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Accuracy Analysis of Structure Modeling using Continuous Panoramic Image

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Abstract

In this study, a 3D model was constructed using Continuous Panoramic Image and accuracy analysis of 3D modeling data was performed. The way for 3D modeling using images and SketchUp greatly reduced the time and the coordinates of the target object were effectively collected in panoramic images. Accuracy analysis of the modeling result was performed by comparing coordinates with the total station. As a result of the accuracy evaluation of the 3D model, the horizontal and vertical deviations were 0.06m and 0.128m, respectively. Our results suggest that it is possible to reduce the operation time by 30% compared to modeling using existing laser scanner; also, panorama images can be used in various content businesses. The proposed method of 3D modeling reported in this study greatly reduces effort and time and can contribute to 3D modeling and other relevant areas.

Keywords: *3D Modeling, Panoramic Image, GNSS, Accuracy Analysis*

1. Introduction

Spatial information is not merely delivering the location information; rather, it is gradually becoming a part of our life. In recent years, it has also developed into a technique changing our life-style [1-5]. In many advanced countries, 3D spatial information is used in major national projects, and those countries are striving for dominating the market in advance. In the United States, the distribution of spatial information is very active in private studies and in creating business models. “Spatial data industry future vision” policy has been recently published in Japan and it is being fully employed as a crisis management system in the disaster and prevention fields. In China, the “Digital City Geospatial Platform Construction” project was launched in 2010; until 2015, the plan is to construct high accuracy 3D spatial data of 286 cities in China [6][7]. Recently, 3D modeling data have been variously utilized in many fields, as, for example, GIS (Geographic Information System) analysis, 3D Content industry, and so on. Among global 3D content industries, the 3D display market is expected to grow by 40% annually. One of the estimates predicts that the 3D content market in Korea will increase by 90% each year, creating a market of 2.5 trillion won by 2015 [8]~[10]. 3D models represent a 3D object using a collection of geospatial information in 3D space, connected by various geometric entities, such as triangles, lines, curved surfaces, among others. Being a collection of data, such as points with 3D coordinates, 3D models can be created manually, algorithmically, or be scanned [11-12].

3D modeling of spatial information has a characteristic for observing the entire image area by moving a point of sight or rotating 3D models. In order to construct 3D models, data source, equipment(S/W & H/W), modeling method, and visualization technique are generally needed. In the spatial information construction fields, various techniques of

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getting spatial data, such digital aerial photogrammetry, high-resolution satellite image data, unmanned aerial vehicle, MMS (Mobile Mapping System), and others are now being developed[13-16]. However, 3D model construction is a high-cost and labor-intensive work. In this context, it becomes crucial to develop ways to efficiently construct high-precision geometric structure.

In this study, a 3D model of Dongnimmun Gate was made by digital photogrammetry system using V10 Imaging Rover. Panoramic images of the research area were acquired, from which the coordinates of the target object were collected. Accuracy analysis of the modeling results was performed by comparing with the total station. Figure 1 shows the study flow diagram.

