RESEARCH ON UPDATING OF URBAN LARGE SCALE ROAD MAP BASED ON HIGH RESOLUTION REMOTE SENSING IMAGE

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ABSTRACT:

Road feature is one of the most important features of urban. The change of road reflects construction speed of an urban. map road updating timely and exactly becomes an urgent issue. Current method updating of road feature is carried out complete manually, and has the disadvantage of tending to lose changed road and low automatic level.

The updating of map road feature including two parts: one is change detection, and the other is map road revision. Map road updating method which is used currently is to do the change detection and map revision at the same time manually, which is tending to lose changed road, and the automatic level is low. This paper designed a new method to update map road feature named "revision based on change detection", it detects disappeared or partial changed road primarily and then revise changed road according to the change detection result. Firstly the change detection method for map road feature is presented, secondly applies the method to map road revision and put forward a new method of road updating, lastly experiments are presented. One is to testify the efficiency of change detection method, the other is to compare new method and current method on omission of changed road and a comprehensive evaluation is presented. As a result, the change detection method this paper put forwards is able to detect disappeared or partial changed roads efficiently, improves the level of automation of change detection. The road map updating methods of "revision based on change detection" this paper put forwards avoids omission of disappeared or partial changed roads, and improves the automation level of road map updating.

1. INTRODUCTION

Road feature is one of the most important features of urban, it plays a significant role in urban traffic, planning and management and so on. The change of road reflects the construction speed of an urban. Nowadays, Beijing's developing and changing rate is very fast, and the updating speed of topographic mapping on road can't catch up with the change speed of actual road features, map road updating timely and exactly becomes an urgent issue. The updating of map road feature including two parts: one is **change detection**, the other is map road **revision**.

Current updating method of road feature is carried out complete manually, and has the disadvantage of tending to lose changed road and low automatic level. The aim of this paper is to find a new method to update road in map with high automation and veracity. Firstly the change detection method for map road feature is presented, secondly applies the method to map road revision and put forward a new method of road updating, lastly experiments are presented using IKONOS image and the map of 1:2000 in scale: One is to testify the efficiency of change detection method; the other is to compare new method and current method on omission of changed road and evaluation is presented.

2. MAP ROAD FEATURE UPDATING METHOD

The map road feature updating method of this paper is generalized to "revision based on change detection", the flowchart is as Figure 1:

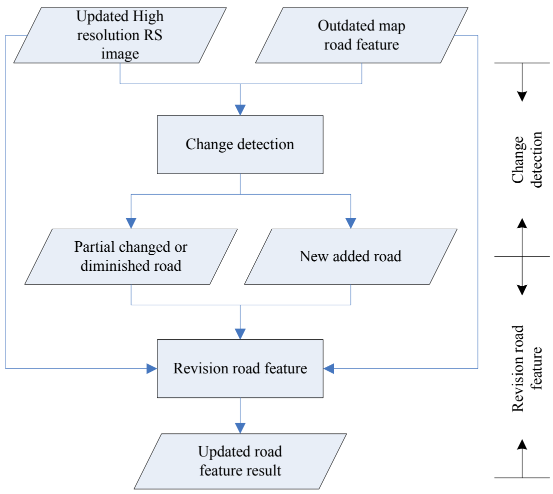


Figure 1 The flowchart of map road feature updating method

In this flowchart, the updating is divided to two parts, one is change detection, and the other is revision. The change detection including the detection to partial changed or diminished road and new added road, the former is automatically and the latter is semi-automatically. Based on the result of change detection, revise the changed road feature manually.

The current map road feature updating method is different from our method, it combine the change detection and feature revision together. The flowchart of current updating method is as Figure 2.

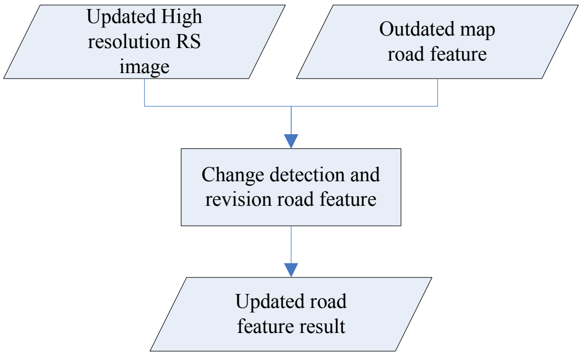


Figure 2 The flowchart of current map road feature updating method

Searching for the changed road by current means is manually, the automatic level is low, and tends to omit changed road.

