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PROPOSAL OF LOCATION CORRECTION METHODOLOGY OF 3D BIM/GIS MODELS FOR EFFECTIVE DATA CONNECTION

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ABSTRACT

As the demand on 3D spatial information has increased in South Korea, 3D spatial information services have been provided by the Ministry of Land, Infrastructure and Transport, Seoul City, DaumKakao and other local governments and related companies. In the map-based 3D spatial services, location correction is an important factor that determines the applicability of specific task. Since existing BIM data consists of relative coordinate values, it has been difficult to be interlinked with GIS data which have absolute coordinates. Therefore, this study proposes a location correction method for indoor and outdoor 3D spatial information through the construction of BIM/GIS platform-based modeling data. To do this, a target of the platform testbed was selected and a process of data construction was conducted using three steps to identify a mismatch between the BIM model that deals with indoor spatial information and an orthophoto-based textured 3D model for realistic visualization thereby designing a location correction algorithm. An algorithm that converts relative coordinates into absolute coordinates was implemented to interlink the BIM model data based on relative coordinates and texturing data based on absolute coordinates for a single building to calculate the absolute location of the building first. Then, a second mapping of texturing data over the BIM/GIS platform map was conducted to correct the final location in the 3D model data.

Keywords: *Building Information Modeling (BIM), Geography Information System (GIS), 3D modeling, Unmanned Aerial Vehicle (UAV), Location correction.*

I. INTRODUCTION

As the demand for three-dimensional (3D) spatial information has increased in South Korea, 3D spatial information services have been provided by the Ministry of Land, Infrastructure and Transport, Seoul City, Google, Microsoft and other local governments and related companies (V-World, 2017; Seoul, 2016; Google, 2017; Microsoft, 2017). These map-based 3D spatial information services help users to have an intuitive understanding through effective 3D visualization and realistic virtual experience as if the users were actually in that place.

Currently, the Korea Institute of Civil engineering and Building Technology (KICT) interlinks a Building Information Modeling (BIM) that deals with object-based indoor spatial information and a Geography Information System (GIS) that deals with regional based outdoor spatial information to implement a BIM/GIS inter-operable open-type platform (Kim et al., 2014). In the process, BIM data, which have relative location information, are required to be converted into absolute coordinate values of actual locations and mapped with the orthophoto-based textured 3D model to complete a series of location correction tasks. The location correction is an important factor that determines the applicability to specific tasks (Lee et al., 2016).

The process of this study is summarized as follows: First, a trend of national and international studies on location correction of 3D spatial information data is analyzed to derive the main implications of the study. Second, a target is selected to construct the BIM/GIS platform-based modeling data and a process of data construction is divided into three steps. Third, a linkage method of indoor and outdoor 3D spatial information is proposed along with the location correction process in order to resolve the location correction issue between the texturing model and BIM model.

II. RELATED WORKS

Location correction, which was mentioned as one of the main issues during 3D spatial information data construction through laser scanning in existing location survey fields, has been studied to provide various methods considering data characteristics for the creation and utilization of 3D modeling in a number of GIS-related fields in recent years. In this section, trends of national and international studies on location correction of 3D spatial information data are investigated.

Park (2016) proposed a method of location correction utilizing a smartphone camera and commercial digital maps in urban areas where GPS error occurs considerably. In his study, user location and directions were corrected to have location correction required for indoor and outdoor augmented reality through location optimization in three places in the downtown in Seoul. Reitmayr et al.(2004) utilized a tour guide application operated in the downtown in Vienna to propose an efficient matching algorithm to manage a large-amount of 3D geographic model data. Choi et al.(2015) conducted a study on location correction of spatial information with regard to small areas using Ground Control Points (GCPs) for analysis on location correction of Digital Surface Model (DSM) and shooting images during aerial photographic survey utilizing Unmanned Aerial Vehicle (UAV). Wagner et al. (2010) searched feature points to compare panorama images and camera images utilizing mobile phones and conducted a study on matching with Point of Interest (POI) information based on the search with a descriptor form.

