COMPARATIVE ANALYSIS OF BUILDING CHANGE DETECTION USING AERIAL IMAGERY AND LIDAR DATA

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Abstract: Updating of building models may be achieved by two approaches: reconstructing buildings for the entire area, or only updating parts of the areas where there were changes. The reconstructing is to re-map the entire area through a standard mapping procedure. It is costly and time consuming. The alternative is to only update the ever changed areas followed by a reconstruction procedure. Thus, detection of building changes becomes an important task. Commonly used data for building change detection include aerial images and Light Detection And Ranging (LIDAR) data. This paper compares the performances of change detection from different data. For the same test area, we compare the building change parts by (1) only using aerial images, (2) only using LIDAR data, and (3) using both data sets. Building change detection is based on the discrepancy between 3D point clouds from new data set and old building models with spectrum information of images. In the case using aerial images only, image matching is employed to generate 3D point clouds. LIDAR data provide height information. Thus, LIDAR can compares with building models directly. For the case with both data, the 3D shape information in LIDAR is used for change detection with the spectrum information in images. Experimental results indicate that using both data can achieve the highest accuracy.

1. INTRODUCTION

The three dimensional building models are widely used in GIS applications, such as city planning, disaster prevention and rescue, tourism and etc. (ViewTec, 2012). Considering the rapidity of urban growth, the 3D building models are needed for updating. Updating of building models may be achieved by two approaches: reconstructing buildings for the entire area, or only updating parts of the areas where there were changes. The reconstructing is to re-map the entire area through a standard mapping procedure. It is costly and time consuming. The alternative is to only update the ever changed areas followed by a reconstruction procedure. Thus, detection of building changes becomes an important task. Thus, building change detection is become an important issue.

Conventional change detection is usually done using multi-temporal images through the spectral analyses (Ceresola et al., 2005). Those images provide 2D spectral information without including 3D shape information. Some researches employed Light Detection And Ranging (LIDAR) data (Girardeau-Montau et al., 2005; Murakami et al., 1999), aerial imagery (Jung, 2004) or integrated data set (Chen and Lin, 2010) for building change detection with 3D shape information. According to those researches, it's obvious that commonly used data for building change detection include aerial images and LIDAR data. Compared with imagery, LIDAR data provide accurate height information directly. The accuracy of height information for imagery is depended to the quality of image matching, converging geometry etc. On the other hand, imagery provides plentiful spectral information such as color and texture. LIDAR data are less the characteristics than imagery. Both of two kinds of data have their own advantages and disadvantages. Thus, this paper aims to compare the performances of change detection from different data. For the same test area, we compare the building change parts by only using aerial images, only using LIDAR data, and using both two data.

2. METHODOLOGY

There are three cases for building change detection, namely (1) only using aerial images, (2) only using LIDAR data, and (3) using both data sets. The major works contain data pre-processing and change detection. In this study, building change detection is based on the discrepancy between 3D point clouds from new data set and old building models. LIDAR data provide height information. Thus, the LIDAR point clouds can compares with building models directly. It needs to perform the image matching to generate 3D point clouds in the case only using aerial images. In addition, the vegetation areas could result in wrong detection (Knudsen and Olsen, 2003). The spectrum information in images is also used for vegetation areas detection. In the data pre-processing part, image matching and vegetation area detection are implemented for images hence. The workflow is shown in Figure1. The details of each step are given below.

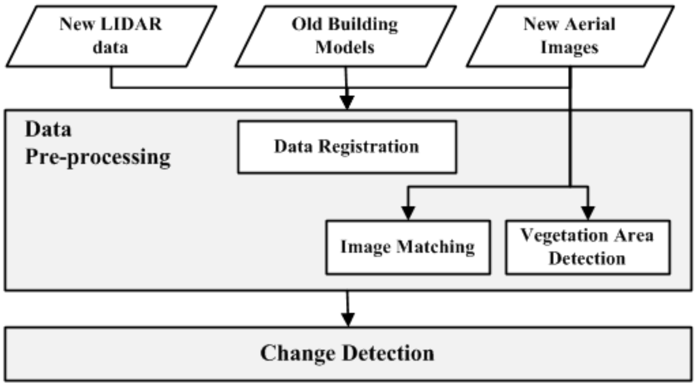


Figure 1: Workflow of the propose scheme

Data Pre-processing

In data pre-processing, the steps include data registration, image matching and vegetation areas detection. Firstly, we register the LIDAR data, aerial images and building models. After selecting mapping functions, control points are measured to register the three data sets in the same coordinate system. In this investigation, three shifts are employed as mapping functions for X, Y, and Z directions. Image matching is employed to generate 3D point clouds for the case only using aerial images. In this study, we used the ERDAS IMAGINE to perform image matching. And the vegetation areas are detected by the Normalized Difference Vegetation Index (NDVI). We build up the vegetation indexmap through the NDVI and the setting threshold for change detection.

