AUTOMATIC ROAD NETWORK EXTRACTION USING LIDAR RANGE AND INTENSITY DATA

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ABSTRACT:

Recently the necessity of road data is still being increased in industrial society, so there are many repairing and new constructions of roads at many areas. According to the development of government, city and region, the update and acquisition of road data for GIS(Geographical Information System) is very necessary. In this study, the fusion method with range data(3D Ground Coordinate System Data) and Intensity data in stand alone LiDAR data is used for road extraction and then digital image processing method is applicable. Up to date Intensity data of LiDAR is being studied. This study shows the possibility method for road extraction using Intensity data. Intensity and Range data are acquired at the same time. Therefore LiDAR does not have problems of multi-sensor data fusion method. Also the advantage of intensity data is already geocoded, same scale of real world and can make ortho-photo. Lastly, analysis of quantitative and quality is showed with extracted road image which compare with 1:1,000 digital map.

KEY WORDS: LiDAR Intensity Data, Road Extraction, Feature Extraction, Digital Image Processing.

1. BACKGROUND

The road data such as geometry(width, length, direction) and positional information is very important information in CNS, Urban Planning, Control of Traffics, Management of Road, 3D GIS and Constructing of Ubiquitous. Traditionally the acquiring method of road data is based on feature extraction using photogrammerty system. This method has disadvantages which are time consuming, man-power and high pricing equipments. Recently the study about automatic road extraction is increasing according to many use of GIS(CLODE, KOOTSOOKOS, 2004). Alharthy and Bethel(2003) firstly studied simple algorithm for extraction road using intensity and 3D positional LiDAR data in small urban area. CLOODE and KOOTSOOKOS(2004) classified road points and non-road point using a hierarchical classification technique from LiDAR point cloud data and morphological filtering method is used for accurate DTM extraction and then intensity data in LiDAR is applied for road extraction in small urban area and the condition of less dense LiDAR point data. In this study the fusion method which use 3D range and intensity LiDAR data is applied for candidate road extraction from raw LiDAR data and accurate road extraction from candidate road points using advantage of digital image processing method in Daejun City data set.

2. RESEARCH CHALLENGES

The following <Figure 1> briefly shows the outline of this research. Under assumption of definition of road in this study is "homogeneous material which exist on ground point and have same correlation", All algorithms for road extraction is used. The 3D positional LiDAR data is suitable source for classifying ground point and non-ground point from raw LiDAR data. This method have bottle-neck problem for extraction road data on the ground data. Intensity data have specific character which is different intensity value according to different materials. If we know intensity value of asphalt with pebbles, it can be used in intensity filtering which is extraction candidate road points from ground points.

The <Figure 2> indicates intensity values in LiDAR data. Candidate road point is not perfect road geometry, because of non-road area extraction, lack of road point according to painting mark in the road. Therefore digital image processing method such as creating binary image,

morphological image processing(Closing) and connected component labelling recover fine more accurate road geometry from candidate road points.

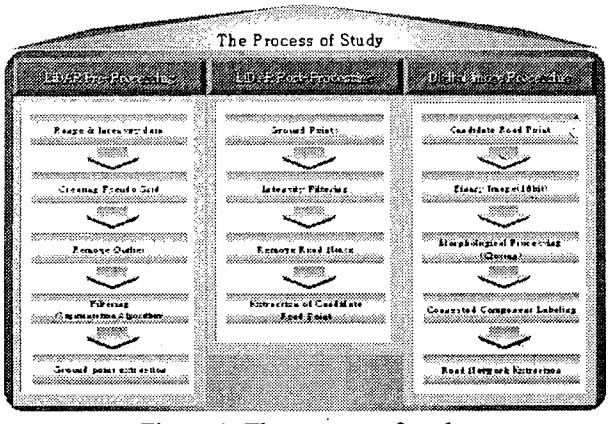

Figure 1. The process of study.

Material	Reflectivity(%)
White paper	Up to 100
Snow	80 ~ 90
Beer foam	88
Limestone	Up to 75
Deciduous trees	60
Toilet paper	60
Dry sand	57
Wet sand	41
Coniferous trees	30
Concrete	24
Asphalt with pebbles	17
Black neoprene	6

Optech

Figure 2. Intensity value in LiDAR data.

