BUILDING AREA DETECTION USING POINT CLOUDS PRODUCED BY DENSE IMAGE MATCHING METHOD

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KEY WORDS: Stereo image, SGM, Superpixel segmentation

ABSTRACT: Automatic extraction of building information is not only useful for three dimensional mapping but also for urban monitoring, disaster management, and military field. With the recent presence of various high-resolution earth observation satellites, optical satellite images have the advantage of detecting objects and obtaining ground information. In this regard, this study proposes a method of extracting building areas using point clouds produced by dense image matching using high-resolution satellite (HRS) images. First, a point cloud is produced by applying semi global matching (SGM) to HRS stereo images. Subsequently, ground points and non-ground points are separated from the produced point cloud. The separated ground points and non-ground points are interpolated to generate digital terrain model (DTM) and digital surface model (DSM), respectively. A superpixel segmentation is implemented to extract candidate building areas through the difference between DSM and DTM, and the building areas are finally automatically detected using the building characteristic conditions based on superpixel segmentation. The possibility of automatic building detection was confirmed experimentally for the selected area in this study.

1. INTRODUCTION

Automatic detection of buildings from remote sensing data has been one of the important research topics because of its various applications such as urban monitoring, disaster management, land use land cover mapping, change detection, and military field. Laser scanning technology, which provides ground information with high accuracy, has been widely used for detecting buildings. However, it has a limitation in acquiring laser scanning data in a non-accessible or wide area. On the other hand, optical satellite images have the advantage of obtaining information about non-accessible or wide areas with the recent presence of various high-resolution earth observation satellites such as IKONOS, QuickBird, and WorldView 1-2. The high-resolution satellite (HRS) imagery provides detailed information of ground objects, but it is still challenging to detect buildings from the complex scene of urban areas. Thus, this study proposes a method of detecting buildings using point clouds produced by dense image matching using HRS images.

2. METHODS

The methodology adopted for automatic building detection has been described below.

2.1 Point cloud generation from stereo images

A point cloud was produced by using semi global matching (SGM) algorithm, which is proposed by Hirschmuller (2008). The SGM algorithm determines the disparity by accumulating COST from 8 directions to 16 directions, instead of using threshold values to find matching points within searching space. The performance of SGM was confirmed as satisfactory in the field of stereo matching (Kwon, 2019). In this study, high-density point cloud was generated by applying SGM to HRS stereo images.

2.2 Ground filtering and model generation

In this step, the point cloud extracted in previous step was separated into ground points and non-ground points. The main reason for ground filtering is to generate a digital terrain model (DTM) and a digital surface model (DSM). The DTM is approximated by using the extracted ground points. Then nDSM was generated by calculating difference between DTM and DSM. In this study, cloth simulation filter (CSF) developed by Zhang et al. (2016) was applied to extract ground points. Then interpolation was performed at the ground points separated by filtering to create a DTM. In a similar way, a DSM was created at the same resolution as the DTM. In order to effectively extract buildings, nDSM was generated by subtracting the DTM from the DSM.

2.3 Superpixel segmentation

The DSM and DTM generated in the previous step have noise because the height error in the point cloud cannot be completely eliminated. In order to minimize the effect of the height error, superpixel (SP) segmentation was applied in this study. By using SPs, each height value can be clustered while maintaining the overall shape of buildings. In this study, SPs were created using DSM and then nDSM was updated by recalculating DSM and DTM based on the segmented SPs.

2.4 Building area selection based on adjacency between superpixels

In order to find SPs only corresponding to the building, this study used the adjacency among SPs. The graph was constructed using the height value of each SP in nDSM, and the adjacency was determined using the height difference. The node, the center point of each SP, whose nDSM value is close to zero was excluded from candidate areas for buildings, and it is determined that the nodes are not adjacent if the height value between the nodes changes drastically.

