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Road Network Extraction and Recognition Using Color Clustering From Color Map Images

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Abstract. This paper use a color image digital map of Beijing area to do road feature extraction.It takes full advantage of color map by using clustering to get road network highlighted first, and then picks road network out through denoising, and does post processing works by using mathematical morphology algorithms to make road network more clearly.Combined with color map and clustering features to complete extract.Proved by the simulation experiments, the whole process of extraction does work and obtains a good results.

Keywords*:*Feature extraction, Clustering, Denoising, Mathematical morphology

1 Introduction

Geographic information system (GIS) has been used in various fields of national economy with its rapid development recently. Road information play an important role in geographic information, and the road extraction have gradually developed into a hot issue. The urban road map such as Google Map, Baidu Map, Google Earth, represented by its rich electronic color map resources, especially the global coverage satellite map. Therefore a large number of domestic and foreign institutions attend the study about color map road extraction currently(see [1,2]). These researches are divided into three areas, some are based on the road map topology recognition and extraction, some aim at using color feature on the map road recognition and extraction; others take advantage of both basic theory of gray morphological and noise characteristics to identify and extract.

So far domestic and foreign research institutions or software vendors to develop no less than dozens of topographic maps softwares can be used for scanning recognition. These research results have quite a part in the national fund project support and research team's joint efforts. Also it put a lot of manpower, material resources in dom, for instance road extraction based on area segmentation[3].When road gray statistical properties is given, it can use threshold method to segment road area. And also edge extraction method is used widely in this field, according to edge, treating road as a set of parallel lines, this leads to many related road extraction methods. In addition background feature is also a key role in road extraction.

This article chiefly uses color clustering to extract road. It’s a method based on area segmentation and color feature. That is so-called color clustering. Because of the nature of color map, each element has its unique color with it, so color clustering makes it more easier in extraction. After the clustering, we

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almost have a good outline about road, so the following work is to do post processing work, such as denosing，expansion and so on. The ultimate goal is to get a better road network from color maps.

2. related works

Color road map extraction involves many aspects, according to the basic theory of color, using color differences on the map to identify different categories, then utilizing the theory of image segmentation to extract road objects. The following work is to do the image denoising, corrosion expansion processing operations, finally get optimal results. About the entire processing of recognition and extraction will describe in detail below.

2.1 Image segmentation

Image segmentation is to divide the image into different characteristics of the area, make it easier for people to select their areas of interest for research and treatment. Attribute can be intensity, color, texture etc. Goals can correspond to a single area or more than one area. Sometimes in order to identification and analysis target, the relevant regions need to be extracted, and do further processing work, such as feature extraction and measurement.

Image segmentation algorithm such as based on image segmentation of discontinuous change, recording to the gray-scale discontinuity between the search area boundary, there are still algorithms based on image edge similarity segmentation, pursuant to guidelines established by the prior image segmentation for similar areas, such as thresholds, regional growth, and regional separation and polymerization. In this paper, we adapt the clustering segmentation method.

Clustering segmentation related

Since color maps are particular, different regions, sections etc. marked with different colors, so this article is based on the use of color to segment the road and interrupt

Color basis. Three-color base [4] is the red, green and blue, the human eyes to the red, green, and blue have the most sensitive, most of the color can be red, green, and blue color scale according to the type of synthetically produced. Also the majority of monochromatic light can be broken down into red, green and blue lights.That is basic theory of colorimetry,called the trichromatic theory. There is also addition subtraction principle and subtract principles.

Basic color theory in this paper played a very important role in the foundation, this article takes advantage of the color characteristics being the input image to distinguish road information and other things[5].

Clustering's strengths. Aimed at this kind of input image according to this article, it will more fast to use clustering to do segmentation work. It is also a kind of region-based image segmentation which can use the spatial characteristics to classify the pixel. These kind methods can also work well for complex scenes. Because it really has a high sensitivity to color, while color is just the biggest characteristic of this kind map. This method also has a high accuracy rate in element tags. It can also be told in later experiment.

Edge extraction

Given the nature of the map of Beijing, roads are straight in right direction. From the map,we can tell most of roads are two parallel lines, also some roads have angles about 45° or 135°. So, prewitt operator and sobel operator can respectively process the X direction and Y direction gradient estimation template, Robert crossover operator corresponding to 45° and 135° Direction. Both two algorithms can combine with other segmentation methods to make clearly extraction results[6].