The above studies proposed solutions to ensure location correction of 3D data through laser scanning, shooting via smartphones and aerial shooting images mostly. It is important to propose a method by analyzing appropriate measures suitable for individual characteristics in order to apply a construction method for each environment according to utilization objectives and methods of 3D spatial information modeling. This study proposes a correction method to resolve location mismatch occurred during interlink of BIM data and 3D texturing data during 3D modeling data construction over the BIM/GIS platform, which is one of the various 3D modeling construction methods, thereby linking indoor and outdoor 3D spatial information.

III. CONSTRUCTION OF 3D MODELING DATA BASED ON BIM/GIS PLATFORM

Overview of BIM/GIS data

The BIM/GIS interoperable platform provides effective visualization services utilizing 3D modeling data by operating and managing spatial information seamlessly in a single platform, which was provided separately into indoor and outdoor data previously, via linking BIM and GIS technologies (KIM et al., 2014). A scope of this study is data construction for the testbed and BIM/GIS modeling data are created with regard to a site in the KICT.

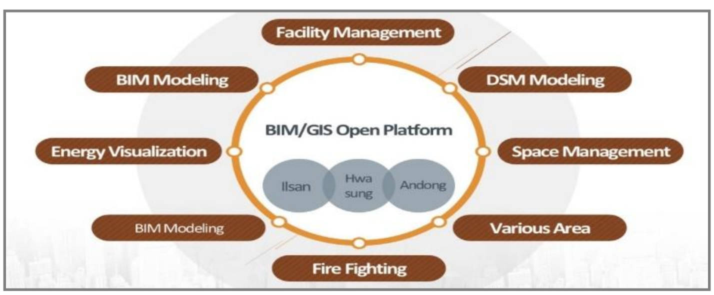

Figure 1: Concept of BIM/GIS platform

Geographical information was constructed via DSM modeling in Ilsan Headquarters, Hwaseong, and Andong centers of the KICT, which were selected as the target region for this study, and effective visualization can be ensured through the use of aerial shooting orthographic images. This can be a basis to provide various applicable services in facility maintenance, response to fire accidents, and energy usage visualization by systematization of existing facility maintenance data and linking the data with the current modeling data in the future (Fig. 1).

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Construction of BIM/GIS modeling database

The following database (DB) tasks were performed: construction of satellite/aerial images, which were the bases in the platform, an administration border between the target and surrounding sites and the verification of names, POI construction, the construction of a standard classification system, the construction of basic attribute information, and the construction of survey and real images (Fig. 2). Next, BIM modeling was conducted based on the arranged data and texture task and exterior modeling were performed for texturing according to Level of Detail (LOD). After the basic design task was completed, the main MEP modeling and structural modeling inside the facility were conducted. Then, the data verification was conducted after converting the data to the final BIM standard format, which was Industry Foundation Class (IFC). Finally, the data was converted to the internal service format for interoperability inside the BIM/GIS platform through the data conversion module, and the data was mounted in the platform.

The construction of the BIM shape and attribute information modeling based on existing building drawings was conducted as follows: For shape information, 3D BIM data was modeled based on 2D drawings and existing maintenance data of facilities inside the KICT. The modifications of existing buildings due to new construction, extension, removal, or remodeling were reflected through actual image shooting.

Figure 2: Process of BIM/GIS modeling

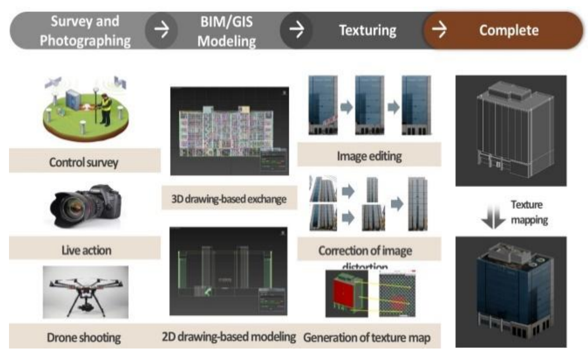

Figure 3: Process of building shape texturing

UAV shooting and 3D texturing data modeling

This step is a procedure of texturing of facility exteriors for a more realistic 3D visualization than the existing BIM modeling images such as Google Earth and V-World. In order to interlink the data surveyed and be shot at the target site via control survey, actual image shooting, and UAV shooting with the above BIM/GIS modeling data, shot images were edited and distorted images were processed to create a texture map and the final texture was mapped (Fig. 3).

