ISBN 978-981-11-3671-9
Proceedings of 2017 the 7th International Workshop on Computer Science and Engineering (WCSE 2017)
Beijing, 25-27 June, 2017, pp.307-312
doi: 10.18178/wcse.2017.06.053

Recognizing and Extracting of Rivers in Colorful Map

Na Wang[+]

Information Engineering Department, Liaoning Jianzhu Vocational College, LiaoYang, China

Abstract. The method of recognizing and extracting the rivers in colorful map is studied. There is a binary extracted method to be proposed: based on gray image, and there are some related problem to be introduced, for example: gray convert, binary, thinning and vectorization. Through the study, there is result that this method is not only simple and fast, but also is able to realize the process of binary when the rivers are extracting. At last, this extracted method is used to the certain area map, and obtains the good experiment result.

Keywords: river extraction, gray convert, binary, thinning, vectorization.

1. Introduction

In recent years, the rapid development of geographic information system technology in resource management, urban planning management, transportation and military is widely, and many other aspects. With the increase of the amount of geographic information, the batch processing of geographic information and the manufacturing of high performance computers, the processing of massive geographic information is becoming more and more quickly. The artificial recognition is a time-consuming and laborious task. The recognition of geographic information is becoming a bottleneck in the development of geographic information system. Map data of scan input and automatic extraction of research by more and more attention[1].

Recognizing and extracting of rivers in the map is an important part of the geographical information recognition and extraction. At present, people have done a lot of research on how to identify and extract rivers from the color map, and many methods are put forward; However, these methods are summarized, nothing more than three kinds of: (1) river recognition and extraction based on map topology; (2) river recognition and extraction based on map color feature; (3) combining the above two methods to identify and extract the river.

In a normal map, including water system, vegetation, topography, traffic, boundary, zoning, building and other major categories of geographical elements. Different elements are represented by different colors in the map. Such as water system in blue, road in brown or black, etc. Therefore, in the map recognition system, we can consider the color as the basic feature, according to the different colors of the geographical elements to be separated, so as to obtain the color map, that is, the recognition of the map elements convert to identify the color.In a normal map, including water system, vegetation, topography, traffic, boundary, zoning, building and other major categories of geographical elements. Different elements are represented by different colors in the map. Such as water system in blue, road in brown or black, etc. Therefore, in the map recognition system, we can consider the color as the basic feature, according to the different colors of the geographical elements to be separated, so as to obtain the color map, that is, the recognition of the map elements convert to identify the color.

[+] Corresponding author. Tel.: 15941959416.
E-mail address: + *wnbird@hotmail.com.*

As everyone knows, any color can be red (R), green (G) and blue (B) three kinds of color combination, records of monochromatic image pixel gray value need to use a byte; In the color image, each pixel will need at least 3 bytes to record three primary colors of grey value respectively. Accordingly, in order to make the process more simple and speed up the processing speed, we use a method based on the gray image of binarization to extract the river, that is to transform the color image into gray image, then point discriminant grey value and binarization method is used to extract the rivers information in the map.

2. Implementation Steps

Before the identification and extraction of river information, the color map is scanned into a computer by a scanner.

2.1. Gray conversion

2.1.1. Theoretical basis

Colors can be divided into black and white, gray and color. In the practical application of the image, we often need to convert color images to gray image. By color into gray process called grayscale processing, it is to make R = G = B in the RGB model. Gray processing is containing the brightness and color of the color image into gray image process.

Normally the gray value of a pixel in a black and white image is represented by a byte, and the value is between 255 and 0, the value is greater, the more white, the more light, the value is smaller the more black. Conversion formula [2]:

$$\text{Gray}(i, j) = 0.3R(i, j) + 0.59G(i, j) + 0.11B(i, j) \quad (1)$$

Among them, gray (I, J) is the gray value of the black and white images in (I, J) point , we can observe this formula, the proportion of green the largest, so the G value can be directly used as gray after conversion.

In gray image, each pixel is represented by 8 bits, so it can show 256 (28) levels, so the range of the component value is (from 0 to 255), so the gray image can only show 256 colors, and the gray images only gray and no color.

2.1.2. Processing step

The maximum value of the 3 components is used as the gray value. Specific processing steps are as follows:

- to obtain the copy of the image file;
- to obtain a pointer of data area, get the pixel of red, green, blue three score;
- compare the red, green and blue three values to obtain the maximum value;
- the maximum color value is returned to the red, green and blue three components;
- display image.

2.2. River extraction

We need to preserve the gray image, and then use the software to get the gray value of the river information. This is an important preparation for river extraction.

In order to extract the gray river information from the map, it can be used to distinguish gray value and use the method of binarization to realize the extraction.

2.2.1. Binarization

In order to facilitate the identification and extraction of map information, usually needed to division the gray image or layered color image to generate binary images. The purpose of binarization processing is to segment the map elements from the map gray image and transform it into binary images. At present, the most commonly used map scanning image binarization method is fixed threshold binarization method, which can obtain satisfactory results for the larger contrast map image. But in practical application, it is often encountered in the map of the smaller contrast between the line and the background, the use of the fixed threshold method is difficult to obtain the ideal results, mainly due to select threshold only considers the gray image without local gray feature of image. To this end, we have made a variety of improvements to the fixed threshold binarization method, and proposed a variety of binarization method with local characteristics,

which has a representative method of variable threshold method, adaptive method and the optimal threshold method, etc [3].

