling Process

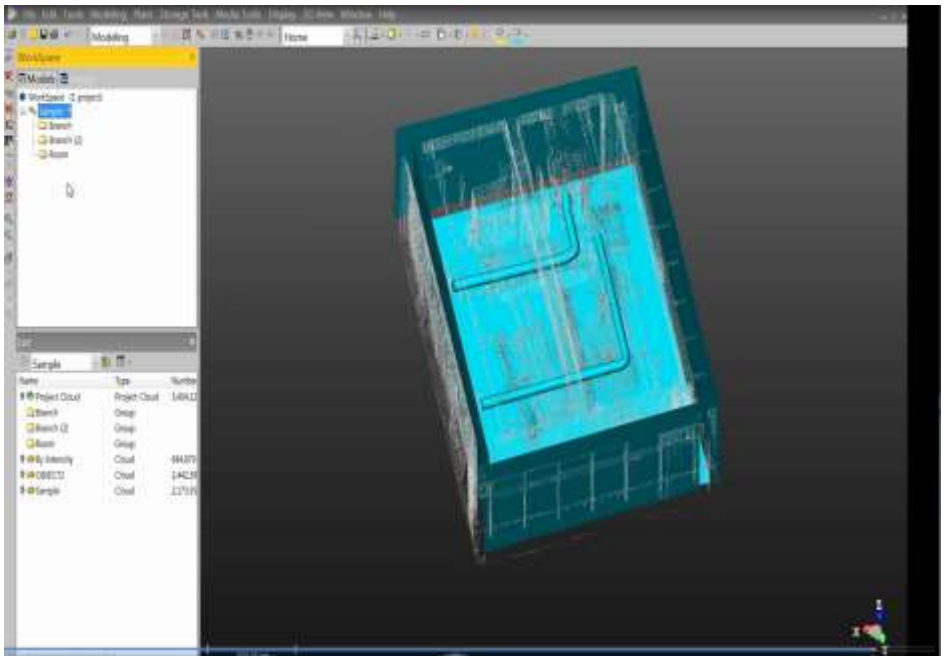

Figure 10. Modeling Result

In recent days, reverse engineering of indoor space that does not have drawings has drawn attention. Modeling data which use data acquired with TIMMS can be used in BIM related field. As there is no definition on accuracy and rules on establishing information on indoor space by law, it is difficult to judge with proper criteria but it is expected that accuracy of TIMMS will be used in establishing information on indoor space. It is

expected that a method devised in this study will shorten time that it takes to establish spatial information significantly.

4. Conclusions

This study established information on indoor space of the building by using Indoor Mobile Mapping System in which various sensors such as IMU, camera, 3D laser scanner, DMI were combined and evaluated utilization of the information. Findings of this study are as follows.

Spatial information on 9 indoor spaces which lay in area of about 50m × 30m was established. Accuracy of established data was found to be no more than 2cm. Time which takes to establish information when using TIMMS is significantly shorter than that when using Total Station or 3D laser scanner. Using point cloud helps conduct modeling of the building efficiently. As far as accuracy is concerned, now that there is no definition on accuracy and rules on establishing information on indoor space by law, it is difficult to judge with proper criteria but it is expected that accuracy of TIMMS will be used in establishing information on indoor space. As far as efficiency of establishment of spatial information, it is expected that a method devised in this study will shorten time that takes to establish information significantly. If relevant laws and rules are established and equipment which is related to establishing information, a method devised in this study will make a great contribution to developing relevant industry.

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