The UAV shooting was conducted as follows: A flight area was set considering the control range of wireless reception and the maximum and minimum flight distances of UAV inside the target site, and the minimum rotation radius of the UAV and weather conditions were checked thereby expanding the flight area for the set up. After this, a map boundary of the target area was calculated as a shooting area and altitudes were verified using a digital map in Digital Elevation Model (DEM) to set up the appropriate shooting altitude and overlap. Finally, site shooting was conducted considering weather, site conditions, and electromagnetic shaded areas.

After the aforementioned shot data was collected, spatial distribution of shot images was verified based on the original shot images, and photos of overlap or unnecessary area were removed due to a difference between the map boundary area and the expanded analysis area. Geometric correction and partial correction were conducted using GCP after the first filtering completion. The areas where a large error occurred were selected and corrected partially and GCP were added between the image division boundary and correction boundary parts to minimize the effect from other regions.

Results and analysis

The modeling data constructed through the above process was uploaded into the BIM/GIS platform and visualized as shown in Fig. 4. The above 3D data included not only outdoor spatial information but also indoor spatial information and object-based shape and attribute information thereby visualizing the indoor and outdoor data in contrast with the 3D data indoor map data in Seoul City and V-World data. Accordingly, facilities inside the actual target area were shot to interlink the texturing model and BIM modeling data. Thus, realistic 3D data could be constructed and utilized.

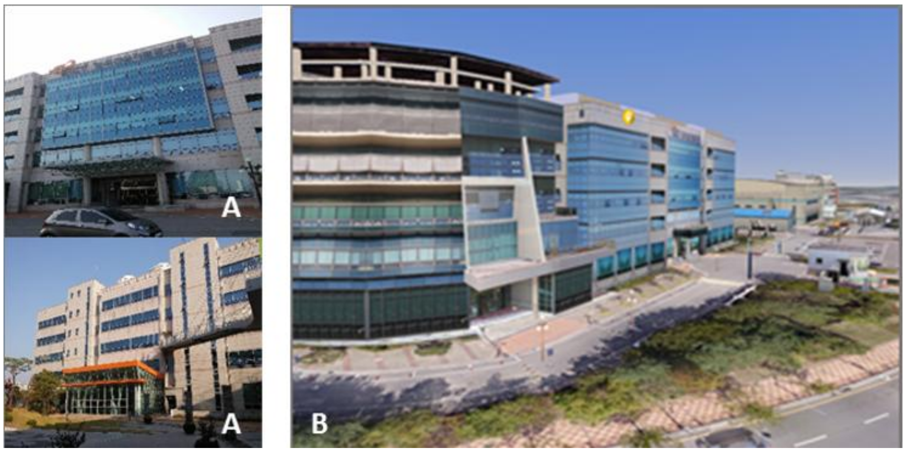

Figure 4: (A) Real building images, (B) Result of BIM/GIS modeling

However, while the absolute coordinates in the BIM/GIS platform map was applied by utilizing control points for the 3D texturing data, the relative coordinates were utilized in general for BIM data during modeling creation. Thus, it was mandatory to have location correction to interlink BIM data with that of the texturing model over the platform. As a result, this study proposed a measure of location correction and designed a process to construct indoor and outdoor 3D spatial information through the interlink of BIM data and 3D texturing data.

IV. CONNECTION OF 3D INDOOR-OUTDOOR SPATIAL DATA

Location correction process between 3D spatial data

The location correction process for the indoor and outdoor 3D spatial information is as follows: First, IFC files, which are BIM model data, are loaded (Fig. 5). This data is exported to IFC after being processed in the Revit architecture. These are created based on relative coordinates and their own origin points and arranged arbitrarily near actual building locations by users.

After this, a coordinate conversion algorithm based on IFC data is created thereby being converted and mapped to absolute coordinates that are corresponded to actual locations as follows (Fig. 6). A process of the IFC data-based coordinate conversion algorithm is as follows: Once the IFC file is loaded, the detailed precision and control points as well as volume information set in the IFC are verified. Here, longitude, latitude, rotation angle, and size information are modified by performing a coordinate correction of origin point if the control point needs to be changed. The modified control point information is updated through updateHeader in the BIM/GIS data schema structure, and BoundingBox and OctreeBox, which are related to detailed precision and 3D model visualization, are calculated automatically based on the set coordinate values. Finally, coordinate automatic conversion is performed based on the data in the coordinate setup window.

