EXTRACTING COMPLEX BUILDING FROM AIRBORNE LIDAR AND AIRBORNE ORTHIMAGERY

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ABSTRACT: Many researches have been tried to extract building models and created a 3D cyber city from LiDAR data. In this paper, the approach of extracting complex building by using airborne LiDAR data combined with airborne orthoimagery has been performed. The pseudo-building elevations were derived from modified discrete return LiDAR data. Based on information property of the pseudo-height, building features could be extracted. The results of this study indicated the improvement of building extraction.

KEY WORDS: LiDAR, building extraction, Normalized Digital Surface Model (NDSM)

1. INTRODUCTION

Nowadays, there are several applications based on Light detection and ranging (LiDAR) technology which can provide 3D spatial information for urban planning and ubiquitous city studies. The application of LiDAR data becomes increasingly popular and helpful for cyber city modelling. In those applications, to build 3D models for city is still a lot of work to be done. The first task that is the extracting the building boundary. Extraction of buildings using LiDAR data can be solved the problem of shadow that most of spaceborne images data did not solve that. Because of LiDAR data is not dependent on energy from the sun. In other words, it was active remote sensing. There are several approaches has been developed over past 10-year. Park *et al.* (2006) has proved the method of automatic extraction of large complex buildings using LiDAR data and digital map. Tarsha-Kurdi *et al.* (2006) described a new approach for detecting building in an airborne LiDAR point cloud, using exclusively the first echo. Kim and Habib. (2007) showed a significant technique for planar patch segmentation using airborne laser data. In addition, Nobrega *at al.* (2006) also recommended segmentation and object extraction from anisotropic diffusion filtered intensity data. And Chikomo *et al.* (2007) performed an integrated approach to level-of-detail building extraction and modelling using airborne LiDAR and optical imagery. However, all of those researches are tried to extract buildings that were high and large sizes.

2. METHODOLOGY

A feature of LiDAR data is usually contained at least three parameters: longitude (x), latitude (y) and height (z). The x and y values are important and could not be changed for establishing 2D map. Our theory is that changing value of the buildings is independent on changing shapes of buildings. That corresponds to the observing a building from the sky, shapes of the building will not change when the point of the view has height value changed.

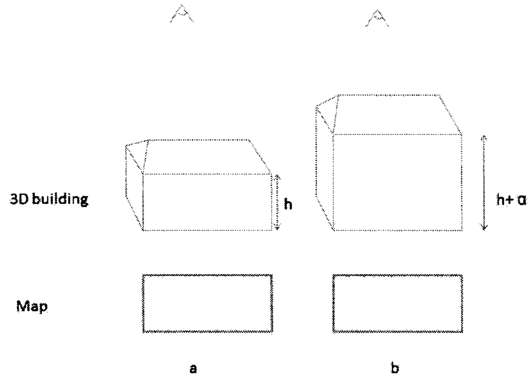

Figure 1. The model display for proposed idea.
(a: 3D building and 2D in the map, b: 3D building and 2D in the map after added height)

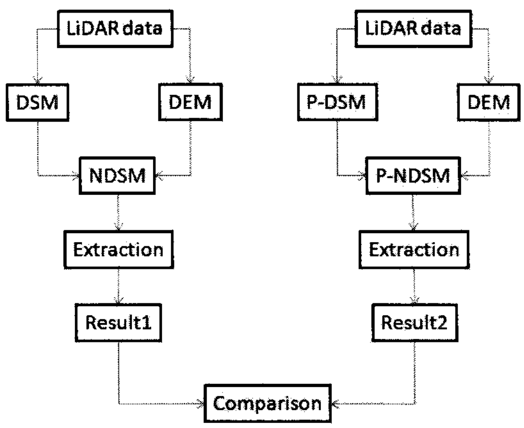

Figure 2. Flowchart of data processing.
(P-DSM: Pseudo-Digital Surface Model,
P-NDSM: Pseudo-Normalized Digital Surface Model created from P-DSM and DEM)

As the framework shown in Fig 2, the proposed extracting approach includes four main stages that are comprised of pre-processing input data, created Digital Surface Model (DSM), Digital Elevation Model (DEM) and created Normalized Digital Surface Model (NDSM), and extraction and comparison.
The aerial digital imagery data were also used for the extraction. The point density is 3.329 point/m^2. And the spatial of the aerial images is 0.25m. The LiDAR data were geometrically corrected by the aerial othoimages. Then LiDAR points around and inside each building boundary are extracted by using the height of points compared with the ground. We also removed some noisy points as low points and high points.

