Automatic Building Extraction Using LIDAR Data

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Abstract: This paper proposed a practical method for building detection and extraction using airborne laser scanning data. The proposed method consists mainly of two processes: low and high level processes. The major distinction from the previous approaches is that we introduce a concept of pseudo-grid (or binning) into raw laser scanning data to avoid the loss of information and accuracy due to interpolation as well as to define the adjacency of neighboring laser point data and to speed up the processing time. The approach begins with pseudo-grid generation, noise removal, segmentation, grouping for building detection, linearization and simplification of building boundary, and building extraction in 3D vector format. To achieve the efficient processing, each step changes the domain of input data such as point and pseudo-grid accordingly. The experimental results shows that the proposed method is promising.

Keywords: LIDAR, Building Detection, Extraction, Airborne Laser Scanning, Pseudo-Grid

1. Introduction

In recent years, accurate 3D data in urban areas is in great demand for many applications such as urban planning, mobile communication, 3D city modeling and virtual reality. Usually urban areas are dynamically changing due to construction and extension of urban features, especially buildings. Detection and reconstruction of buildings are of highest interest in the geospatial community. Since manual digitizing is time consuming and very costly, a fast and automated method for detecting and extracting buildings is required by many users of geographic information system(Palmer, 2001).

Airborne laser scanning is a relatively new and promising technology for obtaining Digital Surface Models (DSMs) with high density and high position accuracy of the earth surface. The development of airborne laser scanning started in the 1970s. Airborne laser scanning system comprised of laser scanner, GPS receiver and IMU computes the range to the target point by emitting a laser pulse and measuring the round-trip time. Contrary to the passive sensor such as optical sensor, the laser scanner is an active sensor so that it works day and night, and is less affected by the shadow and weather (Baltsavias, 1999).

A number of research works have been performed on building detection and reconstruction from airborne laser scanning data in automated fashion(Maas and Vosselman, 1999; Morgan and Tempfli, 2000; Lee and Schenk, 2001; Elaksher and Bethel, 2002). Figure 1 illustrates the schematic diagram of the proposed approach for building detection and extraction using airborne laser scanning data.

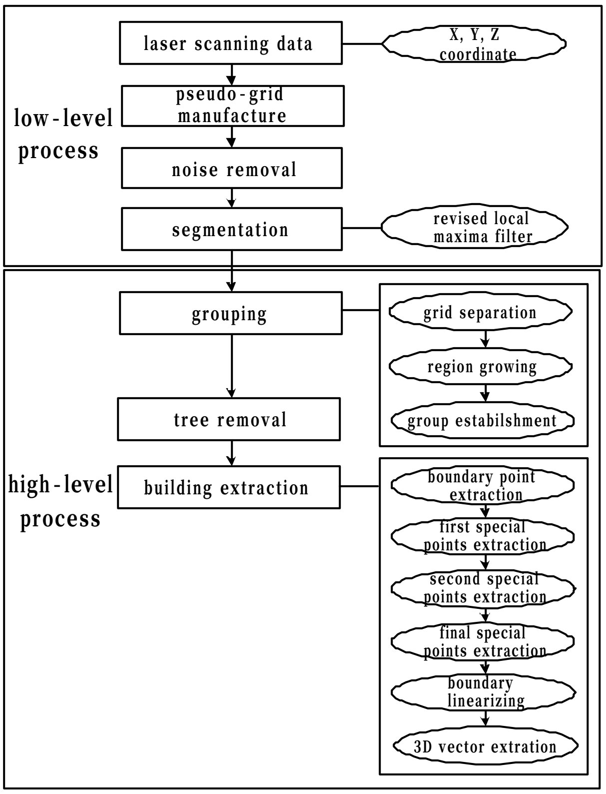

Fig. 1. The schematic diagram of the proposed approach for building detection and extraction.

2. Building Detection and Extraction

The proposed approach is divided into two processes: low level and high level process. The low level process consists of pseudo-grid generation, noise removal and segmentation. The high level process consists of grouping, tree removal and building boundary extraction. In addition, each step changes the domain of input data such as laser point domain and pseudo-grid domain in order to achieve efficient data processing.

Figure 2 shows the change of data domain in the proposed approach for building detection and extraction.