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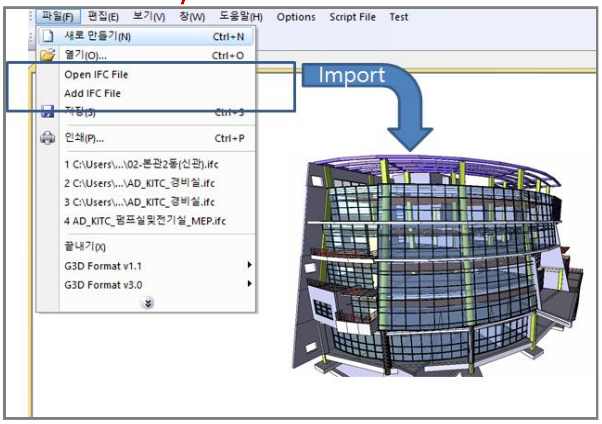

Figure 5: BIM(IFC) data load

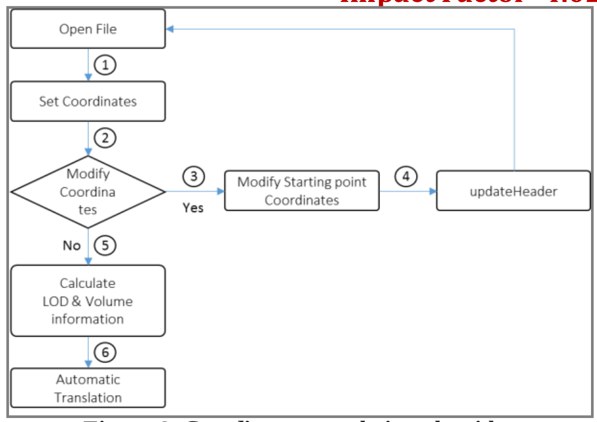

Figure 6: Coordinates translation algorithm

Next, once the DB index information and LOD levels are entered as shown in Fig. 7, and the reference position value (relative control point) inside the IFC is entered, the absolute coordinate information of the buildings is automatically calculated to be re-adjusted to the actual location very closely. Finally, a detailed location of the IFC data is manually corrected to be accurate using 3D texturing data uploaded based on the survey points beforehand. As shown in Fig. 8, the first location-adjusted IFC model is mapped to texturing data, which are laid on the actual location, to confirm the final location.

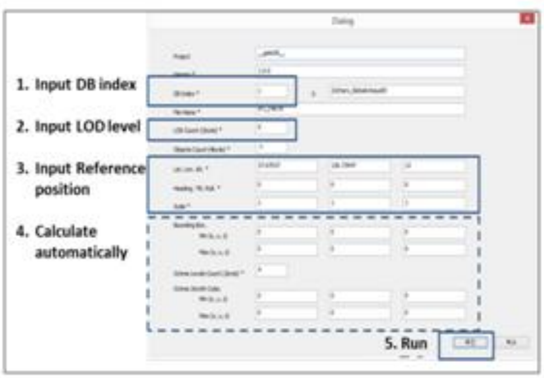

Figure 7: Absolute coordinate mapping to IFC data

Figure 8: Location correction between BIM/GIS data and 3D texturing data

Application of location correction algorithm

Since the IFC data has no coordinate information of absolute longitude and latitude, they require absolute coordinate values such as longitude, latitude, and altitude in the GIS-based viewer or during data inter-operation. In this study, location correction was performed through rotation, movement, expansion, and reduction of objects in the 3D space of the IFC model based on high-precision (5cm) aerial images acquired via UAV to interlink the IFC and GIS information. Here, the high-precision aerial images acquired through UAVs are geographically coded and verified data through at least 50 or more GCP. As the IFC has no schema that stores spatial geographic references, manual operation is essential when it is interlinked with the absolute coordinate-based GIS.

