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Automatic Building Change Detection and 3D Map Generation Using Multispectral Imagery and Height Data

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Original Research Article

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Abstract: Automatic building change detection required for metropolitan and urban planning , industrial city planning, road and highway planning, unauthorized construction detecting, stopping any new construction on risky or highly dense areas, planning for homeland security etc. This research proposal aims for automatic building change detection and 3D map generation using multispectral imagery and 3-dimentional height data. The goal for this research proposal is to detect building changes with precise geometric accuracy and use the detected building changes data to generate 3D building map. High resolution aerial and satellite imagery and highly dense height data from LIDAR can detect building change and can generate an accurate up-to-date 3D building map.

Keywords: Automatic building change detection, 3D map, 3-dimentional height data, LIDAR.

INTRODUCTION

Automatic building change detection and semi-automatic update of building map is very useful for getting an up-to-date 3D building map. It can be possible using multispectral imagery and highly dense height data detected by 3D LIDAR Scanner. 3D LIDAR can scan 360 degree field of view at high resolution and with a high frame rate. For example Figure 1 shows Velodyne HDL-64E LIDAR scanner [1] which has the capability of 3D scanning with 360 degree field of view (FOV) at a high resolution with 1.3 mpps and with 5-15 Hz high frame rate.

3D LIDAR collects 3-dimentional data with accurate dense 3D points. This 3D points can be combined together to generate a 3D point cloud. Figure-2 shows a highly dense 3-dimentional building image collected using 3D-LIDAR [2]. Data collected from several angle of the building can combine together to generate a 3D point cloud.3D-LIDAR can detect the buildings changes and vegetations more accurately and effectively. However to get accurate breaklines information we can combine high resolution multispectral aerial and satellite imagery with the 3D-LIDAR data for detecting building change [3]. Aerial and satellite imagery can provide more accurate data for building region and texture information. So the combination of 3-dimentional data from LIDAR and multispectral aerial imagery from satellite can provide accurate and effective data for constructing 3D-map.

Fig-1: Velodyne HDL-64E LIDAR

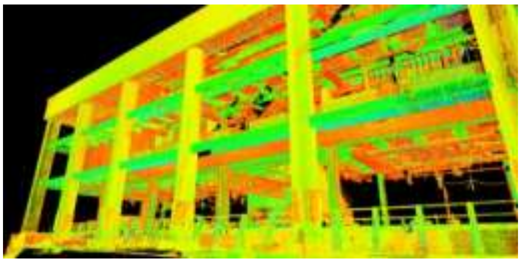

Fig-2: 3-dimentional data of a building collected by 3D-LIDAR

Automatic Building change detection is useful for the map user because due to modernization of metropolitan,urban areas and rural community everywhere new buildings are making, demolishing or changing existing buildings so, automation of building change detection and automatic updating of building map database helps to get an up-to-date 3D building map. This technique can reduce manual digitizing, time-consuming manual updating of map database, human error, searching and updating any changed objects. Automatic change detection of buildings can be used for metropolitan and urban planning , industrial city planning, road and highway planning, unauthorized construction detecting, stopping any new construction on risky or highly dense areas, planning for local security. Identification of building changes also help to take any precautions or issue warnings for any upcoming natural disaster (e.g: earthquake, tsunamis, floods etc.) to save live and minimize the loss of properties. In the year of 2012 there ware approximately 905 natural disasters in worldwide and most of them (93%) was weather-related disasters (e.g: floods, storms, earthquakes, volcanic eruptions, wildfires etc) and the loss of property was US$170 billion [4]. During any disaster Automatic building change detection can help the local authority or government to immediately identity the affected areas and plan for a quick rescue operation. Moreover after the disaster the authority can estimate the loss of property and resettlement plan for the effected people. Due to the enormous benefits of Automatic building change detection its generates huge interests to the researchers, mapping organizations and government authorities and others on this field.

High resolution aerial and satellite imagery and highly dense height data from 3D points cloud can be used for automatic extraction of different construction such as roads and highways, buildings, market places, play ground etc over a large geographic area within short time. Multispectral image can provide good horizontal accuracy for building detection and 3D height data can provide good vertical accuracy for building detection. so, using the combination of both technique it is possible to achieve the desired goal. High resolution aerial imagery can be captured using survey aircraft or from satellite using high regulation sensors. Normal aerial surveys can capture full stereo mapping capability (60%-80% forward overlap between images and 30% side overlap) which generates high degree of accuracy [5]. Satellite image can be captured by earth observation satellites for a large geographical area. 3D LIDAR can be used to measure distance, speed, rotation and chemical composition and concentration of any clearly defined object such as buildings, vegetation and others constructs. 3D LIDAR scanners can be ground based and can be used to generate 3D models for the objects by emitting pulses of light [6].So High resolution aerial and satellite imagery and highly dense 3D height data from 3D LIDAR can detect building change and can generate an accurate up-to-date 3D building map.

Previous Studies

M. Awrangjeb *et al*., [7] shown in his recent work that a high 2D building detection rate (DR) on Australian data sets including Fairfield (NSW, DR = 95%), Mooney Ponds (Vic, DR = 94%). His building change detection technique can be used for city planning, homeland security and disaster management. He used LIDAR data and multispectral imagery for building change detection. His method shows that the primary building mask derived from the LIDAR data and the final building position are obtained by extending the initial building position based on color information. This two masks ensure the accurate delineation of the buildings. So, the proposed technique can detect rectilinear buildings of different shapes with a high success rate.

