Change Detection of Buildings Using High Resolution Remotely Sensed Data

YU ZENG, JIXIAN ZHANG, GUANGLIANG WANG

Institute of Photogrammetry and Remote Sensing, Chinese Academy of Surveying and Mapping,

Beijing 100039, P.R.China, zengyu_casm@yahoo.com.cn

Abstracts

An approach for quickly updating GIS building data using high resolution remotely sensed data is proposed in this paper. High resolution remotely sensed data could be aerial photographs, satellite images and airborne laser scanning data. Data from different types of sensors are integrated in building extraction. Based on the extracted buildings and the outdated GIS database, the change-detection-template can be automatically created. Then, GIS building data can be fast updated by semi-automatically processing the change-detection-template. It is demonstrated that this approach is quick, effective and applicable.

Keywords: Remote Sensing, Building Extraction, Laser Scanning, Updating

1. INTRODUCTION

Urban area is not only the highly dense place for human activities, but also the highly dense place for information and substances. With the development of technology and economy, the urban system is becoming more and more complicated, data and information is getting more and more, and the requirement to the service of the urban system is also increasing. Urban Geographic Information Systems(UGIS), have been the modern tools for urban planning, construction and management. It can facilitate and guarantee the process of urban modernization, ecological balance and sustainable development.

At the same time, the fundamental data of UGIS and other kinds of thematic data should be maintained and updating regularly in order to keep them up to date, to carry out the multi-temporal analysis and urban area dynamic monitoring.

Digital topographic map updating is of the most importance in UGIS spatial data updating. In order to meet the demands to quickly update large-scale topographic maps, the method that automatically detecting, extracting and updating changes should be developed. An approach for quickly updating GIS building data using high resolution remotely sensed data is proposed in this paper. Based on the extracted buildings and the out of date GIS database, the change-detection-template can be automatically created. Then, GIS building data can be fast updated by semi-automatically processing the change-detection-template.

2. WORKFLOW

Workflow described in figure 1 is listed as follows:

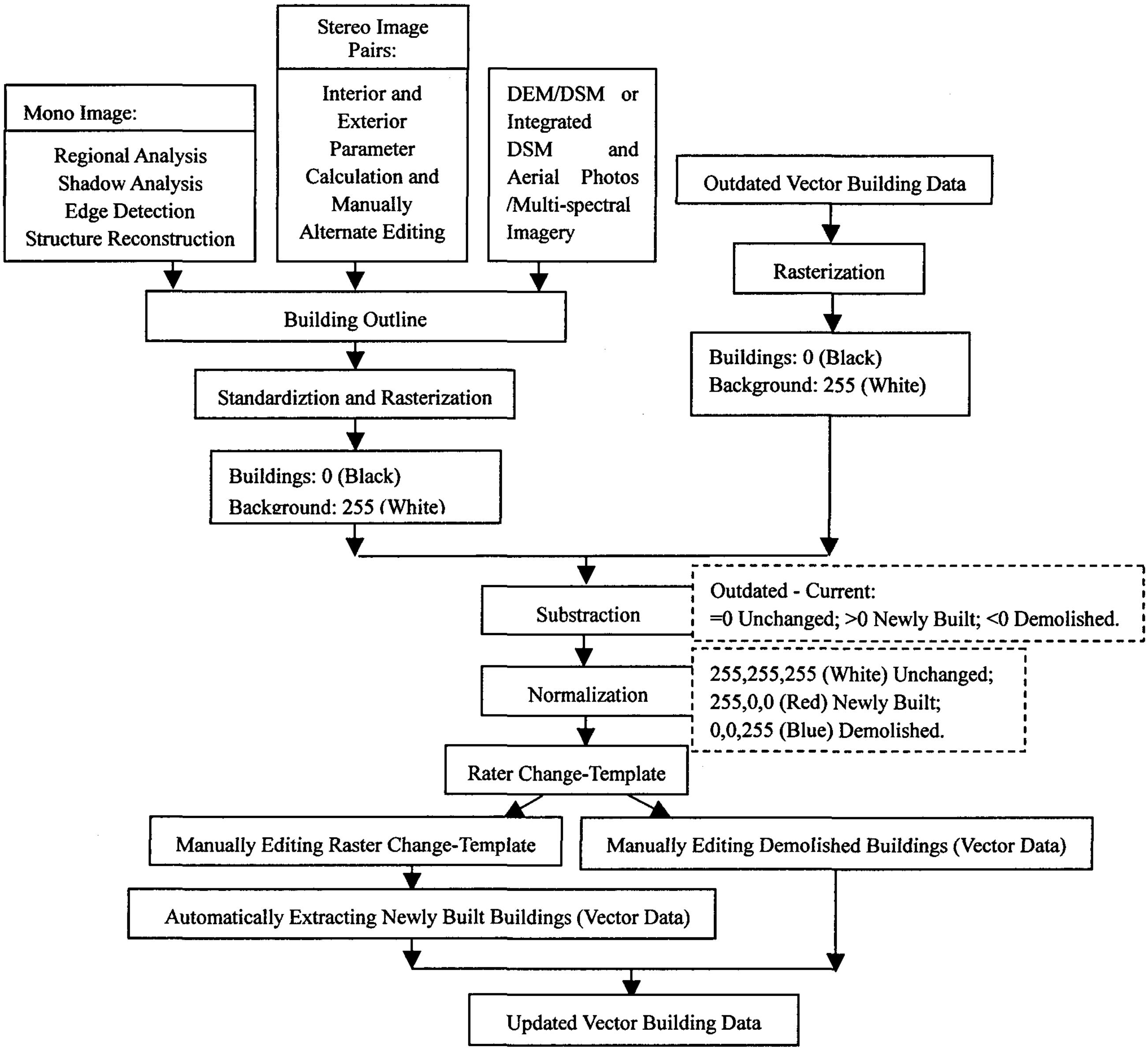

Figure 1. Building Updating Workflow

3. AUTOMATIC BUILDING EXTRACTION

Automatically recognizing and precisely extracting buildings from the remotely sensed data is the key point to fulfill building updating.

Generally, there are three types of methods for urban area building extraction from remote sensing data. Firstly, using mono images. Representative works are Nagao and Matsuyama's regional analysis, Yuh-Tay Liow, R.Bruce Irvin and He Guojin's shadow analysis, A.Huertas, C.Lin and Tao Wenbin's edge detection and synthetic analysis, and J.Chris McGlone's structure reconstruction etc. Secondly, using digital elevation model (DEM) and digital surface model (DSM). Representative works are Jee-cheng Wu, W.Eckstein and Uwe Weidner's work and Ackermann, Zheng Wang, Michel Morgan and Hiroshi Masaharu's edge detection, morphological filter and region segmentation methods using DSM acquired by LIDAR. Thirdly, integration of image data and DEM/DSM. Such as Caroline Baillard, Michel Roux, Frederic P.Perlant's work using stereo image pairs to get DEM, then to separate ground objects and extract the boundaries.

A new primitive-structure-based approach for automatic urban area building extraction from aerial photographs presented by Tao Wenbin and the method that using airborne laser scanning data and high resolution multi-spectral satellite image data to automatically extract buildings will be discussed in this paper.

3.1 A Primitive-Structure-Based Approach for Automatic Building Extraction from Aerial Photographs

In this method, Canny operator is used to extract building edges. Then, the straight-line-graph can be produced by contour tracking and straight-line splitting. By employing the geometric primitive structure analysis method, all kinds of primitive structures that compose rectangular buildings can be extracted. According to the merging rule, these primitive structures can be merged into rectangular structures. This approach is robust and time saving. It is more accurate in rectangular building extraction. Figure 2 and figure 3 are aerial photo of Tokyo and rectangular building extraction result by employing this approach respectively.