3. LIDAR DATA PREPROCESSING

3.1 Creating Pseudo-Grid

Pseudo-Grid can access quickly LiDAR point and easily treat LiDAR point. Pseudo-Grid is a regular grid shape and also contain 3D ground coordinate system LiDAR data. Using these advantages of Pseudo-Grid, it is used until Outlier remove, Filtering, Intensity filtering, Road noise remove and Binary image generation process in this study. The size of Pseudo-Grid is determined by LiDAR point density and half width of real road around 1.8m.

3.2 Outlier removal

Outlier remove process consists of high outlier and low outlier. The parameter for Outlier remove process is the user defined length of rectangular(W), user defined number of points(N) and user defined height variance(H). The principle of removing high outlier is that number of LiDAR point(H) in Pseudo-Grid smaller than user defined number of point(N). The principle of removing low outlier is vice versa.

3.3 Segmentation Algorithm

Segmentation algorithm is used for classifying ground point and non-ground point in filtering. This algorithm has the parameter which is slope difference and height difference between reference LiDAR point and around LiDAR point. The <Figure 3> displays the simple principle of segmentation algorithm.

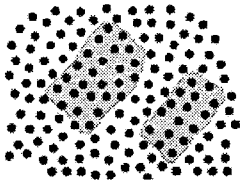

Figure 3. Segmentation algorithm.

4. LIDAR DATA POSTPROCESSING

The result of LiDAR data preprocessing is just classification ground point. As we know, road points exist on ground point. Intensity data is used for extracting candidate road points on ground points in LiDAR data postprocessing.

4.1 Intensity Filtering

Intensity filtering has two trash-hold values which are minimum intensity value and maximum intensity value. Two trash-hold parameter is determined by trial and error method, until road point is well classified by naked eye. The <Figure 4> shows the result of Intensity filtering in Daejun city.

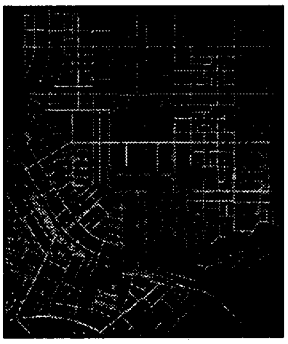

Figure 4. Result of intensity filtering.

4.2 Road noise removal

There are still non-roads points after intensity filtering, because intensity filtering just use intensity value of asphalt with pebbles. So parking lots and some areas exist around real road points. Road noise remove process use 2 parameters which are LiDAR point density and road width(1.8m). The <Figure 5> shows principle of road noise removing method. Point A is wanted real road point and Point B is non-road point.

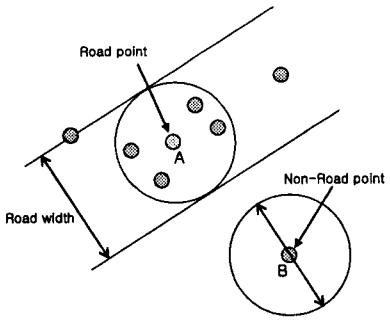

Figure 5. Principle of road noise removal.

The <Figure 6> shows result of intensity filtering which overlapped with candidate road point(white colour) and 1:1,000 digital map(red vector line). It still contains some holes in the underpass road, over-road bridge and paint marking areas on the road and breaking road line. The digital image processing method can overcome these problems.

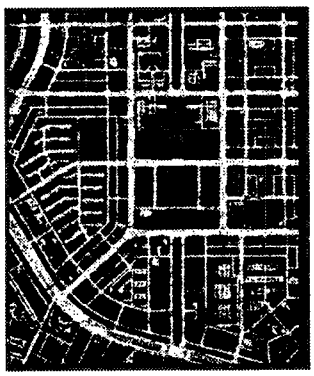

Figure 6. Candidate road point and 1:1,000 digital map.

5. DIGITAL IMAGE PROCESSING

5.1 Binary image generation

In this research, 16bit(65,535) binary image generation method is applied, because many gray values are used in connected component labeling. If road point exist in 1 pixel, that pixel have "0(black)" gray value. If any road point does not exist in 1 pixel, that picel have "65535(white)" gray value. 1 pixel size determined by LiDAR point density and real road width. In this study, 1 pixel size use 1m.