Change Detection

For the performances with aerial images, the first step is to exclude the 3D point clouds which are located in the vegetation area. The case only using LIDAR data is employed all point clouds for change detection. In this study, the height differences between the 3D point clouds and building models is the change information. We use these information to detect each building model is change or not. Each 3D point will be discriminated change or unchanged points by a height difference threshold. Then we calculate the number of changed point in each building model. The change detection using the percentage of change points in each building model to detect whether is change or not. Figure 2 shows the workflow of the change detection for the cases with aerial images.

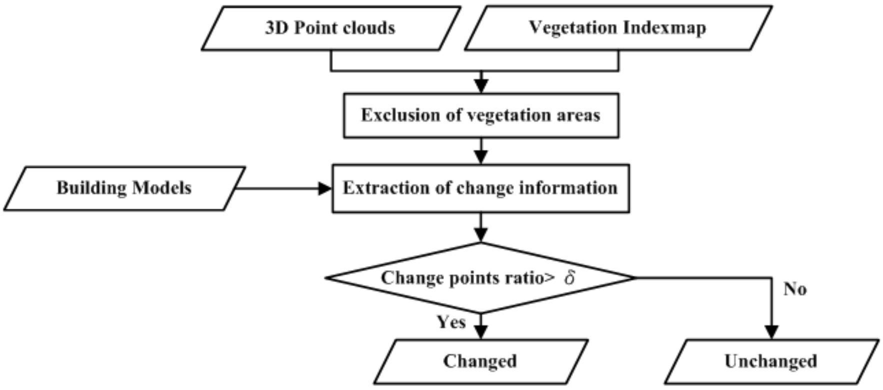


Figure 2: Workflow of the change detection for the cases with aerial images

3. EXPERIMENTS

The test site is located at Taipei of Taiwan. The building models are reconstructed in polyhedron form by aerial images in 2002. LIDAR data and aerial images are acquired in 2011. The LIDAR point clouds were acquired by a Optech ALTM Pegasus with a density of 10 pts/m^2. And the images are the Digital Mapping Camera II (DMC II) images with about 10 cm spatial resolution. Figure 3 shows the test area and the building models. We compare the building change parts of Case **1 (only using LIDAR data)**, Case **2 (only using aerial images)**, and Case **3 (using both two data)**.

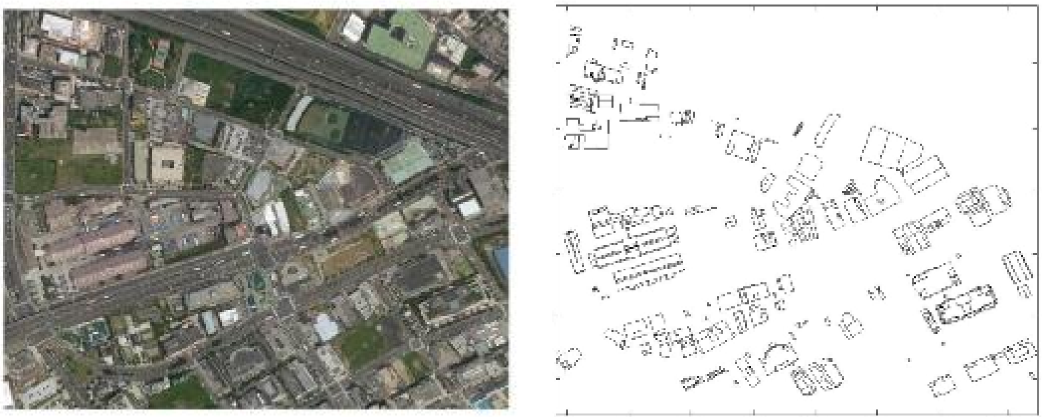
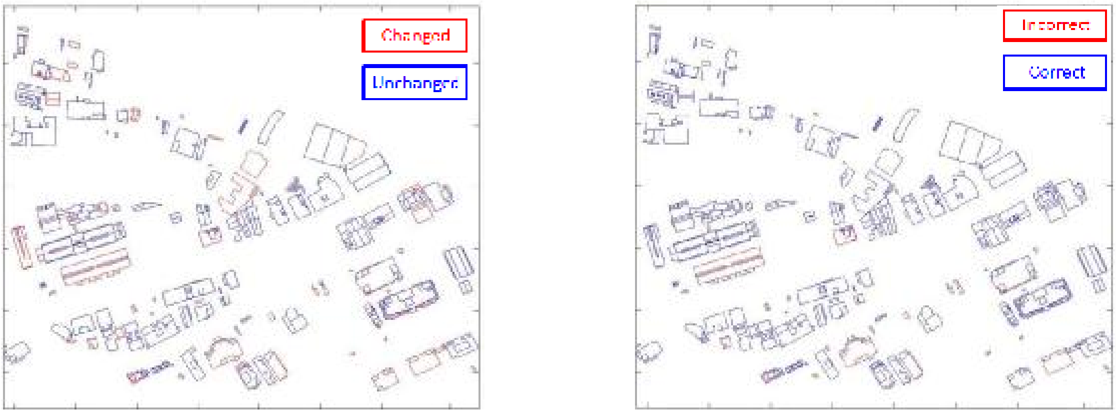


Figure 3: Test area and the old building models

Figure 4 to Figure 6 show the detection results with different data sets, individually. And the corresponding error matrices are shown in Table 1. The overall accuracy of the Case 1 is 91.32%. Case 2 is the worst results with 81.92% overall accuracy. The case with both data sets has the best result. The overall accuracy is more than 93%. Although the images provide the spectrum information for excluding the vegetation area, the most important factor is the height differences between the 3D point clouds and building models in the proposed method. This means that the LIDAR data has a better advantage than images because of the accurate height information.