3. EXPERIMENT

3.1 Dataset

The dataset used in this study includes a panchromatic stereo pair of WorldView-2 (WV-2) imagery. Table 1 shows the specifications of the WV-2 imagery. The extent of images covers an area of about 100 sq. km (9.5 km by 10.6 km) in Daejeon, South Korea. Daejeon. As shown in Table 1, the stereo pair from WV-2 was acquired on 15 June 2011, presenting a convergence angle of about 33°. It was collected on Ortho-Ready Standard (OR2A) format.

Table 1. The technical characteristics of WV-2 imagery

Parameters	First scene	Second scene
Platform	WorldView-2	
Acquisition Date	2017-06-15	
Scan Direction	Forward	
Product Type/Level	Stereo OR2A	
Image size (pixel)	26556 × 29324	
Band	Pan	
Bits per pixel	16	
Convergence angle (°)	32.97	
Asymmetry angle (°)	6.80	
Bisector elevation angle (°)	60.30	
GSD (meter)	0.569	0.630
Sun Azimuth (°)	122.4	122.9
Sun Elevation (°)	68.9	69.1

3.2 Results

Figure 1 shows the extracted point cloud of the study area. The point cloud is a partly extracted area from the whole area and has 16,130,107 points in about 1.7 sq. km. The coordinate system of the point cloud was converted to UTM for computational convenience.

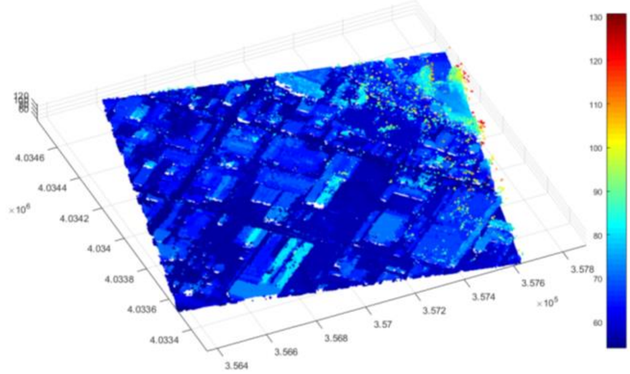

Figure 1. The point cloud generated by SGM

By applying CSF, the point cloud was classified into ground and non-ground points. Figure 2 shows the ground points (left) and the DTM was interpolated by using the ground points (right). The DTM was used to extract the candidate area of buildings through calculating nDSM, the difference from the DSM.

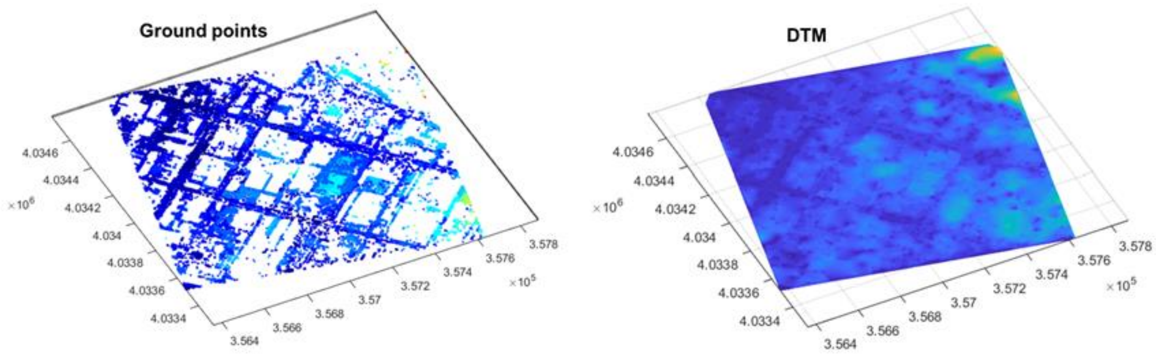

Figure 2. Extracted ground points (left) and DTM (right)

Figure 3 shows nDSM with original grid (left) and nDSM aggregated with SPs. As shown in the left figure of Figure 3, the maximum height is about 70 m, while the maximum height of the right figure does not exceed 40 m. It means that the height error in the point cloud was reflected in nDSM with original grid, and the error was reduced through SP aggregation.