5.2 Morphological binary image processing(Closing)

In this research, the suitable structure element for closing process in korea road. The <Figure 7> shows structure element and it's mask. This study recommends that Diamond Element[5][5] is good result for korea road.

Closing method can fill holes and link breaking roads on the binary image. Dimond Element[5[5] is used three times(3m).

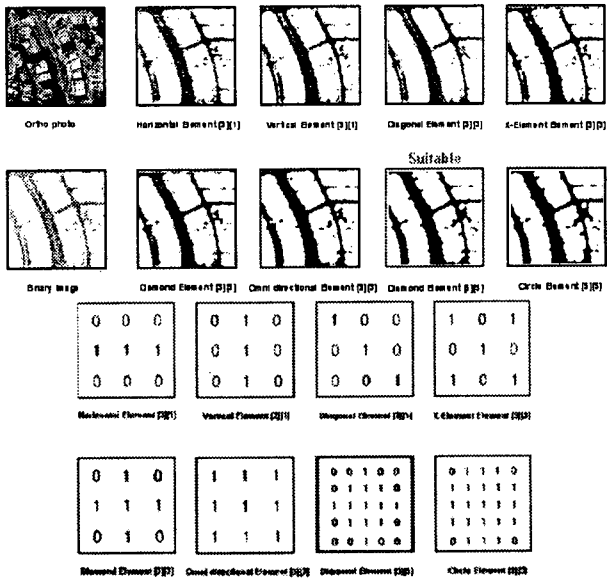

Figure 7. Structure element and mask for closing process.

5.3 Connected component labeling

In the above <Figure 7>, there are some non-road areas, if connected component labelling method can remove these garbage areas. Sequential labelling algorithm is used.

6. CONCLUSION

In this study, two LiDAR data set is used Daejun city. It is acquired by Optech ALTM 30/70 and flying date is Feb.6.2005 and Flying height is 1,300m. The <Table 1> shows preprocessing result and <Table 2> shows postprocessing result and <Table 3> shows digital image processing redult in Daejun City.

Table 1. Result of LiDAR preprocessing

	Raw data	Noise	Ground point	Non ground	Building
Point	692,414	6,328	450,521	235,565	172,111

Table 2. Result of LiDAR postprocessing

	Ground point	Intensity filtering	Road noise	Candidate road
Point	450,521	160,549	9,859	150,690

Table 3. Result of digital image processing

	Binary image	Closing	Labeling
Pixel No	1,279,471	362,958	356,901

The <Figure 8> shows that overlap with last road image between ortho-photo(above picture) and 1:1,000 digital map(below picture).

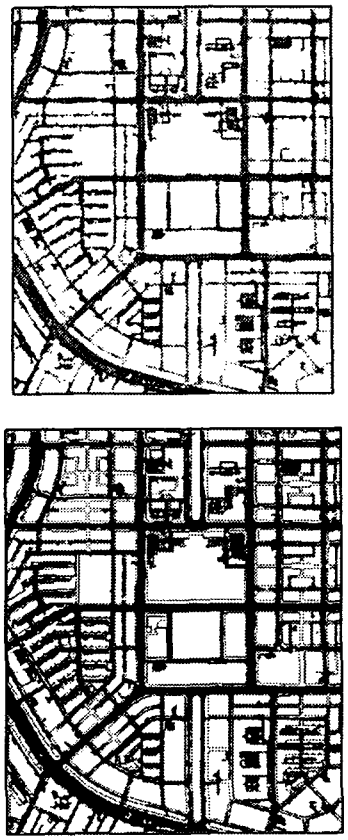

Figure 8. Final road image and 1:1,000 digital map.

This study have good quantitative result that Error of omission is 67.27% and Error of commission is 93.69%.

Compare to ATOMI project for updating automatic road extraction using high resolution aerial photo and satellite sensor image in Swiss Federal institute of technology, the result of road extraction accuracy is equal to Quick Bird(70 cm) image. Extraction road accuracy of Quick Bird image is that Error of omission is 72.68% and Error of commission is 89.58%. It expects more high road extraction accuracy using the LiDAR sensor specification is new equipment.

Future study need for perfect linking road method using building outline around parallel road lines or more suitable methods.

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