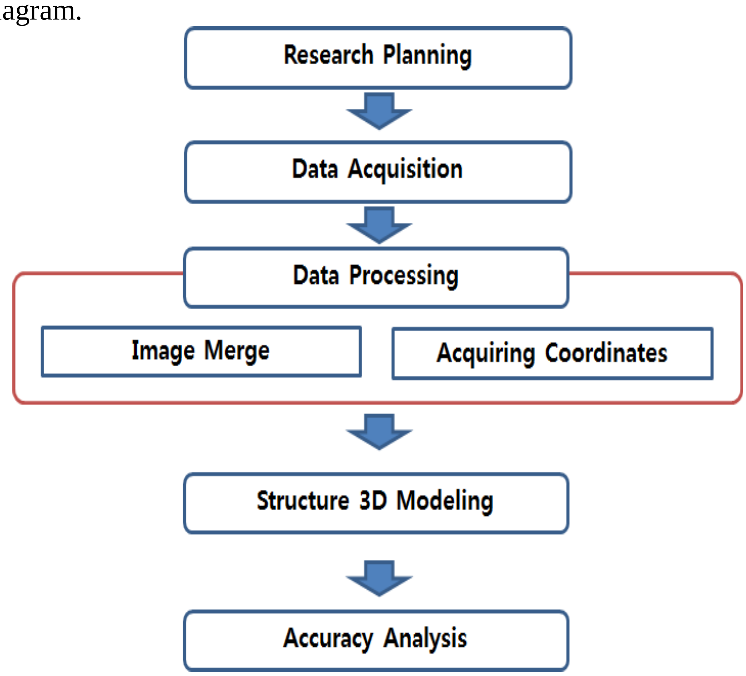

Figure 1. Study Flow

2. Data Acquisition and Processing

In this study, Dongnimmun Gate was selected as the target object furthermore, the data for 3D modeling were acquired. Dongnimmun Gate was constructed under an independent association which was organized by Seo Jae-pil, and the construction was greatly supported by many patriots. It was modeled on the Arc de Triomphe in Paris. Figure 2 shows Dongnimmun Gate.

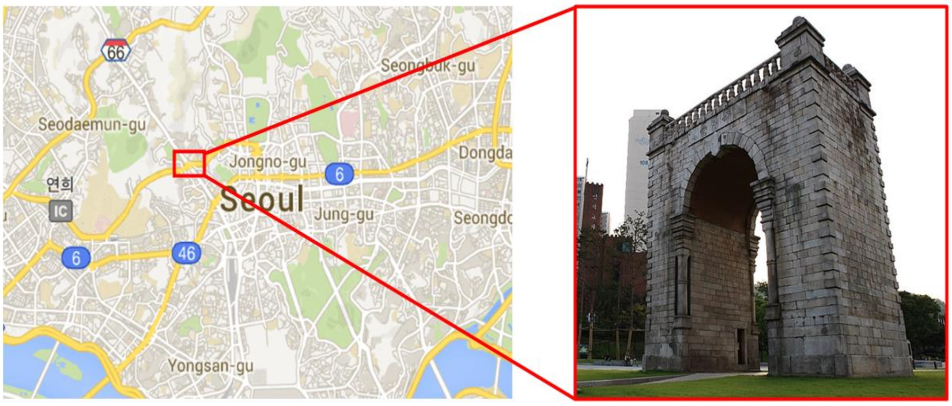

Figure 2. Dongnimmun Gate

Trimble V10 Imaging Rover was used to acquire a panoramic image for 3D modeling. V10 can get a 60 million pixel panoramic image using 12 cameras that conduct calibration work; it consists of a controller and the main body mounted on the position sensor, tilt sensor, and electronic compasses. There are two methods to get a panorama image for digital photogrammetry. The first one is to connect GNSS and the total station; the second one is to measure the target object from the station point. In this study, the first method was used for getting the panorama image. Table 1 shows specification of V10; Figure 3 demonstrates the configuration of the V10 Imaging Rover [17].

Table 1. Specification of V10

Specification	Value
Total Panorama Resolution	60 MP
FOV(Horizontal)	360° x 43°, 210° x 57.5°
FOV(Vertical)	93.1°
Operation Temperature	–20 °C to +50 °C
2 axis tilt sensor range	15°
Tilt sensor accuracy	0.03°
Magnetic sensor accuracy	1°
Operation Time	4 hours
Lens type	f-theta
Angle per pixel	0.39 mrad/Pix (1.33 arcmin/Pix)
Focal length	3.63 mm
Depth of field	0.1 to ∞ m
Stability of calibration	2 Pix

