A SYSTEM DEVELOPMENT FOR DETECTION OF BUILDING ROOF PRINT IN URBAN AREAS USING LIDAR SURVEYS

Willora Mudiyanselage Mevan Nishantha Kumar Bandara
Survey Department of Sri Lanka
Photogrammetric Unit
Colombo 05.
bandara14102@alumni.itc.nl

KEY WORDS: 3D surface models, Geometry features, LiDAR data set, Orthophotos

ABSTRACT

This study identified a system for detecting building roof print within the urban area using a LiDAR data. Accurate 3D surface models in urban areas are essential for a variety of applications, such as flood simulations, tsunami damage estimations, visualizations, GIS, mobile communications, monitoring construction, etc.

The method is mainly based on two steps. First is to extract elevation at ground surface from the LiDAR data set. Second step is to extract roof top of the buildings in the area and define with polygons.

In this experiment, building shapes are automatically detected and reconstructed using a model-driven approach according to their geometry features derived from the LiDAR data set. This study was carried out for some areas in "Kalutara" District and results were compared with existing Orthophotos and found that results are more accurate and system is efficient.

1. INTRODUCTION

In urban areas, the building density is more high and very complex than other rural areas. Therefore, it has more chance for missing some buildings when they are plotted by data capturing operator. But, if there is a method to automate this task, will minimize this problem and help the plotting operator to reduce the time consumption for that tedious job.

One of the most important tasks of using LiDAR data is automatic extraction of buildings from LiDAR point cloud. The processing of airborne LiDAR data for automatic extraction of building regions has been a hot topic of research in photogrammetry for the last two decades. (Hu & Ye 2013)

Detecting buildings directly from the raw LIDAR data is not a straightforward problem. This is due to the ambiguity of other vertically extended features which are not buildings in the raw data. Filtering "noise" such as trees and other extraneous objects facilitates the detection of building footprints and consequently the reconstruction procedure.(Alharthy & Bethel 2001)

The more same approaches which was related to this research paper was developed and already implemented with more resource usage. LiDAR data fusion with satellite images can be more precise when extracting complex data. One of very similar research is "New methodologies for precise building boundary extraction from LiDAR data and high resolution image" by Hui Li. (Li et al. 2013). It was created more sophisticated output than many other alternative methods. But this method needs both LiDAR data and satellite data with high accurate geo referencing background.

This LiDAR data processing for DEM generation, the critical step is to correctly separate this LiDAR points into ground and non-ground. This non ground points can be either on natural object or manmade object. Buildings are classified to this manmade objects.

2. RASTER BUILDING GENERATION

i. Create the raster using "last return point cloud data". (low)

ii. Create the raster using "first return point cloud data". (high)

iii. Create the raster using "classified ground point cloud data". (grnd)

- high-low gives the total height differences from first return to last return

veg_pat[*]= iff((high-low)<**0.3**[**]**,**grnd,high)

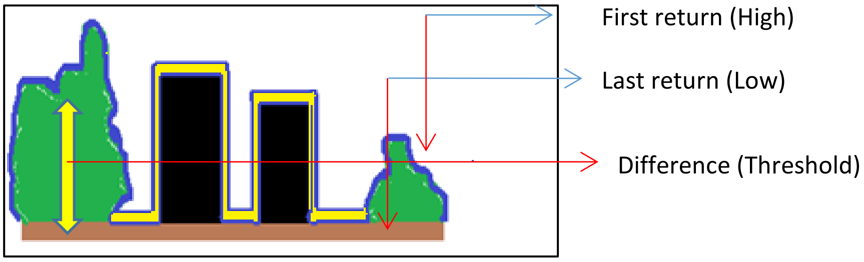

Figure 2.1: First return and the last return

- After this process was completed, then the bare filled (roofs/roads etc.) surfaces were classified as ground and unfilled rough surfaces are classified as vegetation patches (Eg. "veg_pat" raster data set).
- Then we have both "High" and "veg_pat" raster files, and the difference is the building/ structure class region ;

building_area = high – veg_pat

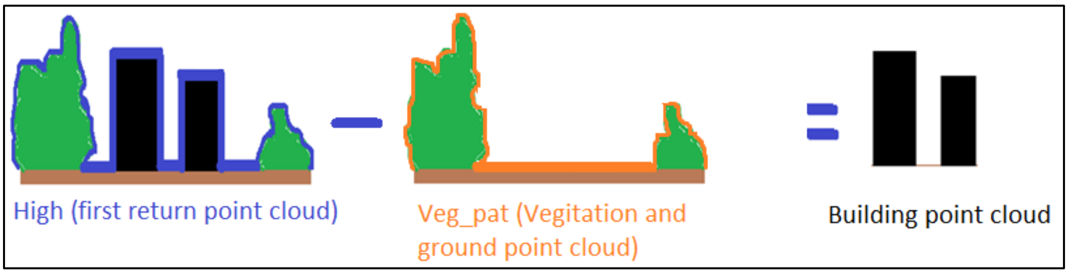

Figure 2.2: Building extraction process

3. NOISE REMOVAL

In this case, it was used the Median filter to remove the noise and the output is reasonably satisfied. It was implemented using as below.