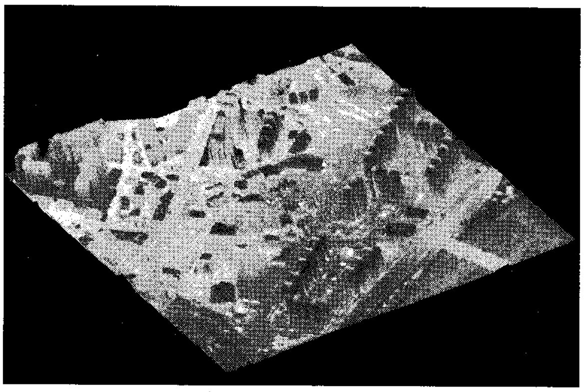

Fig.3: DSM - 3D view

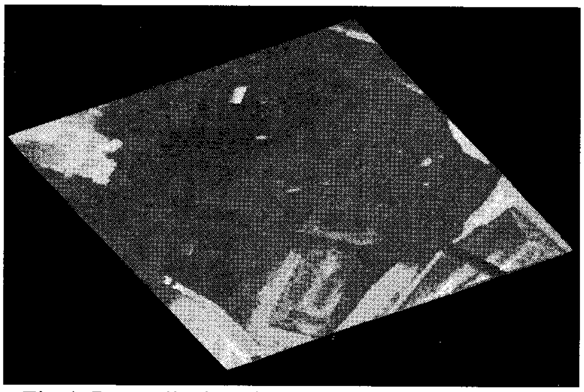

Fig.4: DEM displayed as 3D discrete points elevation.

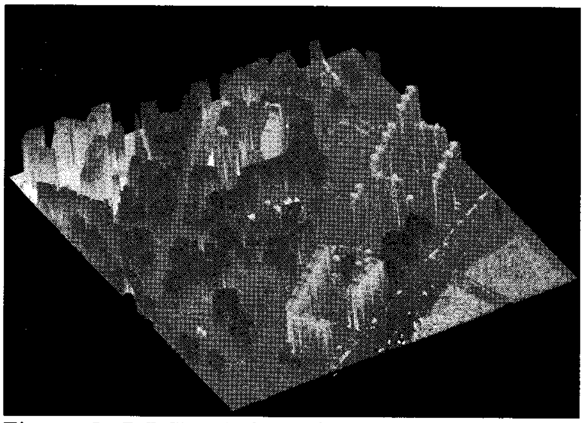

Figure 5. P-DSM (DSM after building elevation was increased 50m)

DSM is topographic elevation models of the earth's surface that provide a geometrically correct reference frame over which other data layer can be draped. The DSM data includes buildings, vegetation, and road, as well as natural features. In DSM creation processing, these factors have been categorized into four separate classes: building class, tree class, ground class and remain feature class. The classification is based on characteristics of LiDAR data combined with aerial imagery using a commercial Terrascan and Terraphoto software.

DEM is digital representation of a portion of the earth's surface, derived from elevation measurements at regularly space horizontal intervals. A bare-earth DEM is void of vegetation and man-made features.

NDSM. LiDAR is an optical remote sensing technology that measures properties of scattered light to find range and other information of a distant target. The prevalent method to determine distance to an object or surface is to use laser pulses. Information we get from ground is LiDAR returns consist first return and last return. First return related with the reflection of features on the ground as building, tree, etc. And last return related with the reflection of surface ground.
LiDAR data provided us the value of absolute height of the points this causes difficulties for the process of sorting later. The information about the coordinates of the points may overlap with information of the surface of the height, so it is hard to classify. The creation of NDSM makes a comparison the height of the points with the surface, this method should be effective in sorting process and in obtaining information of the objects simultaneously.

NDSM = DSM – DEM

Figure 6. NDSM

After creating NDSM, we conducted to extract building using feature extraction tools (ENVI 4.5 software). The results showed high rise buildings will be extracted better than others. Some low rise houses and complex houses have been omitted in the process extraction.

Figure 7. The results of extracted building from NDSM.

The DSM and NDSM were modified throughout determining pseudo elevation to the building class.
The assignment of false elevation for building class has conducted by using MS Excel software.

Figure 8. P-NDSM (NDSM created from DSM added 50m)

The result after extraction from P-NDSM proved that almost building, particularly, low rise and complex houses have been extracted.

Figure 9. The extracted building from P-NDSM

3. RESULTS

The percentage of high-rise buildings that are extracted correctly is 100% from NDSM and 100% from P-NDSM whereas 55.29% of the houses, low-rise building are extracted correctly from NDSM, 9811.82% from P-NDSM and the total accuracy are 62.74% from NDSM and 99.03% from P-NDSM respectively (Table 1).

On the real world, there are so much complex building with many part of building have different elevation, therefore some low-rise building and houses are already extracted, but just a part of complex building has high elevation was extracted. In comparison with result, they did not count because they were not complete buildings. In addition, the distances among buildings are very close, so even if it has increased the height up to a limit, that it was still close to each other. In extraction process, the buildings connecting each other will be extracted into an object.

Table 1. The comparison of NDSM results with NDSM added 50m results.

Type	Original building foot prints	Building extracted from NDSM and percentage	Building extracted from NDSM added 50m and percentage
High-rise buildings	19	19 (100%)	19 (100%)
Houses, low-rise building	85	47 (55.29%)	84 (98.82%)
Total	104	64 (62.74%)	103 99.03(%)

4. CONCLUSION

This paper presents alternative procedures for extracting complex buildings using LiDAR data and aerial imagery. In general, building footprints have extracted from NDSM, but some low rise house and complex building were lost when the extraction of the processing. More specifically, this paper proposed the approach for extracting building based on the assignment false height value for building class.

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