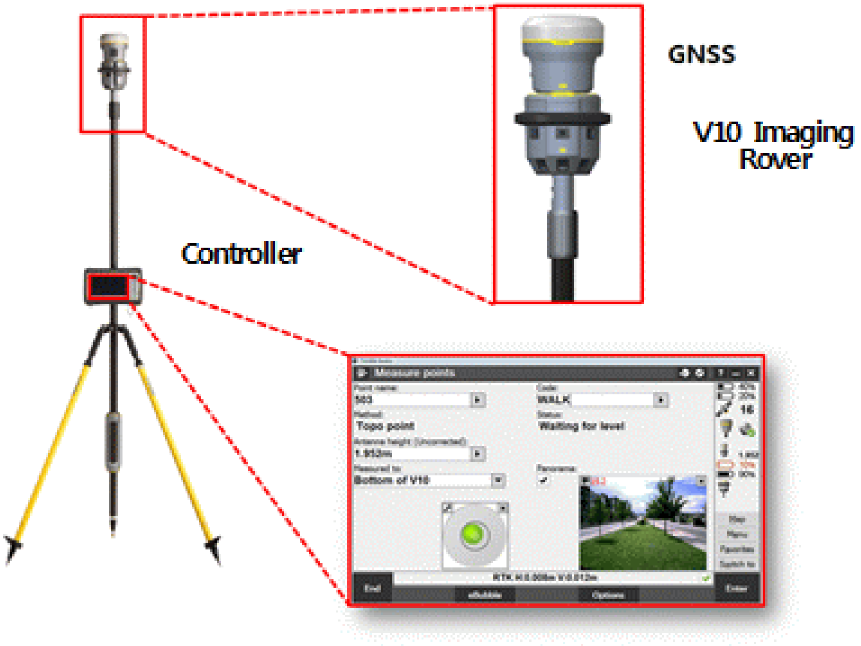

Figure 3. Configuration of the V10 Imaging Rover

The sequence of 3D modeling using V10 Imaging Rover includes taking a picture of the target object, image data post processing, and 3D modeling. Taking a picture 45m away from the target object was conducted 9 times and, after the image data post-processing using TBC (Trimble Bussiness Center), a 3D model was constructed by SketchUp. Figure 4 shows the work flow of 3D Modeling.

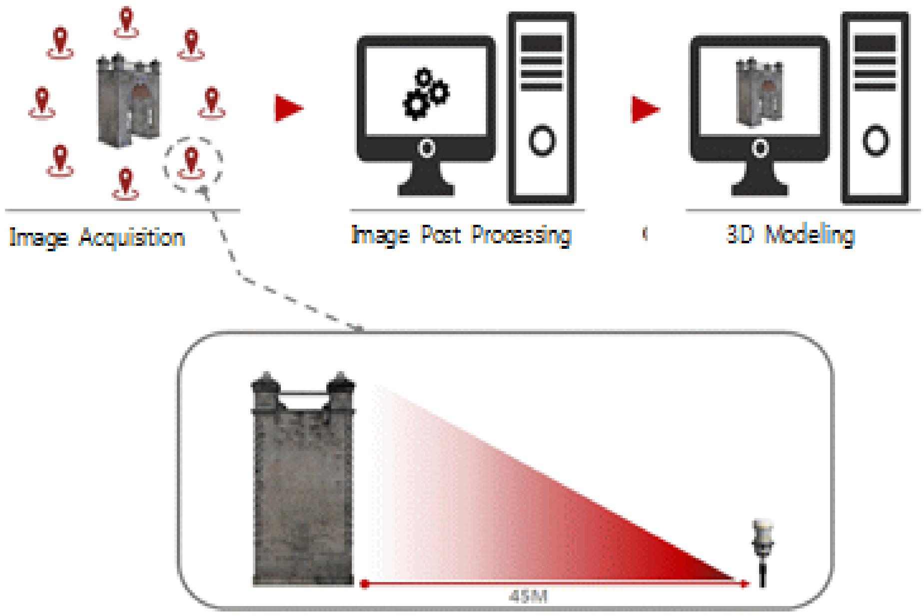

Figure 4. Work Flow of 3D Modeling

In the image, 9 coordinates were acquired using VRS (Virtual Reference Station); furthermore, 13 check points were directly measured for accuracy evaluation. 12 pictures, including acquired points from the image, were automatically created as panoramic image through TBC; then, coordinate acquisition from the video was conducted by adjusting type point. Figure 5 shows the data acquisition screen; Figure 6 represents the status of measuring point.