In this paper, the "revision based on change detection" road feature updating method is discussed in detail, and the current road feature updating method is present only for comparing.

2.1 Change detection

In map road updating course, the change detection method is the key technique. In the process of change detection, image understanding technique of filtering, registration and multi-scale template matching are three main steps.

2.1.1 The detection to partial changed or diminished road

2.1.1.1 Filtering

Filter the RS image to enhance the fuzzy texture using Wallis filter. Wallis filter [1]] can increase the contrast and suppress noise of original RS image, thus it can raise the quality and accuracy of image feature in template matching.

2.1.1.2 Registration

The registration to the remote sensing image and the outdated map road feature. After choosing several control points equably on image and corresponding map, using polynomials rectify model to do the registration, the accuracy of registration should reach 1 pixel.

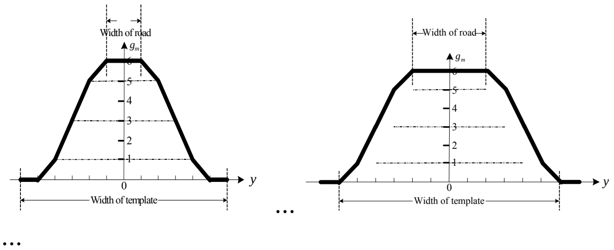
2.1.1.3 Multi-scale template matching

The character of the road in remote sensing image can be concluded as gray scale, geometry, topology, function and conjunction or context obligation etc. Among the characters, gray scale is the most important one, the gray scale of road can be expressed as linear feature with gray difference between the sides and the middle, so the ribbon-like (for ideal road) or ridge-like (for general road) template can be applied to match the road. This paper takes the outdated road vector as initial place, to match the updated RS image by multi-scale template matching method. The results are:

1) The maximum template matching point;
2) the width of the road in image;
3) whether the road in image is bright or dark compare with the background;
4) whether the road is partial changed or diminished.

The templates this paper designed are a series of ridge-like templates with multi-scale in width (Figure 3), they are one-dimensional templates. g_m axis represents template gray scale, y axis represents the template width, the middle part with even g_m value represents the width of road. The difference of the width of template and the width of road is a constant. A series of templates were designed, they are differ in width of road, the width are respectively 3, 5, 7,…, 25(pixel)…, etc. In figure 3a, the width of template is 13, the width of road is 3; in figure 3b, the width of template is 15, the width of road is 5.The template with 3 pixel of road width will get max matching result with a narrow road in image, and the template with 25 pixel of road width will get max matching result with a broad road in image. While the width of a road in image is unknown, it can be obtained by multi-scale template matching method.

The road in image may be either bright or dark strip comparing to the background, two series of templates are designed: the first series of multi-scale templates are bright ridge-like (figure.3), and the second series of multi-scale templates are dark ridge-like (Figure 4). The former match bright road more efficient, and the latter match dark road more efficient. Whether the road is bright or dark could be judged by this means.



a b
Figure 3 Bright ridge-like multi-scale template

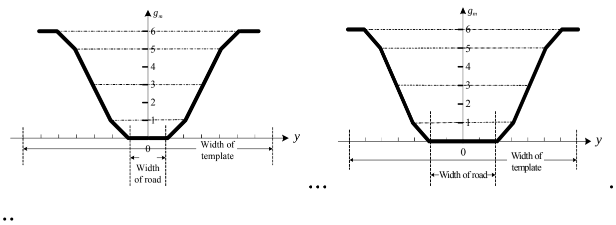


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Figure 4 Dark ridge-like multi-scale template

Figure 5 is the overlap of outdated road vector and updated RS image, the white line represents road vector, the line between two vector vertexes is a vector segment, and a road vector is make up of several vector segments. The broken line represents the direction of template matching, the crosses represent the max matching point produced by multi-scale template matching method.