Threshold segmentation

the most classic image segmentation method is based on gray threshold segmentation, which is accomplished by setting the threshold to split pixels into several classes at different gray levels to implement. Image binarization is the most simple example of threshold segmentation. In addition threshold method is also divided into artificial selection, automatic threshold method, minimum error threshold and watershed algorithm[7].

In this paper, region segmentation has a big contribution to road extraction, mainly color clustering based on region. It colors the same area with tags to make road completely extracted.

2.2 Image denoising

Due to imaging clustering, something useful all have its color tag , and the rest are noise that must be removed, because it will block useful things like road network details and make road extraction unclear enough.

What we need to do is to get image have road in it only, because of the same features,we can use some denosing knowledges to get it.This article takes advantage of the noise pixel's 8-neighborhood characteristics to classify them, according to the conditions set for the road or the background, so as to achieve denoising.

2.3 Mathematical morphology

Mathematical morphology is based on morphological concept evolved with strict mathematical theory of science, and has been successfully applied in the field of image processing and pattern recognition. Except as regional shape characteristics of extract image, such as borders, bones and the convex hull of tools, it is often used for image pre-processing and post-processing, such as morphological filtering, thinning and pruning. Morphological image processing, we are mainly interested in the binary image based on mathematical morphology and mathematics is the language of set theory.

The application of mathematical morphology can be simplified to image data,to maintain their basic shapes characteristic and remove irrelevant structures. The basic idea is to use a certain form of structural elements to be measured and the corresponding shape of the extracted image in order to achieve the purpose of image analysis and identification. This article intends to apply this method to do road extraction.It can repair the break caused by denoising and enhance the coherence of the road.

3 Road network extraction algorithm

3.1 Road feature analysis

Electronic color maps such as baidu maps, google maps, etc. all has their own characteristics, mostly including different roads, like the common road, railways, rivers and all kinds of labels (names, road names, etc.) in them. From Fig.1 can be seen that the same elements using a kind of color in show, dark or light. Rivers, lakes and landscaped areas,etc. have different morphological characteristics, and map elements have some labels which covered road.

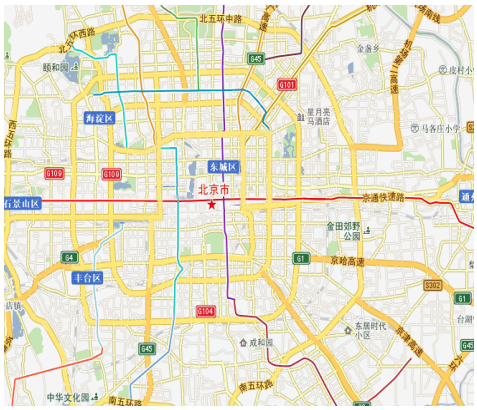

Fig.1 Color traffic map

After scanning color maps are labeled on the different elements, roads, rivers, forests, gardens, text, symbols, etc., roads generally tags in yellow, light blue represents rivers, forests, gardens, and other planar regions is green, text is black and white.

3.2 Map color clustering algorithm

a.Color Range

Because of the road value of the pixel is not a single color, sometimes a yellow or pale yellow, which may be due to color of scan map itself is not a single value, or the impact of scanning light intensity and the scanner itself. Thus, it is necessary to make some image preprocessing, classify and tag roads, regional, word marks respectively with a single color. According to color distance cluster the similar color. The distance is considered about color close degree. As shown in Equation (3.1).

$$F=\sqrt{(R_1-R_2)^2+(G_1-G_2)^2+(B_1-B_2)^2} \tag{3.1}$$

where R、G、B are image color components respectively.

The map is divided into several main sections, the first section is set as the background of the map itself, forest or park, rivers, etc. which will be classified as the background with the black marked. And the road which involved road information are represented by white color. Others are classified as noise, using red to present.

b. Color threshold

It should select typical samples of area pattern on the map firstly, and get color distance about samples and the area on the map.Using typical color of element as the cluster center, if the distance is less

than the set threshold, it will think the pixel approximate as region pixel of the map and then go on doing circulating comparison until the major elements of the map are all carrying out color clustering.

On the basis of color distance formula to do color cluster, the threshold has great effect on the results of clustering.Threshold formula as shown in Equation (3.2).

$$\sqrt{(R-AveR)^2+(G-AveG)^2+(B-AveB)^2}<Thre \tag{3.2}$$

where AveR、AveG、AveB are values after averaging between the given color patch and map elements.