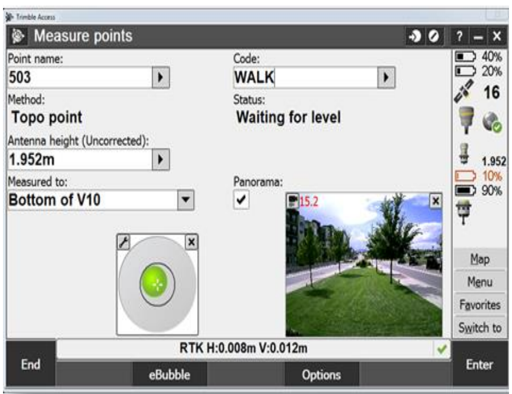

Figure 5. Data Acquisition Screen

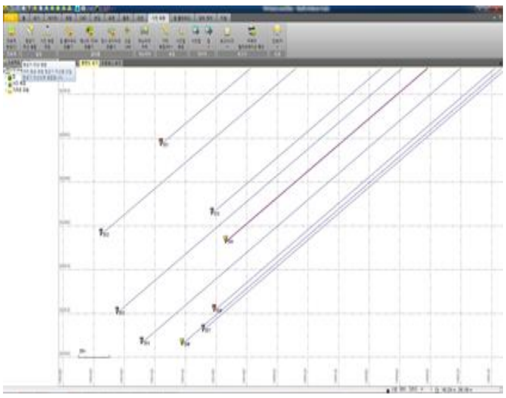

Figure 6. Status of Measuring Point

Type point adjustment is generally conducted manually or automatically and the points of contact are extracted between the acquired panorama images and then adjusted. In this study, automatic adjustment was conducted through standard resection and more than 12 points in each image were extracted. After adjusting the type point, it was measured for 3D modeling. Figure 7 shows the result of Tie Point Adjustment; Figure 8 presents surveying using the panoramic image.

