AUTOMATIC BUILDING EXTRACTION FROM HIGH RESOLUTION AERIAL IMAGES USING ACTIVE CONTOUR MODEL

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ABSTRACT:

Various governmental organizations need accurate, correct and up to date information for optimization of resource and service management. In this issue, geospatial information is very important. Geospatial information as essential part of Geospatial Information System (GIS) has important role in performance of civil projects, urban service management. Using conventional surveying methods for producing geospatial data require a lot of cost and time. Thus, utilization of modern methods in production and updating of this kind of data is necessary.Photogrammetry and Remote Sensing are methods that produce geospatial data in extensive area with acceptable accuracy. In various countries of the world, many researches have been carried out and many algorithms have been introduced in order to decrease human operation in automatic feature extraction of satellite images. Building is one of the features that take the maximum of time and cost of feature extraction due to its abundance in urban area. As a result, on access to a model or algorithm of automatic or semi-automatic extraction of this feature not only minimizes human role in producing large scale maps but also has a dramatic effect on time and cost of the project. The aim of this paper is automatic extraction of boundary of this feature from high resolution aerial images in a way that its output is a vector map that needs the least editing in GIS. the main goal of this research is to introduce a method based on active contour model that the initialization stage of algorithm can be carried out automatically and active contour be ultimately optimized in building extraction. A new model is also suggested for automatic detection and extraction of boundary of buildings. New model of active contour can detect and extract boundary of building very accurately compared to classical model of active contour model and avoid detection of the boundary of features that are in neighbor of buildings such as streets and trees. The result of applying this model shows that the active contour model works better than other models of detection and extraction of building boundaries in urban area.

1. INTRODUCTION

Photogrammetry and Remote Sensing are methods that produce geospatial data in extensive area with acceptable accuracy. Furthermore, project cost and time of using these methods is lower than other production methods of geospatial information. Because of the fact that nowadays, spatial and spectral resolution of satellite sensors has been improved and high quality images such as Ikonos and Quickbird are accessed to provide needs of civil users, utilization of these images for providing and updating of maps and geospatial information has been approved all over the world.

Building is one of the features made by human that takes the maximum of time and cost of feature extraction due to its abundance in urban area. As a result, on access to a model or algorithm of automatic or semiautomatic extraction of this feature not only minimizes human role in producing large scale maps but also has a dramatic effect on time and cost of the project. Finding such an algorithm can also be efficient in automatic extraction of other features similar to buildings.

Because of irregular structure and closeness of buildings in urban area, the maximum researches in domain of automatic building extraction from high resolution aerial and satellite images, are done from integration of Lidar data and images (Rottensteiner et al, 2005). For example in the research of (Sohn et al, 2007) at first all features that have a certain height from earth are recognized. After that by using NDVI index and other information, separate the buildings from other features. Then the sharp edges detect and a polygon fits to the close edges as a building boundary. In other researches such as (Weidner et al, 1995, Baillard et al, 1999, Schenk et al, 2002, Guo et al, 2002, Rottensteiner et al, 2005) the position of buildings have been detected by integration of aerial and satellite images into height information such as Lidar data. Halla et al. (1999) have extracted location of buildings from image by using classification algorithms and height data. Zimmermann et al. (2000) produced DSM data from stereo images. Then they detected building's roof model by applying slope and aspect operators. Also in the (Zhao et al, 2000, Jin et al, 2005) height data and morphological operators have been used for extraction of buildings.

In some researches, different active contour models such as Snake model have been employed for building boundary recognition. In (Peng et al, 2004) a specific Snake model has been introduced for building boundaries from aerial images with a new energy function. The paper of) Mayunga et al, 2005) proposed a semi automatic algorithm for building extraction from Quickbird images. In this paper within the boundary of each building, a point is selected. Then the initial curves of the model are produced and the accurate boundaries of buildings are detected in the iterative procedure. In the another paper (Guo et al, 2002) at first the approximate position of building's boundary is extracted from Lidar data and then Snake Model extract precise boundary of each building.

Other researches have been used artificial intelligence such as nero-fuzzy system for recognition and detection buildings from other object in aerial and satellite images (Samadzadegan et al, 2005).