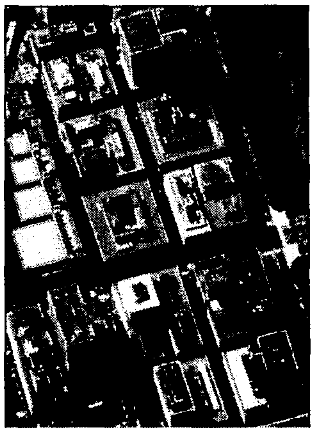

Figure 2. Aerial Photo of Tokyo

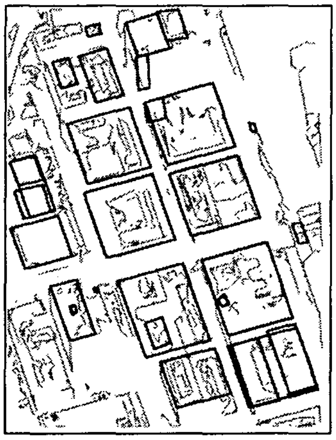

Figure 3. Rectangular Building Extraction Result

3.2 Using Airborne Laser Scanning Data and High Resolution Multi-spectral Image Data in Automatic Building Extraction

LIDAR stands for "LIght Detection And Ranging". The use of this technology from aircraft for ground height measurements can go back to the 1970's. In 1980's, the research and application of this technology have been further got along with developments in determining position and orientation of the laser. The positioning and orientation of the laser has been dependent on the quality of GPS positioning and inertial measurement units (IMU) ability to measure position and attitude. Airborne laser scanning system is active, in which several sensors are integrated to obtain XYZ coordinates of points on the earth and the orientation of the remotely sensed data can be fulfilled without ground control points. Compared with the traditional photogrammetry technology, it can penetrate the foliage to measure the ground points under the canopy, it can acquire the data without the limitation of weather and time, and it can provide highly precise DSM and DEM data within a few hours after the flight. The high quality of LIDAR data is reflected in several aspects: 1. High accuracy. A typical oversea LIDAR system can provide data with 15 cm vertical accuracy and less than 50 cm horizontal accuracy. 2. High consistency of the accuracy, i.e., the accuracy is same everywhere. 3. High consistency in coverage, i.e., points are evenly distributed in the covered area.

Airborne 3D Imager, a type of Airborne Laser Ranging/Multi-spectral Imaging Mapping System developed by Chinese Academy of Sciences can synchronously obtain co-registered DSM data and spectral image data. The ortho-rectified image, DEM and the 3D urban building perspective graph can be calculated quasi-real-time within a few hours after the flight. The mapping precision can reach 1:5000 to 1:2000.

Recent years, LIDAR data has played an important role in building extraction and reconstruction. Lots of research work has been done on automatic building extraction using LIDAR data. But there are some intrinsic deficiencies in building extraction if only LIDAR data is used, such as the situation that trees are extracted with the buildings at the same time. It is also difficult to effectively, automatically extract buildings if only high resolution multi-spectral images and color aerial photographs are applied. An efficient solution is to integrate different types of remotely sensed data that come from different sensors, different spectral bands, and with the different attributes. The building extraction accuracy can be greatly improved when LIDAR data is integrated with high resolution multi-spectral images or color aerial photographs. New-style, commercial high resolution multi-spectral satellite imagery includes IKONOS data (launched by USA, 1999, has 1m resolution panchromatic band and 4m resolution multi-spectral bands including blue, green, red and near infrared bands), QuickBird data (launched by USA, 2001, has 61 cm resolution panchromatic band and 2.44m resolution multi-spectral bands including blue, green, red and near infrared bands) and OrbView-3 data (to be launched by USA, has 1m resolution panchromatic band and 4m resolution multi-spectral bands including blue, green, red and near infrared bands) etc. Some research has been done on integrating LIDAR data and multi-spectral image data or color aerial photographs in building extraction in recent years (N. Haala, V. Walter, 1999 and A. Steel, Thomas et al, 2001). Figure 4 is the DSM data acquired by LIDAR and presented in a grey image. Figure 5 is the building extraction result using LIDAR data and color infrared aerial photographs.

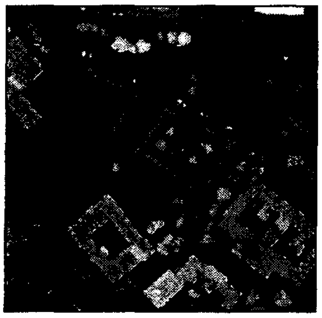

Figure 4. DSM Acquired by LIDAR (Thomas VÖGTLE, 2000.)

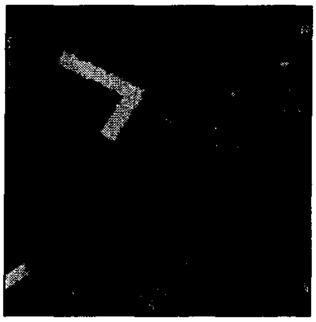

Figure 5. Building Extraction Result Using LIDAR Data and Color Infrared Aerial Photographs (Thomas VÖGTLE, 2000.)

4. GIS DATA RASTERIZATION

Rasterizing the outdated vector building data in GIS database into the raster image that has the same spatial resolution as the remote sensing data used in building extraction.

5. CHANGE-DETECTION-TEMPLATE CREATION AND SEMI-AUTOMATIC BUILDING UPDATING

Two types of building data need updating: the one that does not exist any more and the one that did not exist before. In order to discover the changes, we need to obtain the change-detection-template first.