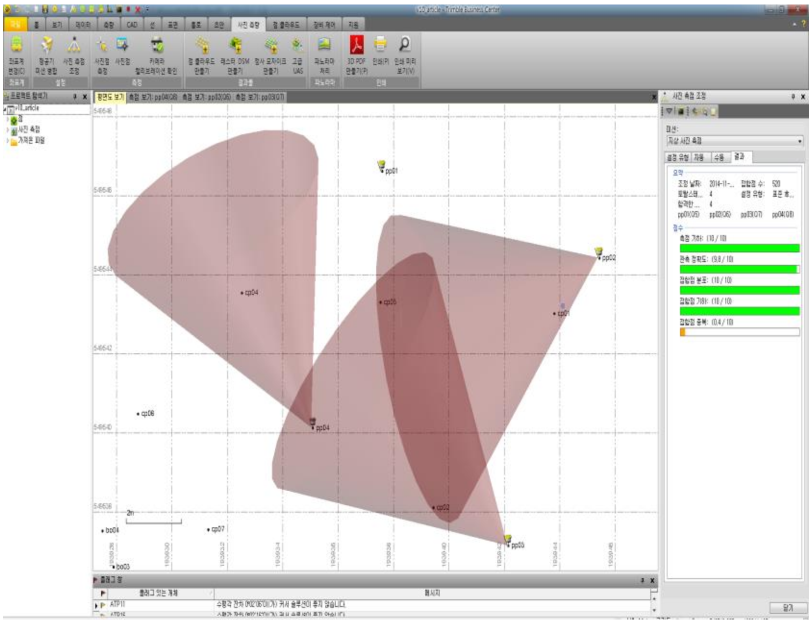

Figure 7. Result of Tie Point Adjustment

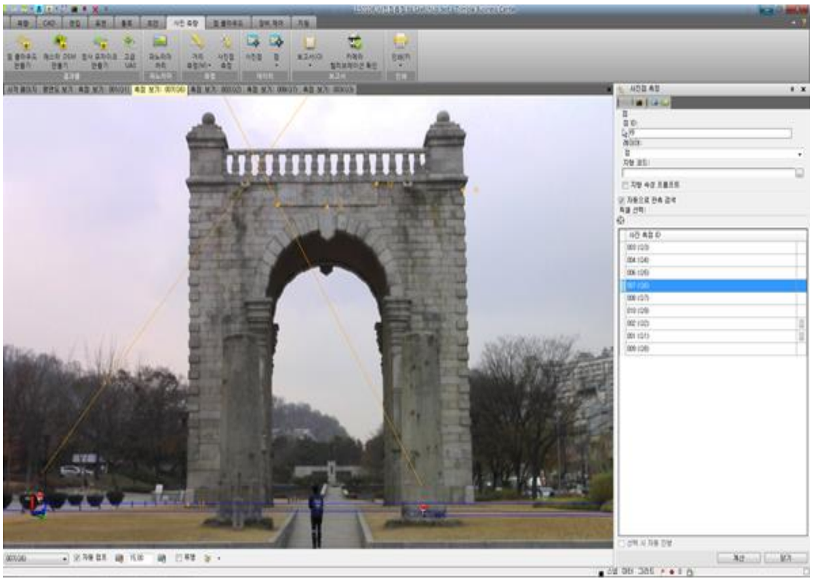

Figure 8. Surveying Using Panoramic Image

3D modeling of Dongnimmun Gate was carried out in SketchUp by using the extracted type point from TBC. The sequence of SketchUp modeling included the creation of an image igloo, 3D modeling, texture mapping, and linkage with Google Earth. Figures 9-12 present the process of SketchUp modeling.