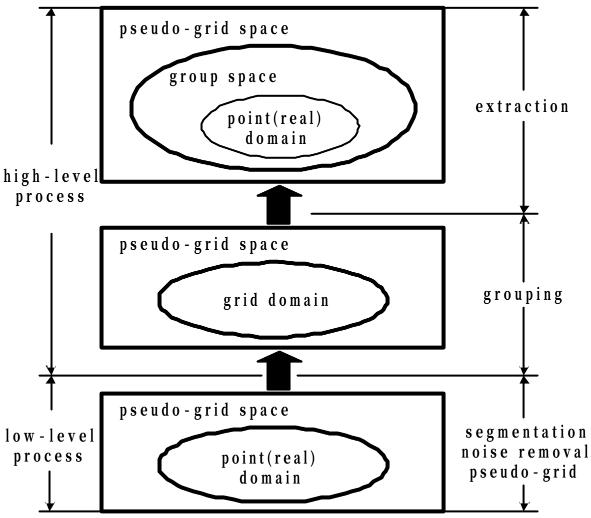

Fig. 2. The change of data domain in the proposed approach for building detection and extraction process.

1) Low-level Process

1. Pseudo-Grid Generation

In many previous research for building detection and extraction, irregularly distributed laser scanning data are converted into grid form so as to enhance speed of data and then building extraction is performed. In doing so, unwanted errors are introduced in the process of interpolation. In order to avoid the errors, we invented a concept of pseudo-grid that virtually contains laser point data in each grid form. The size of pseudo-grid is calculated with average point density of laser point data. Once pseudo-grid is created, the raw laser point data is assigned to each pseudo-grid shown in Figure 3.

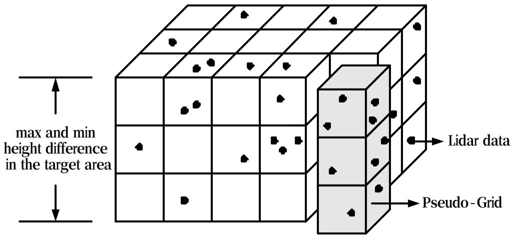

Fig. 3. Pseudo-grid generation.

Since we created pseudo-grid, we don't need to convert laser point data into regular grid form and don't introduce any errors into the raw data through interpolation. In addition, the pseudo-grid improves the adjacency among laser point data so as to speed up the process such as building detection and extraction.

2. Noise removal

There are irregular random errors contained in raw laser point data caused by instrument malfunction, natural phenomena and so on. In this paper, we only consider random errors such as outliers and remove them by statistical method.

3. Segmentation

It is defined here that segmentation is only to extract building candidate points from laser data point cloud. We applied a local maxima filter for segmentation.

2) High-level Process

1. Grouping

The process of grouping is performed on pseudo-grid domain and defined as classifying laser point data as a group resulted from segmentation above. After grouping, we can compute the area and perimeter length of each group, which will be used for building decision criteria.

2. Tree removal

After grouping, the laser points belonging to trees still exist as building candidates. Those laser points could be removed by two simple measures: minimum building area and circularity. However, some of laser points belonging to trees can't be eliminated if their size and shape are similar to buildings.

3. The extraction of building boundary

The process of extracting building boundary is performed on both point and pseudo-grid domain. The boundary of each group is linearized and simplified, and then interest points corresponding to building corners are extracted. Figure 4 shows one example of interest points extraction process.

Fig. 4. Interest points extraction process(example).

3. Experiment results

The target area is located at Chungjoo city in Korea and its size is about 1,100m(width)×750m(length). The equipment was Optech's ALTM 1020. The flight height, flying speed, laser repetition rate, swath width, width overlapping, and average point density per pass are 1000m, 180 km/h, 5,000 Hz, 450 m, 87 %, and 0.2/m², respectively. The threshold values for minimum building height and area are 5m and 50m², respectively. The raw laser scanning data of the target area is shown in Figure 5.