Txomin Hermosilla *et al*., [8] used High resolution images and LIDAR data for automatic building detection in his article. He used Thresholding-based and object based classification approach for building detection where imagery and three-dimensional information is available. Quality assessment has been performed at two different levels (area and object). Area-level evaluates the building delineation performance and object-level evaluates accuracy in the spatial location of individual buildings.

Leena Matikainen *et al*., [9] shows a methods for automatic detection of building changes using laser scanner from airborne and using digital aerial image data and show the potential usefulness of the methods. She experiments through 5 km^2 suburban area and shows that 96% buildings larger then 60 m^2 detected correctly in her building detection method.

Thomas Knudsen *et al*., [10] shows an approach for automate change detection using an algorithm inspired by the specific problem of updating the Danish National Topographic Map Database (TOP10DK). Their algorithm uses vector and spectral data as input to an unsupervised spectral classification method which controls a subsequent Mahalanobis classification step. For evaluation they present four test cases based on the TOP10DK database in combination with RGB and color-infrared (CIR) aerial photos. Their experiment shows that RGB photos are barely sufficient for change detection where CIR data gives more accurate and satisfactory results.

Xiangyun *et al*., [11] proposed an algorithm for building extraction using airborne LIDAR data which has three key steps Ground Filtering, Scan Line Segmentation and Object Based Classification. This is a simple and first algorithm to separate points of the building roofs from variegation points after filtering of the point cloud. Based on scan line segmentation and simple rules based classification of the segments it can detect roof points effectively and efficiently. Their proposed method can be used for first detection of buildings. Their proposed algorithm can extract building regions effectively.

M. Awrangjeb *et al*., [12] proposed a new algorithm for automatic segmentation of raw LIDAR data using ground height from a DEM (Digital elevation model). In this algorithm the raw LIDAR points are separated into two groups, first group contains the ground points which forms a building mask and the second group contains non ground points which are clustered using the building mask. The proposed method shows that it can successfully remove vegetation and offers a high success rate for building detection (90% correctness and completeness).

Fei Deng *et al*., [13] proposed an algorithm framework for building recognition in urban area with LIDAR data and image sequence. They used multispectral information provided by color aerial image and geometric information from a laser scanned DSM. They applied a homologue line matching based on geometry constraint for automatically getting the corresponding line features in multi target images. They also shows a integrated step to 3D model reconstruction by multiple data source based on probabilistic approach.

METHODOLOGY

Methodology of the building change detection and 3D map generation is based on input of high resolution aerial image, highly dense 3-dimentional data from 3D-LIDAR. 3-dimentional data represents all the objects in the earth's surface. Building extraction and representation will be based on 3D building detection. Building changes will be detected based on the differences between existing building map and new extracted building information. Existing building map will be updated based on the new extracted building change information. Fig-3 shows the methodology of building change detection.

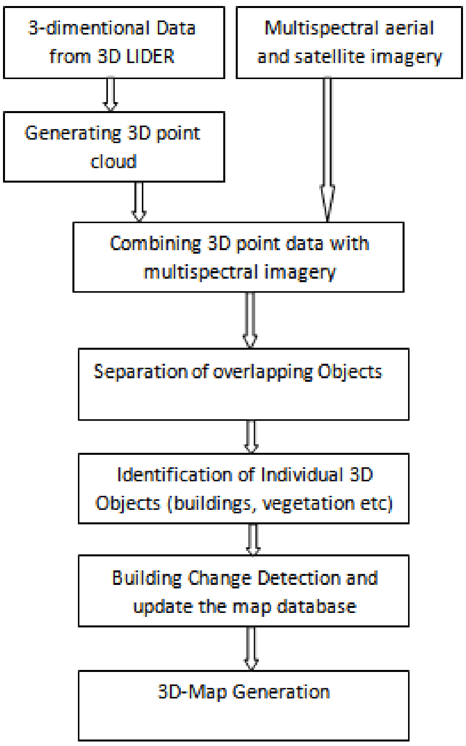

Fig-3: Methodology of Building Change Detection

The proposed methodology of building change detection and generation of 3D building map has several steps such as,

- 3 dimensional building change data collected using 3D LIDAR
- Generating 3D point cloud
- Multispectral aerial and satellite imagery collected using satellite sensor
- Combining 3D point data with multispectral imagery
- Separation of overlapping Objects
- Identification of Individual 3D Objects (eg. buildings, vegetation etc)
- Building Change Detection and update the map database
- 3D-Map Generation

Building Detection algorithm [14] can be used to detect the final building. Building detection algorithm includes several steps such as mask generation, line extraction, classification of building based on color, height and entropy, selecting candidate buildings, separate the trees and buildings using texture and regular pattern. After building detection its required to extraction and representation of the building using 3D information. 3D polyhedral building model [15] can be used to identify different building planes. Each building plane will be represented by unique data structure of a 3D polyhedral building model. When the proper representation of extracted building and existing building are available the we can use a matching algorithm to identify the new, demolished, changed and unchanged buildings. Building change map database can be updated using the result from matching algorithm. May be a minimal manual intervention will required to finally update the building map using computer software (eg:Barista Software) to avoid any erroneous update. Finally, we can generate a accurate 3D building map using the map data from the building change map database.

CONCLUSION

In this Research Proposal I discussed a technique of Automatic building change detection and generation of 3D building map using multispectral imagery and highly dense 3D height data captured using 3D LIDAR. Combining high resolution aerial multispectral image and 3D height data it is possible to achieve more accurate data to identify building changes and generate 3D building map. Extracted data of building change can be comparing with the existing 3D map database and can be update the database semi-automatically with the new extracted 3D data. So, finally an up-to-date 3D building map will be available.

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