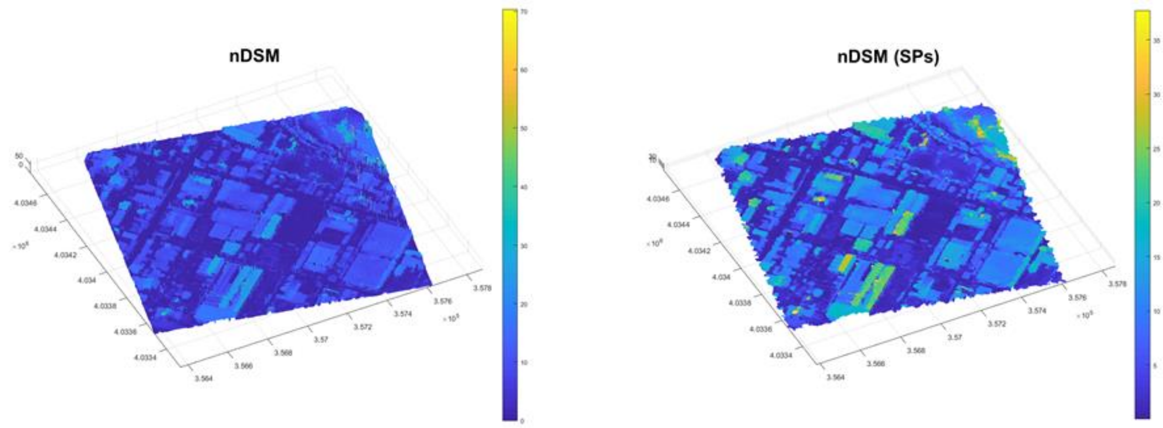

Figure 3. nDSM (left) and nDSM based on SPs (right)

This study used the adjacency among SPs of nDSM to extract building areas. Left side of Figure 4 shows center points of SPs as gray color, and the adjacency are shown as blue lines. In the experiment, the SP was excluded from the candidate area of buildings if the center value of a SP is less than 1 meter and it is determined that SPs are not adjacent if the height difference between two SPs is more than 5 meters. In the right figure of Figure 4, the buildings with large area were detected effectively, but the buildings with small area were not properly extracted. The result also includes a lot of noises.

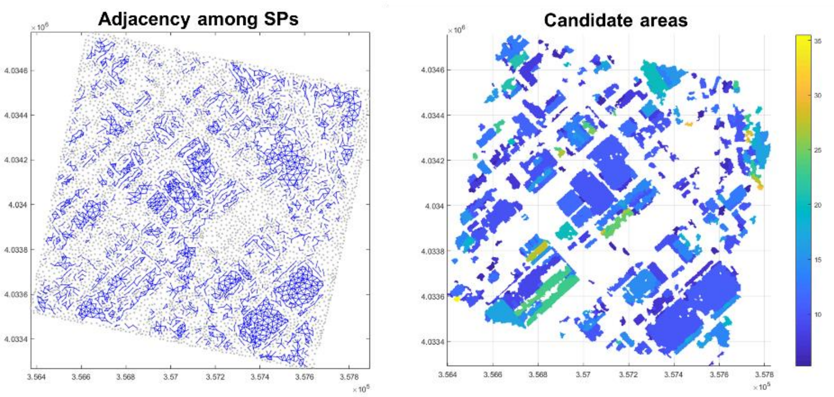

Figure 4. Adjacency among SPs on graph (left) and building area candidates (right)

4. CONCLUSIONS

This paper examined an automatic building detection process using point cloud from HRS imagery. The point cloud was generated by applying SGM from HRS images. The DTM and DSM were created by separating the ground points from the point cloud, and SP segmentation was adopted to reduce the height error in the point cloud. It was confirmed that the SP segmentation effectively reduced the height error by comparing the height distribution of two nDSMs. In addition, the adjacency between SPs based on height differences was introduced in consideration of the geometric characteristics of buildings. To increase the accuracy of building detection, final building area selection process should be improved and will be a future work.

References

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