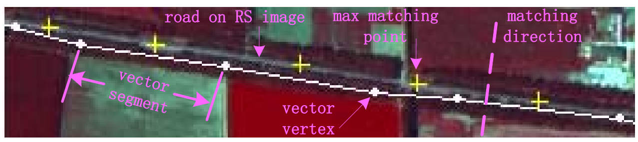


Figure 5 Multi-scale template matching

Take the outdated road vector as initial position, along the vertical direction of road segment, match every vector segment to RS image using multi-scale template. Compute the value of correlation coefficient [2], the formula is as follows:

$$\rho(c,r)=\frac{\sum_{i=1}^{m}\sum_{j=1}^{n} g_{i,j}\cdot g'_{i+r,j+c}-\frac{1}{m\cdot n}(\sum_{i=1}^{m}\sum_{j=1}^{n} g_{i,j})(\sum_{i=1}^{m}\sum_{j=1}^{n} g'_{i+r,j+c})}{\sqrt{[\sum_{i=1}^{m}\sum_{j=1}^{n} g^2_{i,j}-\frac{1}{m\cdot n}(\sum_{i=1}^{m}\sum_{j=1}^{n} g_{i,j})^2][\sum_{i=1}^{m}\sum_{j=1}^{n} g'^2_{i+r,j+c}-\frac{1}{m\cdot n}(\sum_{i=1}^{m}\sum_{j=1}^{n} g'_{i+r,j+c})^2]}}$$

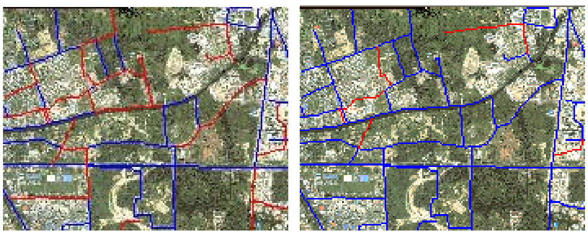
In the formula, *m* and *n* represent the row and column of image block respectively, *r* and *c* represent the searching scope, g and g' represent the grayscale of template and image respectively, the maximal value of correlation coefficient must corresponds the real place of the road.

After the multi-scale template matching, choose the max correlation coefficient as the unique matching result of a vector segment. If the unique result is larger than a given threshold, it's an effective result, each effective result must has an corresponding template, compute the sum length (called L_{same}) of the vector segments who are same in template width, choose the max L_{same} named $L_{sameMax}$, and the length of the road vector (called L_{total}), if the ratio of $L_{sameMax}$ to L_{total} is larger than a given threshold, this road hasn't disappeared or partial changed, vice versa.

The template width corresponded with the maximum length ($L_{sameMax}$) is considered as an efficient template, and its width of the road is considered as the width of road in image, the corresponding dark or bright attribute of the template is considered as the dark or bright attribute of the road in image.

After processing above, compute the sum length of successfully matched road vector segments, and the ratio of it to the total length of the road, if the ratio is less than a given threshold, the road has disappeared or partially changed, or it's unchanged.

Figure 6a is the change detection result of our method, Figure 6b is the actual changed road. There are 87 road feature in total, the actual disappeared of partial changed road is 8, our method detected 41 disappeared of partial changed road, among them 8 are right. The check-out-ratio is 100.00％, the correct-ratio is 62.07％.



a b

Figure 6 Change Detection Result of IKONOS and 1:2000 Map Road Feature

2.1.2 Newly added road detection

Snake[3] model is a spline curve of lease energy, it has three elements: inner force, outer force and image force. The inner force restricts it's shape, the outer force lead it's action, and the image force push it to notable image character. The energy function of Snake E_{snake} is defined as follows:

$$E_{snake}(v)=\frac{1}{2}\int_{\Omega}[E_{int}+E_{image}+E_{con}]ds$$

LSB-Snake[4] is an efficient model to extract liner-like features, it describes Snake curve using B-spline with parameters, and iterative to minimum energy by using the algorithm of least square estimation, allocate the place of node points by the complexity of B-spline.

Before the extraction of road by LSB-Snake model, it need manual input the width and dark or bright character of the road to be extracted, Manual input may not be accuracy and hold down the extract efficiency. Besides this, the LSB-Snake model is not robust while the initial seed points are not dense enough.