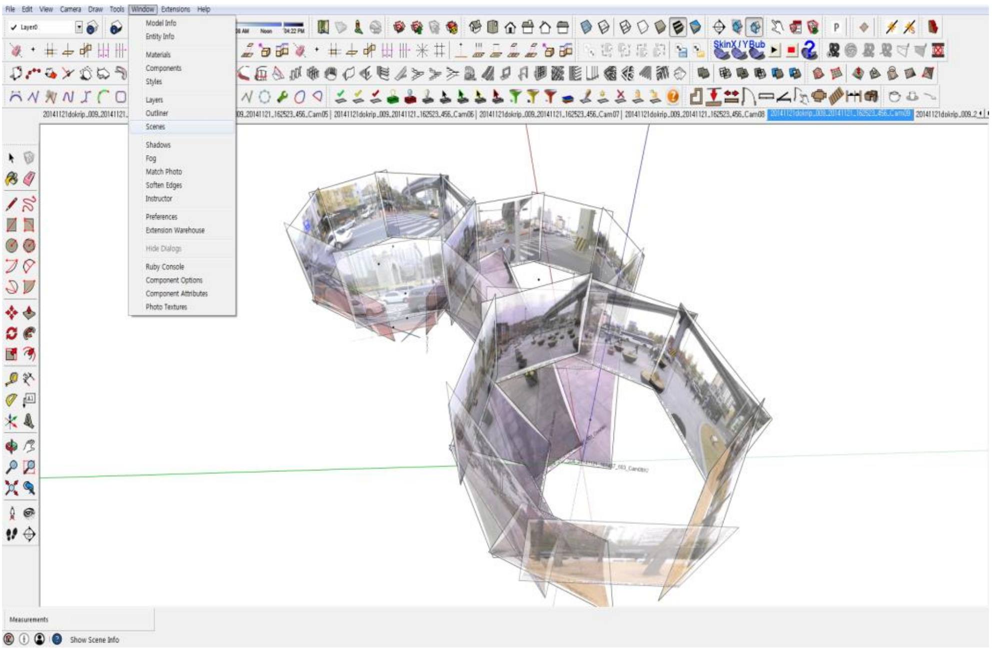

Figure 9. Image Igloo

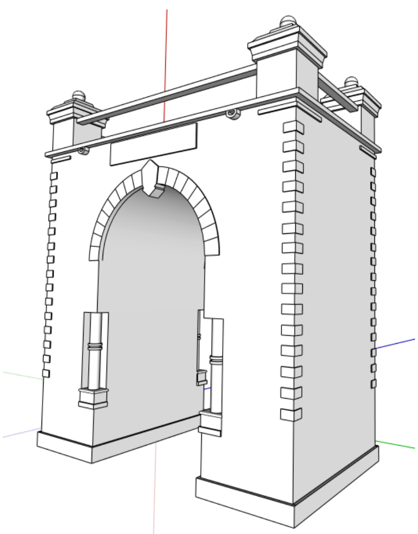

Figure 10. 3D Modeling **Figure 11. Texture Mapping**

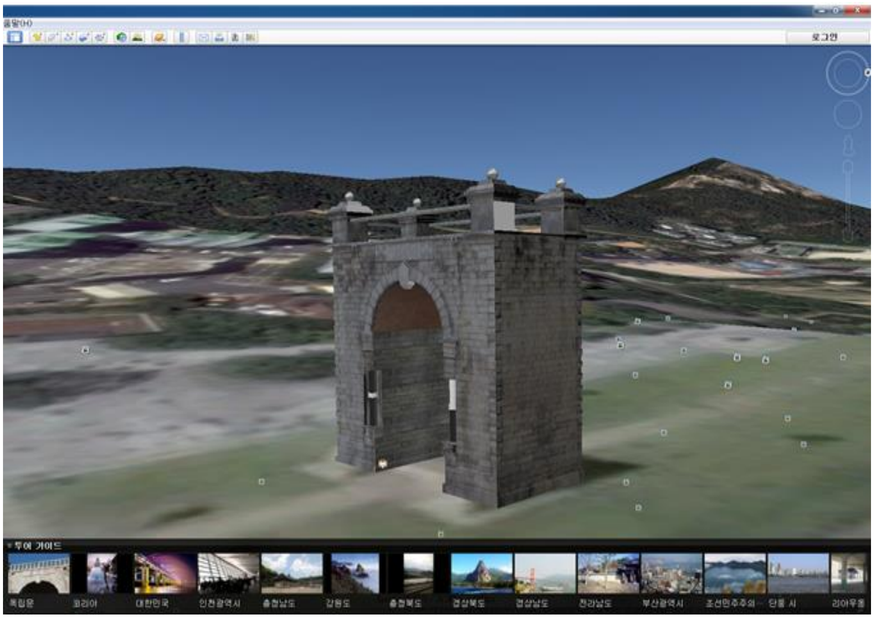

Fig. 12. Link Result with Google Earth

3D modeling of Dongnimmun Gate using V10 Imaging Rover and SketchUp took 6 hours from taking a picture of the target object to the 3D modeling data construction. Therefore, compared to modeling using existing laser scanners, the operation time was reduced by 30%. Panorama images can also be used in various content businesses.

Furthermore, accuracy analysis of the modeling result was performed by comparing with the total station. For accuracy evaluation, a total of 15 points which were clearly detected from the panoramic image were selected as check points and the coordinates of N, E, H directions were compared. Figure 13 shows the check points; Fig. 14 is the deviation graph.