Build_Noise_rem=MapFilter (build1.mpr, Median (3,3))

4. BUILDING VECTORIZATION

Before, the vectorization process to be done, it is suitable to make density slicing.

cut_raster=iff(Build_rem_noise<1,0,255)

The outcome was very clear and crisp. Therefore the vectorization process is easier to perform.

---

veg_pat[*]**:** Vegetation patterns/ Building roof prints are identified using low, high and grnd raster data sets.
Threshold Value - 0.3[**]**:** This is not fixed value and it depends with many factors (location, point density, LiDAR footprint size, etc.). Therefore, it is used by creating many trial and error image creation method and found the most suitable value for this study area.

5. SIMPLIFY BUILDING POLYGONS

After the vectorization process done, the smaller polygon areas to be removed. In that case, less than 30 m^2 areas were removed. The vegetation patches were removed and clean building region can be seen at last.

6. ACCURACY ASSESSMENT

This accuracy was assessed by two different ways. They were, accuracy of specific DEM and the accuracy of the building identification.

6.1 Accuracy assessment of the DEM

- First, assessment was done by field verification method. Some samples points were settled on the low vegetation cover and very few of them were penetrated to the ground. Those areas were checked and reprocessed to extract the correct DEM.
- Finally, the accuracy of that sample area was identified as two categories. First is the accuracy of bare land and the accuracy of vegetation cover.
- The accuracy of the bare land was within 5cm and the accuracy of vegetation cover was within 25 cm.

That above figures were given by JICA team (After the field surveys), therefore, the complete documentation was hard to describe in this section.

6.2 Accuracy assessment of the building identification

- In this part, the total study area was 400000 m^2 and very thick vegetation cover was in that area.

Table 6.2.1: Accuracy assessment of buildings

Building/ Vegetation +other	Buildings	Total Accuracy
Buildings	27	27/30 X100 90 %
Vegetation+other	3	
Total	30	

Table 6.2.1 shows that 27 buildings are identified as buildings and 3 vegetation patches are identified as buildings. Therefore, 90% accuracy is achieved both identifying correct building patch and remove vegetation or other patches with this process.

Following figure 6.1 shows the correct identified buildings in yellow colour and false building identification for vegetation patches in white outline.

Figure 6.1: Final visualization of the building layer

7. RESULTS AND DISCUSSION

In this sample 90% of buildings are identified as buildings. But few buildings' shapes are somewhat different than the real ones due to tree canopies and other obstacles. This output can be easily used with Survey Department data as this output is in SHP format. This file format is more advanced vector file format for mapping projects.

- First results shows the thresholding value extraction from the suitable raster outcome.
  This output results are in raster format.
- Second result shows the processed outcome using this threshold value.
  This output results are in raster format.
- Third result shows the noise removal outcome.
  This results are also in raster format.
- Fourth result shows the vectorized image outcome.
  This results are in vector shape file format.
- Fifth result shows the simplified vector image outcome.
  This final results are also in vector shape file format.

8. CONCLUSION AND RECOMMENDATION

According to the above mentioned results, it is clear that methodology is fine. And the accuracy of identifying the buildings and its orientations are also good. But in some cases, inside parts of the buildings are removed. The reason for that is, if the gap of the building roofs are high then the first hit and the last hit is having high difference, then this algorithm identifies this gap occurs due to the vegetation region and removes that area. Some parts of the buildings are covered with trees and remove the correct shape of that buildings.

After thorough experiments, it is conducted that:

- The registration results are accurate and reliable.
- Filtered ground points has good quality, without missing or redundancy.

- Not all but 90% trees and other clusters which bigger than few grids are detected, and points of walls and other walls like structures are eliminated.
- Detected edges exactly locate at real building boundaries, and statistics show the detection correctness is high, and the detection completeness is 90 percent.

According to the above results,

The applicability of LIDAR data for creating 2D vector building boundary shapes,

The differentiation of buildings from other features using 1st and the last hit of LiDAR data set

and

The method to detect building boundary are successful.

This method has some limitations which was mentioned in third chapter, can be minimized by using a very fine filter and building reshaping algorithm implementation for remove the irregularities of building polygons.

But this outcome is checked with the data visibility in 1:10,000 scale map and it is fine with other small scale mapping projects.

In future, it can be implemented a fine filter and reshaping algorithm to fulfill this problem too.

REFERENCE

Alharthy, A. & Bethel, J., 2001. HEURISTIC FILTERING AND 3D FEATURE EXTRACTION FROM LIDAR DATA.

Esri, A. & Paper, W., 1998. ESRI Shapefile Technical Description. , (July).

Hu, X. & Ye, L., 2013. A FAST AND SIMPLE METHOD OF BUILDING DETECTION. , II(May), pp.7–13.

Li, H. et al., 2013. New methodologies for precise building boundary extraction from LiDAR data and high resolution image. , 2, pp.157–165.