Designation of Buildings in Urban Area of High-resolution Satellite Image Using Generalized Hough Transform

* Seung-Hee Lee, * Sung-Mo Park, * Joonwhoan Lee, * Joon-Cheol Kim
School of Electronic and Information Engineering, Chonbuk National University
664-14 1ga Duckjin-Dong Duckjin-Gu Jeonju-city Chonbuk 561-756 South Korea
chlee@chonbuk.ac.kr

Abstract: Analysis of high-resolution satellite image becomes important for cartography, surveillance, and remote sensing. However, there are lots of problems to be solved for automatic analysis of high-resolution satellite image especially in urban area. The problems are originated from the increased complexity due to the unnecessary details and shadows, and time-varying illuminations. Because of such obstacles, it seems impossible to make automatic analysis. This paper proposes a way of change detection of buildings in urban area by using digital vector map. The proposed way makes the buildings on the vector map parameterized, and searches them in the preprocessed high-resolution image by using generalized Hough transform. The searched building objects are overlaid on the satellite image. The overlaid image can help to detect the change of building rapidly.

Keywords: high-resolution satellite image, urban area, change detection of buildings, designation of buildings, digital map, Hough transform

1. Introduction

Analysis of high-resolution satellite image becomes important for cartography, surveillance, and remote sensing. However, there are lots of problems to be solved for automatic analysis of high-resolution satellite image especially in urban area. The problems are originated from the increased complexity due to the unnecessary details and shadows, and time-varying illuminations. Because of such obstacles, it seems impossible to make automatic analysis in a pure bottom-up manner. Rather top-down or knowledge-based approach is more desirable for the specific purposes

In this paper, our goal is the designation of buildings in urban area that can help human operators to detect changes in buildings. The proposed method in the paper assumes the digital map of corresponding area with DXF format is available. The designation means the superposition of the buildings in a digital map into satellite image. In order to achieve the goal generalized Hough transform is used, which is robust to relatively poor preprocessing of satellite image.[1][2]

The proposed model-based approach shows promising results to overlay a group of buildings as well as separate building, which can be useful to find an area of interest with building complex.

The paper is organized as follows. The proposed scheme is outlined in section 2, and the experimental results are shown in section 3 with some discussion. The summary and conclusion is included in section 4.

2. Proposed Scheme for Building Designation

Fig. 1 shows the overall scheme of our designation scheme that eventually helps human operators to detect changes in buildings. In the scheme, the digital map is assumed to have the same resolution and direction as the satellite image after compensation of geometric distortion.

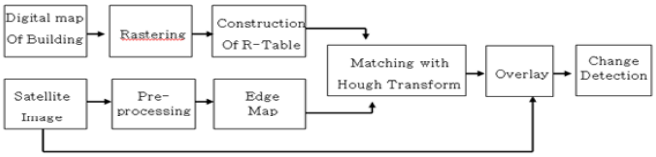

Fig. 1. Overall scheme of successive change detection

A. R-table Construction from Digital Vector Map

The buildings in the area of interest in digital map are rasterized into BMP format, and a group of buildings to be searched is parameterized via R-table.[3][4] Fig. 2 shows the geometry taken for making R-table and Table 1 is an example of R-table. In the figure, (x_c, y_c) is an arbitrary center of the buildings, ϕ_i is the angle of gradient at a boundary point with respect to positive x-axis, and α is the angle of the vector r pointing from a boundary to the center. The R-table provides a template of a group of buildings in digital map to be searched, in which the shape of the buildings arrangement is uniquely parameterized by $r(\phi_i)$ and $\alpha(\phi_i)$ along their boundaries. Note the center is given by

$$\begin{aligned} x_c &= x + r(\phi_i)\cos(\alpha(\phi_i)) \\ y_c &= y + r(\phi_i)\sin(\alpha(\phi_i)) \end{aligned}, \qquad (1)$$

and $r(\phi_i)$ and $\alpha(\phi_i)$ are function of ϕ_i, that can be used as an index of R-table.

Also, note that we can construct the R-table for a group of buildings choosing some prominent parts of boundaries and this can reduce the size of the table. But this may produce the problem in the matching process, because the edge map of satellite image is not good enough. Therefore, we take all the boundary points of a group of building to construct the R-table.

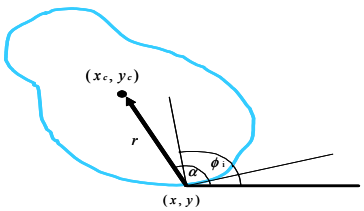

Fig. 2. Geometry for R-Table

Table 1. Example of R-table

Angle measured from figure boundary to reference point	Set of radii $\{r^k\}$ where $r = (r, \alpha)$
ϕ_1	$r_1^1, r_2^1, \ldots\ldots, r_{n1}^1$
ϕ_2	$r_1^2, r_2^2, \ldots\ldots, r_{n2}^2$
.	.
.	.
.	.
ϕ_m	$r_1^m, r_2^m, \ldots\ldots, r_{nm}^m$

B. Preprocessing of Satellite Image

The monochrome satellite image with 256 gray levels is preprocessed to construct an edge map. In order to obtain a proper edge map, Navatia operator is used. The operator provides the magnitude and the direction of gradient of a pixel with one of 6 different directions, 0^o, 30^o, 60^o, 90^o, 120^o, and 150^o.[6] After taking the operator, we discriminate the edge pixels if they have larger value of the magnitudes of gradients than a given threshold.