Making use of the geometric properties of most buildings, such as orthogonality, parallelism and symmetry etc to standardize the building outlines. The change-detection- template image can then be generated by subtracting the image that structured by the extracted up-to-date buildings from the image that structured by the outdated buildings. Normalization is used in this process. After the normalization, the unchanged area is presented in white color (255,255,255), the newly built area is presented in red color (255,0,0), and the demolished area is presented in blue color (0,0,255). Figure 6 is the change-detection-template image of the tested area of Tokyo.

Figure 6. Change-Detection -Template Image

Picking up the template of demolished buildings from the change-detection-template image, then overlapping it with the outdated vector building data to discover the change and then manually edit the change. The buildings that do not exist any more can be updated through the operation.

Picking up the template of newly built buildings from the change-detection-template image, then validating the data with the up-to-date images. Vectorizing the validated data, then import it into the GIS database. The buildings that did not exist before can be updated through the operation.

Figure 7 is the extracted newly built buildings and figure 8 is the updating result, where the red represents the lately constructed buildings.

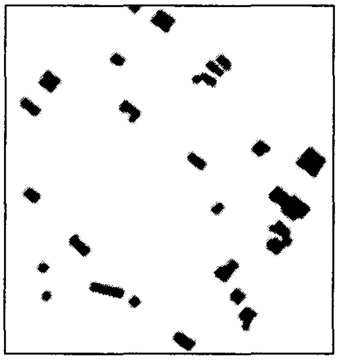

Figure 7. Extracted Newly Built Buildings

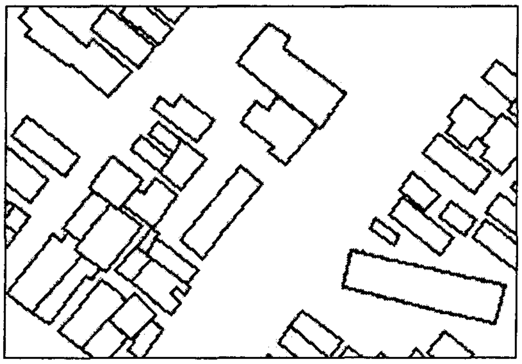

Figure 8. Updating Result of Vector Buildings

6. CONCLUSIONS

Because of the development of the economy and the influence of all kinds of social factors, geo-information data is in a state of changing. People have paid more and more attention to keeping the data current. The automatic building extraction methods are discussed and a semi-automatic building updating method is presented in this paper. It is demonstrated that this method can facilitate the process of urban area building data updating. Precisely extracting buildings is the key point to fulfill the automatic building updating. The building extraction accuracy can be greatly improved when airborne laser scanning data is integrated with high resolution multi-spectral images or color aerial photographs.

REFERENCES

1 A. Steel, M. Barnsley, S. Barr. Inferring Urban Land Cover And Land Use Through An Analysis Of Airborne Multi-Spectral And Lidar Data. *The Annual Conference and Workshops of the NERC URGENT Research Programme.*

2 HE Guo-jin et al. 2001. Extracting Buildings Distribution Information of Different Heights in a City from the Shadows in a Panchromatic SPOT Image. *Journal of Image and Graphics.* Vol.6(A), No.5: 425 – 428.

3 Hiroshi Masaharu, Hiroyuki Hasegawa. 2000. Three-Dimensional City Modeling From Laser Scanning Data By Extracting Building Polugons Using Region Segmentation Method. *International Archives of Photogrammetry and Remote Sensing, Vol. XXXIII, Part B3.* 556 – 562.

4 LI Shu-kai, XUE Yong-qi, 1998. Airborne Laser-Ranging-Multispectral-Imaging Mapping System. *Journal of Wuhan Technical University of Surveying and Mapping.* Vol.23 No. 4: 340 – 344.

5 Michel Morgan, Klaus Tempfli. 2000. Automatic Building Extraction From Airborne Laser Scanning Data. *International Archives of Photogrammetry and Remote Sensing, Vol. XXXIII, Part B3.* 616 – 623.

6 Thomas VÖGTLE, Eberhard STEINLE. 2000. 3D MODELLING OF BUILDINGS USING LASER SCANNING AND SPECTRAL INFORMATION. *International Archives of Photogrammetry and Remote Sensing. Vol. XXXIII, Part B3.* 927 – 934.

7 TAO Wenbin et al. A Primitive-Structure-based Approach for Automated Urban Area Building Extraction from Aerial Images. *Journal of Computers.*

8 Yuh-Tay Liow. 1990. Use of Shadows for Extracting Building in Aerial Images. *Computer vision, Graphics, and Processing.* 49: 242 - 277.