In this paper a model has been introduced for building detection from aerial images using active contour models based on level set formulation.

2. DESCRIPTION OF ACTIVE CONTOUR MODEL

The active contour model that is used in this paper is proposed by Chan and Vese (2001) based on Mamford-Shah image segmentation equation. In this model image is segmented to regions that the value of all pixels within each region have maximum homogeneity and similarity. The most important advantage of this active contour model is the ability of them to extract objects without obvious edges from images. Another advantage of this model is no sensitivity to the noise.

Active contour model based on level set formulation is described by this energy function:

$$F_1(C)+F_2(C)=\int_{inside(C)}|u_0-c_1|^2\,dx+\int_{outside(C)}|u_0-c_2|^2\,dx \qquad (1)$$

Where C is the curve of active contour model, and u_0 is pixel's value of the image and c_1 , c_2 are the average of pixel's value inside and outside of C.

If the cure C is inside of target object then $F_1(C)\approx 0$ and $F_2(C)>0$ and in case that curve C is outside of the target object then $F_1(C)>0$ and $F_2(C)\approx 0$ and finally if curve C is inside and outside of target object then $F_1(C)>0$ and $F_2(C)>0$. After minimization of function of equation (1), the curve C is fitted to the boundary of target object and this relation is obtained:

$$\inf_c\{F_1(C)+F_2(C)\}\approx 0\approx\{F_1(C_0)+F_2(C_0)\}$$

For regularization of equation (1), two terms are added to it and the equation (2) is obtained:

$$F(C,c_1,c_2)=\mu.(length(C))^p+\nu.area(inside(C))+ \lambda_1\int_{inside(C)}|u_0-c_1|^2\,dx+\lambda_2\int_{outside(C)}|u_0-c_2|^2\,dx \qquad (2)$$

Where $\mu\geq 0$, $\nu\geq 0$ and $\lambda_1,\lambda_2>0$ are constant parameters. The equation (2) has a level set formulation that was introduced in (Chan et al, 2001). For this purpose they defined two additional functions:

$$H(z)=\begin{cases}1, & z\geq 0\\ 0, & z<0\end{cases}\qquad \delta(z)=\frac{d}{dz}H(z) \qquad (3)$$

Based on equation (3) the definition of each part of equation (2) is:

$$\begin{aligned}
&length\{\phi=0\}=\int|\nabla H(\phi)|dx=\int_\Omega\delta(\phi)|\nabla\phi|dx\\
&area\{\phi\geq 0\}=\int_\Omega H(\phi)dx\\
&\int_{\phi\geq 0}|u_0-c_1|^2\,dx=\int_\Omega|u_0-c_1|^2H(\phi)dx\\
&\int_{\phi<0}|u_0-c_2|^2\,dx=\int_\Omega|u_0-c_2|^2(1-H(\phi))dx
\end{aligned} \qquad (4)$$

In the above equations Ω shows the entire of image domain. With regarding the equation (4), the level set definition of equation (1) is (Chan et al, 2001):

$$F(\phi,c_1,c_2)=\mu\left(\int_\Omega|\nabla H(\phi)|\right)^p dx+\nu\int_\Omega H(\phi)dx+ \lambda_1\int_\Omega|u_0-c_1|^2H(\phi)dx+\lambda_2\int_\Omega|u_0-c_2|^2(1-H(\phi))dx \qquad (5)$$

In this equation, c_1 and c_2 are the mean of pixel's value if $\phi\geq 0$ and $\phi<0$ respectively and they are obtained from these equations:

$$c_1(\phi)=\frac{\int_\Omega u_0H(\phi)dx}{\int_\Omega H(\phi)dx}\qquad c_2(\phi)=\frac{\int_\Omega u_0(1-H(\phi)dx}{\int_\Omega(1-H(\phi)dx} \qquad (6)$$

In the last step, the equation of curve evolution is:

$$\frac{\partial\phi}{\partial t}=\delta(\phi).\left[\mu.div\left(\frac{\nabla\phi}{|\nabla\phi|}\right)-\nu-\lambda_1(u_0-c_1)^2+\lambda_2(u_0-c_2)^2\right]=0$$

Finally the above curve evolution equation is solved based on finite difference methods and the position of curve is improved in the iteration manner.