C. Matching

Using the R-table of a building in digital map, matching is performed to find the buildings by generalized Hough transform. For every edge points in the edge map, the gradient direction is extracted and the candidate centers are accumulated by Eq. (1). For the calculation, the R-table is referenced to find (r, α) with its gradient direction ϕ_i. After all edges are considered, the bin with maximum number of votes in the 2-D accumulator space is taken as the center. And finally the center of a group of buildings in digital map is coincided with the center in the satellite image.

3. Experiment

The experiment uses Ikonos image with 256 gray levels, the size of 512x512 pixels, the resolution of 1mx1m as in Fig. 3. Fig. 4 shows the buildings of interest in digital map after rasterization. Fig. 5 shows the edge map after Navatia operation and thresholding. The final result in Fig. 6 shows the proposed model-based approach provides a pretty good result to overlay

a group of buildings. The small discrepancy in Fig. 6 is resulted from the geometric differences such as scale and direction between digital map and satellite image**.**

4. Conclusion

This paper proposes the way of detection of the changes of buildings in the urban area by using digital map. The proposed way makes the buildings on the vector map parameterized, and searches them in the preprocessed high-resolution satellite image based on generalized Hough transform. The searched building objects are overlaid on the satellite image. The overlaid image can help to search the change of building rapidly.

Because the proposed scheme is very robust due to the Hough transform, the difficult preprocessing of high-resolution satellite image can be waived. Also, other objects such as roads can also be designated by the way in the paper.

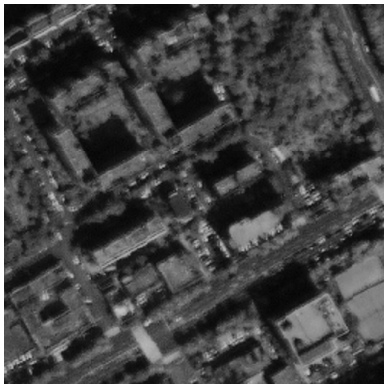

Fig. 3. Urban image from IKONOS

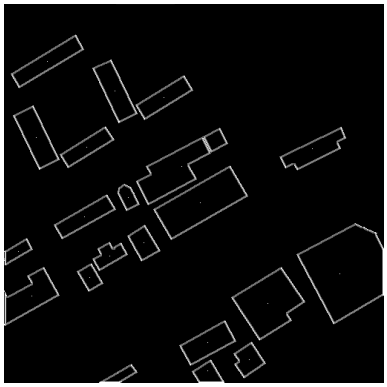

Fig. 4. Buildings of interest in digital map

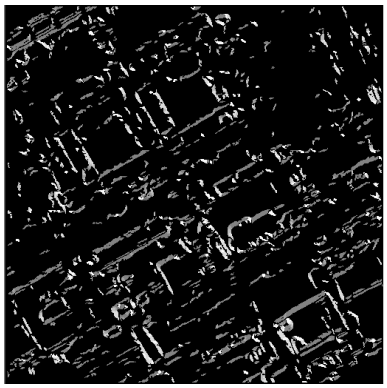

Fig. 5. Edge map from Fig. 3

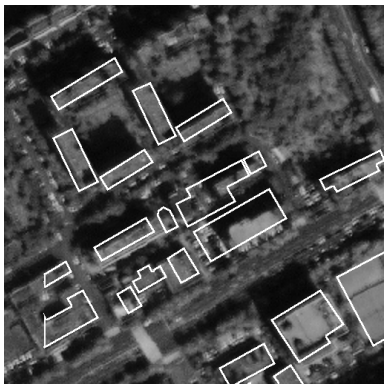

Fig. 6. Result of Superposition

References

[1] P. M. Mather, 1987, *Computer Processing of Remotely Sensed Images*, John Wiley $Sons,

[2] Joon-Cheol Kim, sung-Mo Park, Joonwhoan Lee, Soo Jeong," 2002 Designation of a Road in Urban Area Using Hough Transform" KSRS, Proceeding, pp766-771

[3] D. H. Ballard and C. M. Brown, 1982, *Computer Vision,* 123-131, Prentice Hall

[4] M.Sonka et al, 1998 *Image Processing, Analysis, and Machine Vision*, PWS

[5] Wonkyu Park, Sunghee Kwak, Tak-gon Kim, 2000, *"Line Rolling Algorithm for Automated Building Extraction from 1-meter Resolution Satellite Images*", KSRS, Proceeding, pp31-36,

[6] M. H. Robert, L. G. Shapiro, 1992, *Computer and Robot Vision,* Addison Wesley, pp337-340