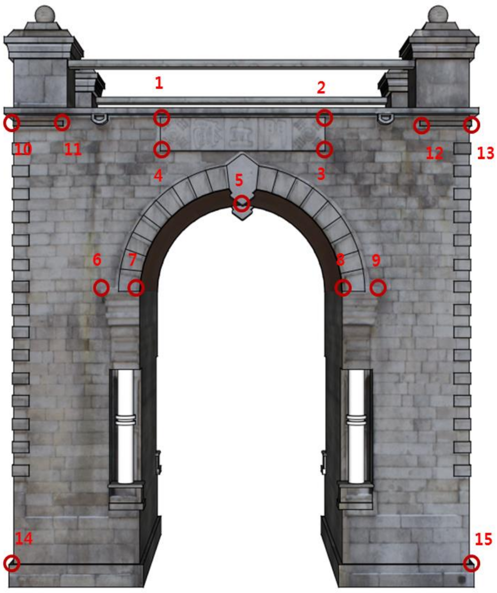

Figure 13. Check Points

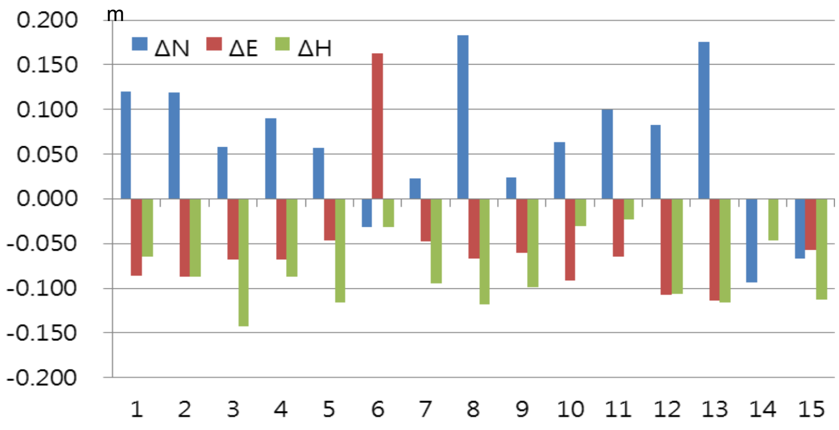

Figure 14. Deviation Graph

Table 2. Results of Accuracy Evaluation

No.	Northing	Easting	Height	Northing	Easting	Height	ΔN	ΔE	ΔH
1	552539.565	196426.247	58.598	552539.445	196426.333	58.663	0.120	-0.086	-0.065
2	552542.219	196429.461	58.538	552542.100	196429.548	58.625	0.119	-0.087	-0.087
3	552542.210	196429.452	57.760	552542.152	196429.520	57.903	0.058	-0.068	-0.143
4	552539.564	196426.255	57.788	552539.474	196426.323	57.875	0.090	-0.068	-0.087
5	552540.885	196427.860	56.493	552540.828	196427.907	56.609	0.057	-0.047	-0.116
6	552538.644	196425.394	54.092	552538.675	196425.231	54.124	-0.031	0.163	-0.032
7	552539.226	196426.217	54.376	552539.203	196426.265	54.47	0.023	-0.048	-0.094
8	552542.288	196429.795	54.093	552542.105	196429.862	54.211	0.183	-0.067	-0.118
9	552542.852	196430.613	54.363	552542.828	196430.673	54.462	0.024	-0.060	-0.099
10	552536.993	196423.376	58.646	552536.929	196423.467	58.676	0.064	-0.091	-0.030
11	552538.058	196424.665	58.635	552537.958	196424.730	58.658	0.100	-0.065	-0.023
12	552543.479	196431.191	58.608	552543.396	196431.298	58.714	0.083	-0.107	-0.106
13	552544.535	196432.470	58.598	552544.359	196432.584	58.714	0.176	-0.114	-0.116
14	552537.228	196423.371	47.726	552537.321	196423.372	47.772	-0.093	-0.001	-0.046
15	552544.387	196432.025	47.753	552544.454	196432.082	47.866	-0.067	-0.057	-0.113
Average							0.060	-0.054	-0.128
Standard Deviation							0.080	0.066	0.115

As a result of accuracy evaluation, the deviation of horizontal (Northing, Easting) direction was -0.114m ~ 0.183m and the average of deviation was ca. 0.06m. The deviation of vertical direction was -0.024m ~ -0.170m and the average was around 0.128m.

These results suggest that 3D modeling using V10 Imaging Rover and SketchUp can be fully employed in modeling work. The method used in this study can reduce the time for actual survey and 3D modeling compared to existing laser scanner, the total station, or GNSS. Furthermore, acquired images can be variously used in texture mapping. Continuous panoramic images will contribute to 3D modeling and various content industries.

3. Conclusion

In this study, 3D modeling using V10 Imaging Rover and SketchUp was conducted, followed by the evaluation of accuracy of the modeling data. Our results suggest the following conclusions.

First, 3D modeling of Dongnimmun Gate was efficiently conducted by the procedure of taking a picture of the target object, image data post-processing, and 3D modeling using the acquired coordinates by panoramic image and SketchUp.

Second, compared to the existing laser scanner, total station, or GNSS, the method of using continuous panoramic image could reduce the time for actual survey and 3D modeling; the acquired images can be used in texture mapping.

Third, the specific values of deviation obtained in horizontal and vertical direction let us conclude that the result using continuous panoramic images can be fully used in 3D modeling work.

Fourth, the results of the present study contribute to the promotion of the 3D content industry and technical capabilities.

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