It is difficult to select a good one because the map contains a variety of colors, So it must do many experiments to adjust the results with a more appropriate threshold.

3.3 Road image denoising

After color clustering, the road has been identified, and except for road and background, the rest are classified as noise, which mainly consists of text, illustration logo and other information. It must do denoising process in order to extract roads.

This paper mainly uses 8-neighborhood features of the noise pixels to denoising. After the experiment it proved to be a very effective for this type noise. First it should scan 8-neighborhood of noise pixels with each tag until find road or background pixels,then stop scanning. It should statistic the number of each pixel in eight direction, when meet the conditions for a given number, it will categorize noise pixel as roads , and put the color for road color (white)， to the contrary put the pixel color as background, the color as the background color (black). Going on scanning all the pixels until they are marked out.

3.4 Image postprocessing

Because of the interference on text or obstruction, the roads have some broken need to be dealed with after denoising, dilate operation is used to repair the broken part, then do corrosion operation to perfect roads.

Both dilation and erosion operations are morphological processing bases, They are the basic operations in many other morphological algorithms. This two algorithm is very similar, but they are not one pair of reversible process.

a.Dilation

Defining a structure element A=logical(zero (row,line)), using it to cover the binary image to do "or" operation.if all is zero, the result pixel of the image is 0. Otherwise, it is 0. Inflation results results in increasing a circle of binary image by appearance.

Scanning image and selecting processing area, defining the same size of array B, its elements are all zero. First of all it should judge whether selected part within the eight neighborhood pixels contained road class (white) or not, if any set the array element is 1, again to scan array , scan pixel is 1,set its corresponding pixel to 0, so the image outward expansion.

b. Erosion

Erosion algorithm is similar to dilation algorithm, scanning each pixel of the image still, using structure elements to cover binary image and doing "and" operation, if result are all 1, and the image of the pixel is 1. Otherwise is 0. Corrosion results will reduce binary image on the appearance.

4 Experiment results

This article selected parts of Beijing of China in Google map images as input, using Matlab to do software simulation,the results are shown below.

4.1 Color clustering results

Using the map color features, roads are marked by white color,background tag black. the rest of information as a noise are marked by red, as shown in Fig, 2(a-c).

(a) tag background (b) tag roads (c) tag noise

Fig.2 Corrosion and expansion results

Most of interferences from Fig 2(a) are get into background color black, like ground surface, river, park,forest etc. But there are still some stuffs leaving, like urban landmarks, road name mark and so on. In the following Fig. 2(b), road are highlighted by white. Thinking about the road network only, it is clearly in human's eye about the result. In addition to these two elements above, the rest all tag noise using red to show from Fig. 2(c).

Up to now, all the mark works has been completed. Due to the complicated road network, and noise impact a lot, so denoising process below.

4.2 Denoising

After denoising work by using road eight neighborhood characteristics of image pixel, Almost all of the interference are removed, but with little fracture in part of the road, as shown in Fig 3. In addition to the black background that those left on the figure are road network that we want. It is clearly to see the whole road network.

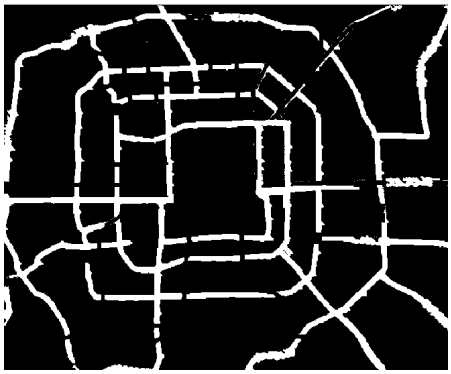

Fig. 3 denoising results

4.3 Post processing results

In order to ensure the quality, the following work is to repair break path, the result is shown in Fig. 4.

Changing the result image into binary image, and then doing corrosion to connect broken road. It can be seen from Fig.4, the erosion get most of road completed the splitting.

Fig.4 Post processing results

5 Conclusion

This article is based on color clustering method, which can extracted road with a clear result. It gives full play to the advantage of color by using clustering to pick each element out in need. Then through some post-processing works like erosion and dilation to make road network more perfect.Ultimately optimization results are obtained.

It shows that the use of clustering algorithms may have a better consequent in road extraction from color map through experiments.

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