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Table 1: Results of location correction algorithm

	Before	After
Latitude	0	127.4243
Longitude	0	38.458222
Elevation	0	18
Heading	32 degree	96 degree
Tilt	0	0
Roll	0	0
Scale X	1	1.2
Scale Y	1	1.2
Scale Z	1	1.2

The values before and after the location correction using the location correction process are as follows: Existing IFC had only direction information since its location information was configured based on relative coordinate points. However, an error range in actual coordinate values and the sizes of buildings and vector values can be corrected to ±5cm after applying the location correction algorithm proposed in this study. The error range can be improved further if more high-precision aerial images are acquired through the UAV the current study.

V. RESULT & DISCUSSION

When 3D spatial information location correction was conducted using the above process, the following two issues were raised: 1) The Z-fighting problem between 3D texturing model and BIM model and 2) the location correction method when no survey points are available.

Z-fighting refers to a phenomenon of flicking, broken polygon and random overlap as if noise occurs when two polygons (primitive) are visualized in a screen with similar Z-depth (Fig. 9). It occurs normally when two or more polygons are overlapped in the same position over a 3D space or polygons are too close to each other. Most Z-fighting phenomena can be prevented beforehand through the adjustment of near and far distance of the screen frustum. That is, since a weight can be higher with regard to the Z-depth as the camera is nearer, a near plane value is rescaled to become far away from the camera to resolve this problem.

However, a visualization area in the 3D client is quite wide in case of the BIM/GIS inter-operable platform. Thus, this problem cannot be solved only with near and far plane rescaling in order to visualize data from the earth to a narrow area in building indoor. Thus, the Z-fighting problem can be solved by making a shape size of 3D texturing modeling larger than that of the BIM by about 1 to 2% (Fig. 10).

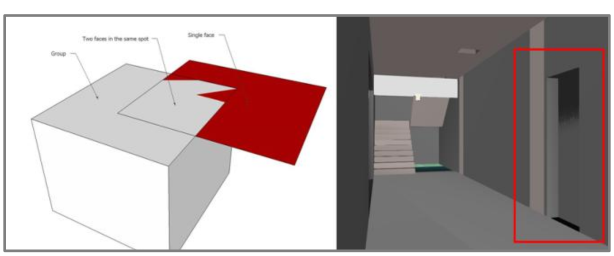

Figure 9: Problem issue about Z-fighting

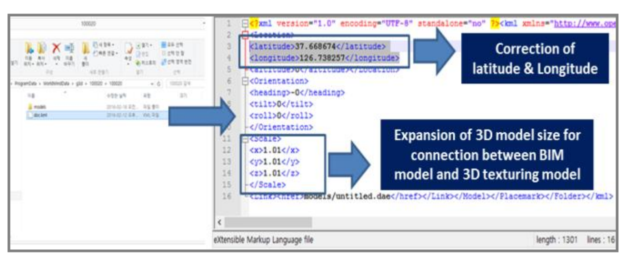

Figure 10: Re-scaling of 3D model to solve Z-fighting issue

The second issue occurs when no survey points are available. Fig. 11 shows a measure of absolute location correction for the BIM (IFC) data or 3D texturing model using high-precision aerial images when no survey points are available.

Figure 7: Location error occurrence

Figure 8: Location correction to solve the error

When the absolute location correction of two 3D models cannot be done through geographical coding as indoor and outdoor survey points are available, location correction can be done using high-precision aerial images (Fig. 12). Here, the longitude value becomes larger as it moves to the right and the latitude value becomes larger as it moves to the top (north) based on the true north in the 3D screen.

VI. CONCLUSION

This study produced and interlinked BIM (IFC) data and orthophoto-based 3D texturing data to construct BIM/GIS platform-based 3D modeling data, and proposed a location correction method to resolve a location mismatch between two models. An algorithm that converts relative coordinates into absolute coordinates was implemented to interlink the BIM model data based on relative coordinates and texturing data based on absolute coordinates for a single building to calculate an absolute location of the building first. Then, a second mapping of texturing data over the BIM/GIS platform map was conducted to correct the final location.

There have been a number of studies on location correction with regard to large regions. It is important to implement a construction method suitable for environments according to utilization objectives and methods of 3D spatial information modeling by analyzing the appropriate measure for each characteristic. For future studies, these techniques can be extended to be utilized to interlink underground facilities in the BIM/GIS platform, the development of facility maintenance systems through the interlink of indoor and outdoor spatial information, and the re-structuring of apartment complex plan.

VII. ACKNOWLEDGEMENTS

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