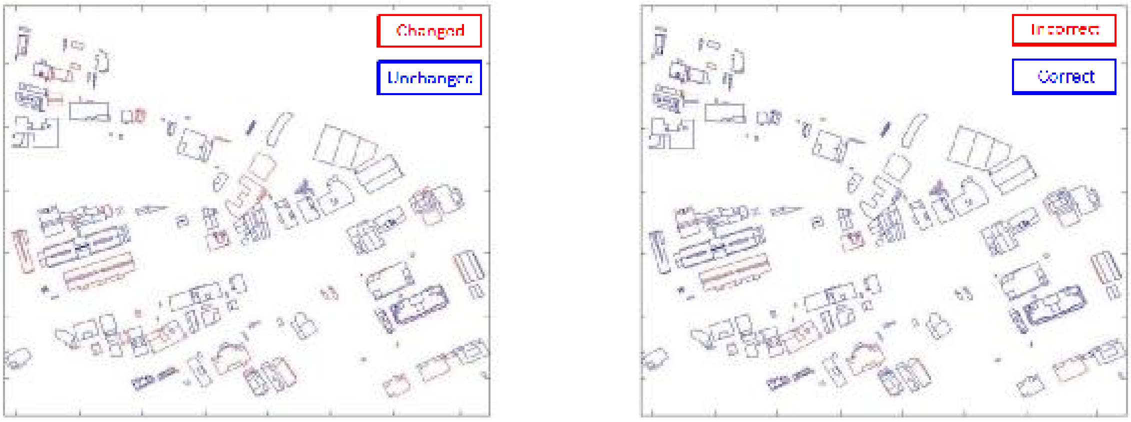
Table 1: Error matrices of three cases' detection results

		Case 1 Detection Results			**Case 2 Detection Results**			**Case 3 Detection Results**		
		Unchanged	Changed	Total	Unchanged	Changed	Total	Unchanged	Changed	Total
Reference data	Unchanged	358	29	387	351	36	387	367	20	387
	Changed	17	126	143	28	115	143	16	127	143
	Total	375	155	530	379	151	530	383	147	530
Overall accuracy (%)				**91.32**			**87.92**			**93.21**
Omission error (%)		7.49	11.89	9.69	9.30	19.58	14.44	5.17	11.19	8.18
Commission error (%)		4.53	18.71	11.62	7.39	23.84	15.61	4.18	13.61	8.89



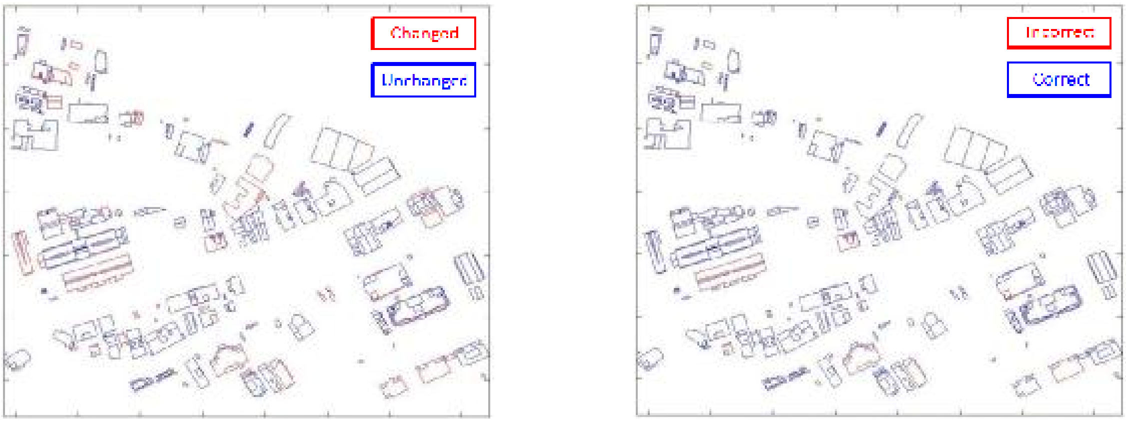
(A) change detection (B) evaluation

Figure 4: The results in Case 1



(A) change detection (B) evaluation

Figure 5: The results in Case 2



(A) change detection (B) evaluation

Figure 6: The results in Case 3

4. CONCLUSIONS AND FUTURE WORK

This investigation compared the performances of building change detection from different data sets. The experimental results indicate that using both of LIDAR data and imagery can achieve the highest accuracy. It also shows that the spectrum information could improve the results of building change detection. However, it might be incorrectly classified when the roofs are occluded by the vegetation canopy. In the future work, it will include texture information to enhance the change detection method. In addition, it only detected the changes of building models in this study. It should be considered that the new added building area in the change detection.

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