3. AUTOMATIC BUILDING EXTRACTION USING ACTIVE CONTOUR MODEL

Our active contour model for building extraction is described in section 2. Our building extraction method is made up four major steps. In the first stage the input image is smoothed using a Gaussian kernel. In next step a point inside a building is introduced to model as a training data. Then the proposed active contour model is implemented on the smoothed image and boundaries of building are detected. Finally the accuracy of detected buildings is evaluated. Figure 1 demonstrates the diagram of steps of proposed model.

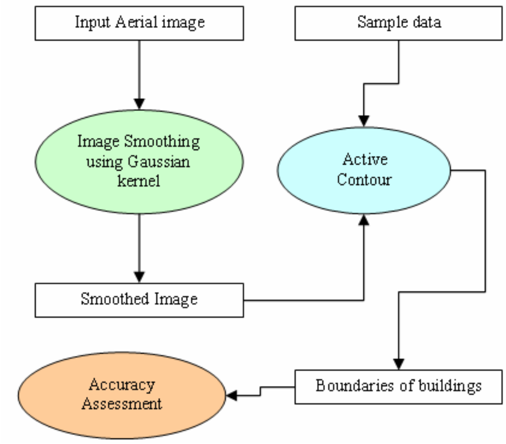


Figure 1: diagram of building extraction steps

Our model is tested on an aerial image from Gachsaran city in Iran. The buildings in this image are dense and attached together. Figure 2 shows the image of test region.

Figure 2: Gachsaran city as the test region

At first step input image is smoothes with a Gaussian kernel:

$$I_g = G_\sigma * I$$

Where I_g , I and G_σ are the smoothed image, input image and Gaussian kernel respectively. By introducing a point inside a building as sample data, the model runs and the initial curves are generated automatically which they are a series of regular circles (figure 3).

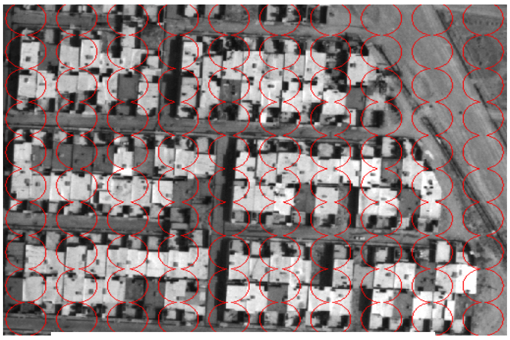
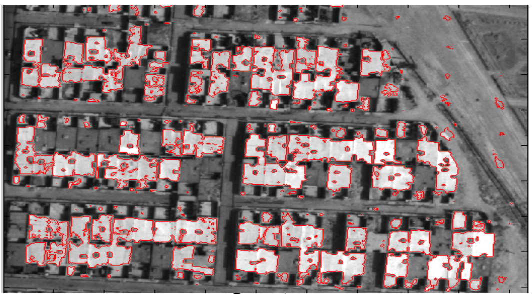


Figure 3: initial curves generation



Step 1

Step 2

Step 3

Figure4. Curve position in three iterations todetect buildings boundary

The result of implemented model shows that the boundaries of buildings are detected accurately and model is not sensitive to noise. Previous models in building extraction don't have this accuracy in dens, irregular an attached buildings urban regions. A problem of our model is in detection of buildings that have similar spectral information with other features such as streets.

4. ACCURACY ASSESSMENT OF THE MODEL

In this paper, we use the McKeon's shape accuracy factor for evaluation of the model. In this relation the area of buildings in ground truth is compared with the area of buildings that is detected by model.

$$shape\ accuracy = (1 - \frac{|A - B|}{A}) * 100$$

Where A and B are area of a building in ground truth and area of its corresponding detected building respectively. Table 1 shows the results of the model.

shape accuracy(%)	
max	80
min	60
mean	75

Table 1: the shape accuracy obtained from the model

5. CONCLUSION

In this paper, an optimum model of Active contour models is utilized for automatic building extraction from aerial images. This model does not need introduction of initial curves near edge of buildings. Results of our model applied to aerial images show suitable results especially in dense and irregular urban areas.

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