In our method, we obtain each road's width and dark or bright attribute by self-adapt template matching and take it as initial value of LSB-Snake, this value is accurate and trusty, and the manual input is avoided. And, comparing with LSB-Snake model in extraction of road, the method this paper put forward can use not only the initial seed points, but also the new added seed points created by self-adapt template matching method, this makes the extracting result of roads more robust.

Figure 7a is the detection result to new added road by LSB-Snake model, and Figure 7b is the result by our method. The round points are inputted manually, the rectangle points are added by multi-scale template matching method. The detection to newly added road by our method is more robust than LSB-Snake model, and the detect efficiency is high.

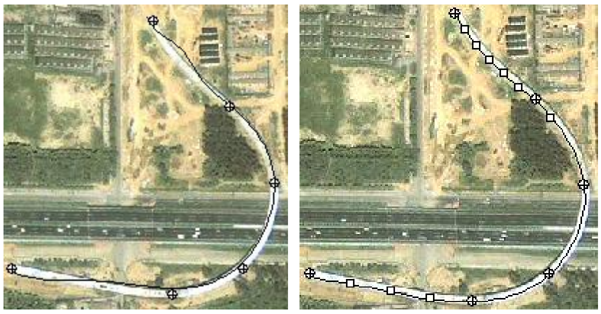


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Figure 7 Comparing of Newly Added Road Detection Results

2.2 Map revision

Take the result of change detection—partial changed or diminished road as reference of revision, overlap them with the outdated map road feature and remote sensing image, delete the diminished road, and revise the partial changed road manually, the result is the updating result of partial changed or diminished road.

Take the newly added road produced by change detection semi-automatically as the updating result of newly added road.

3. EXPERIMENTS

A program is developed to realize the change detection method above using Visual C++ platform [5], the revision is carried out by AutoCAD. We take 5 map sheets with the scale of 1:2000 and corresponding IKONOS image of Beijing, using "revision based on change detection" method and the current method respectively, the comparison to the result of road updating by using "revision based on change detection" method and current used method is presented.

The change detection experiment indicates, about 98% of the disappeared or partial changed roads is detected successfully on average (check-out-ratio), about 55% judgements of whether roads are changed or not is right on average (correct-ratio). Although there are some wrong judged roads, the change detection method was able to detect a majority of disappeared or partial changed roads.

TEST NO.	METHOD	TIME	OMISSION
1	A	4′18″	2
	B	8′24″	0
2	A	7′07″	0
	B	6′45″	0
3	A	4′08″	2
	B	8′59″	0
4	A	4′05″	1
	B	6′18″	0
5	A	3′48″	0
	B	5′07″	0

Table. 1 Comparison of the current method and revision based on change detection method on map road updating

Note: in "method" column, "A" represents current method, "B" represents revision based on change detection method.

The comparison of our "revision based on change detection" updating method results with the results' of currently used updating method indicates:

1) On the time efficiency of map road feature updating, in test1, 3, 4, 5, revision based on change detection method is lower than current updating method, because there are omission roads exist by current method, and the updating workload is less than revision based on change detection method. In test 2, the workload are the same to current method and revision based on change detection method, time costing are the same.

2) Among 5 map sheets, there are 3 map sheets exist omission of disappeared or partial changed roads using current updating method, while there is no omission roads existed using the updating method this paper presented.

4. CONCLUSIONS

This paper put forward a method to update map road feature named "revision based on change detection" method, it divided the updating to change detection and map revision. In change detection, this paper put forward an automatic method to detect the partial changed or diminished road, and a semi-automatic method to detect the newly added road.

Experiments indicate:

1) The change detection methods this paper put forward are able to detect disappeared or partial changed roads and the newly added roads efficiently, improves the level of automation of change detection.
2) The road map updating methods of "revision based on change detection" this paper put forwards avoids omission of disappeared or partial changed roads, and improves the automation level of road map updating.

Further research is needed on taking knowledge such as surface features' height, road joint relation into account to improve the detecting-out factor and judgeing-right factor in road change detection. More experiments are needed to testify the feasibility and stability of the updating method this paper put forward.

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