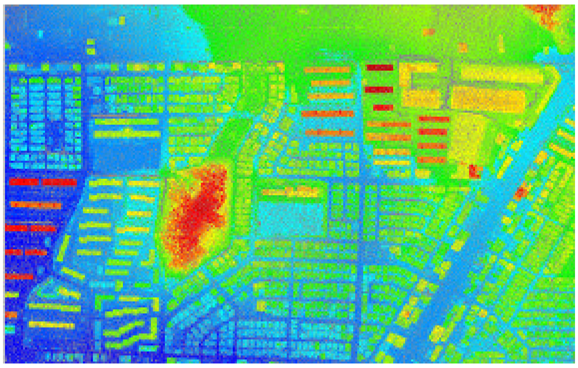

Fig. 5. Raw laser scanning data of target area.

Figure 6 and 7 show the results after noise removal, segmentation, tree removal and grouping.

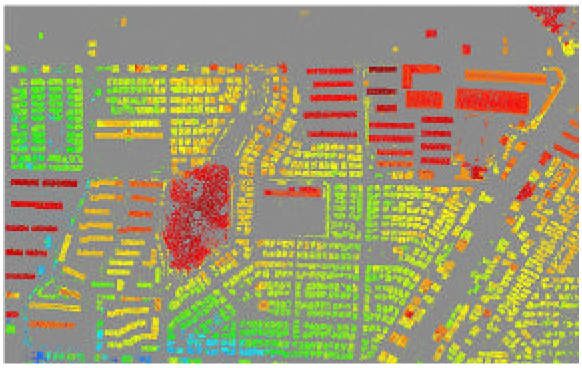

Fig. 6. Result after noise removal and segmentation.

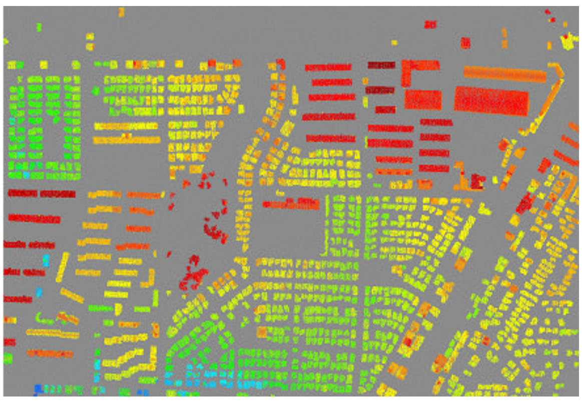

Fig. 7. Result after tree removal and grouping.

Figure 8 shows the final result for buildings extracted in 3D vector format.

Fig. 8. Final result for buildings in 3D vector format.

4. Conclusions

In this paper, we introduced a concept of pseudo-grid into raw laser scanning data to avoid the loss of information and accuracy due to interpolation as well as to define the adjacency of neighboring laser point data and to speed up the processing time. However, the proposed approach suffered from separating trees and buildings. It should be mentioned here that a simple measure such as circularity and height difference is not enough to differentiate them. In order to overcome the drawbacks, we need to incorporate new approach such as data fusion into the proposed approach. Nevertheless, we could conclude that the proposed approach is promising for building detection and extraction in automatic fashion.

Acknowledgement

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References

[1] Ahmed F. Elaksher and James S. Bethel, 2002. Building extraction using lidar data, *ACMS-ASPRS 2002 annual conference proceedings*, unpaginated CD-ROM.

[2] E.P. Baltsavias, 1999. A comparison between photogrammetry and laser scanning, *ISPRS Journal of Photogrammetry & Remote Sensing*, Vol. 54, pp. 83-94.

[3] Hans-Gerd Maas and George Vosselman, 1999. Two algorithms for extracting building models from raw laser altimetry data, *ISPRS Journal of Photogrammetry & Remote Sensing*, Vol. 54, pp. 153-163.

[4] Lee, I. and Schenk, T., 2001. Autonomous extraction of planar surfaces from airborne laser scanning data, *Proc. ASPRS conference*. St. Louis, MO, USA, unpaginated CD-ROM.

[5] Michel Morgan and Klaus Tempfli, 2000. Automatic building extraction airborne laser scanning data, *ISPRS*, vol. XXXIII, Amsterdam. Part B3, pp. 616-623.

[6] Palmer, Trent C., 2000. Urban modeling from LIDAR data in an integrated GIS environment, *ASPRS annual conference*, St Louis, USA, April 23-27.