1) Fixed threshold binarization method

Sets the range of map gray image [g_1, g_2], can choose a appropriate gray image threshold G $\in$ [g_1, g_2], The gray value of each pixel can be completed as follows: binarization of the map image, that is:

$$I(i, j)=\begin{cases} 1, & \text{if } g(i, j) \geqslant G \\ 0, & \text{if } g(i, j) < G \end{cases} \tag{2}$$

Among them, I (i , j) is the image value of any pixel (i , j) in the binary image, g(i, j) is the gray value of gray image.

In the image gray level range, also can choose two thresholds G1 and G2, G1,G2$\in$[g_1,g_2] and G1 < G2, and for each pixel gray value transform as follows:

$$I(i, j)=\begin{cases} 1, & \text{if } g(i, j) \in [g_1, g_2] \\ 0, & \text{if } g(i, j) \in [0, g_1] \cup [g_2, 255] \end{cases} \tag{3}$$

Use this formula to image of a gray scale in a map image binarization locally.

2) Variable threshold binarization method

For any pixel in the image n, the threshold can be obtained by the following formula:

$$T_n= K_n* STDDEV_n+ MEAN_n \tag{4}$$

Among them:

$$\begin{aligned} K_n&=a*HIST_n /M , \\ MEAN_n&=\sum Pi /9 , \\ STDDEV_n&=\sum [(Pi-MEAN_n)^2/9]^{0.5} \end{aligned} \tag{5}$$

In the above various formulas, n$\in$[1,M]， M is the total number of image pixels; Kn expressed pixel, it is determined by the gray histogram $HIST_n$ of the pixel n and the constant a and M; Pi is pixel n 3 x 3 window 9 adjacent pixel gray value, $MEAN_n$ is the standard variance of pixel n.

From the above calculation formula, it can be seen that the algorithm for each pixel to choose different thresholds, and considering the 3 x 3 window adjacent pixel gray value, good for the local characteristics.

3) Adaptive binarization method

Adaptive binarization method is based on curve detection technology, in the window of the 5 * 5,operator half curve is used to determine whether the central point of the window is the point of the curve. Considering length is 3 pixel curve segment, can be summed up 18 kinds of circumstances:

Curve detection is defined as follows:

BS+T<AS and BS+T<CS

Among them, BS=B_1+B_2+B_3; AS=A_1+A_2+A_3; CS=C_1+C_2+C_3. Here, B_1, $B_2$and B_3 are the gray value of the curve, A_1, A_2 and A_3 are the gray values of the adjacent points on the curve, C_1, C_2 and C_3 are the gray values of the adjacent points on the other side of the curve, B2 as the test point. If one of the 18 situations makes B2 meet the above formula, the B2 as a point on the curve, the image value is changed to 1, otherwise it is 0.

Both the variable threshold binarization and the adaptive binarization method take into account the local features, which can effectively inhibit the lines broken and adhesion, the disadvantage is easy to produce a lot of noise.

4) Optimal threshold binarization method

This method is an improvement of the method of the variable threshold binarization. It uses the method of general threshold and local threshold on the selection of the threshold:

$$I(i,j)=\begin{cases}1, & \text{if } g(i,j)<\min(T_{total}, T_{local})\\ 0, & \text{other}\end{cases} \quad (6)$$

Among them, the Tlocal is a local threshold, determined by method 2; Ttotal is determined by the two dimensional entropy which takes into account the overall nature and the local characteristics.

The basic idea of this method is that the amount of information available in the whole image is the largest, and the amount of information is measured by entropy, so the threshold value is optimal when the maximum entropy value is obtained. Two-dimensional entropy is decided by using two-dimensional spatial distribution of gray (that is,the joint probability of each pixel gray value and the average grey value of the pixels and surrounding pixels).

Set image grayscale m different values, then the average gray level there are m different values, each pixel gray value and the average gray value are a pair, each pair is a two-dimensional units. The total number of two dimensional unit is m * m, and the total number of pixels is M * N. Each pair of gray values i and j appear in the frequency of f_{ij} and the total number of pixels M x N ratio is defined as the joint probability P_{ij}, namely :

$$P_{ij}= f_{ij} /(M \times N)$$

Among them, I, j∈[1,m]， there are clearly: $\sum_{i=1}^{m}\sum_{j=1}^{n} P_{ij}=1$. Assuming that the image is made up of two parts of the foreground A and background B,the joint probability distribution of the foreground A is P_{ij}, i∈[1, s]， j∈[1, t],the joint probability distribution of the background B is P_{ij}, i∈[S+1, m], j∈[t+ 1, m], then the probability density distribution:

$$A:\frac{P_{11}}{P_{st}},\frac{P_{12}}{P_{st}},\ldots,\frac{P_{st}}{P_{st}}; \qquad B:\frac{P_{s+1,t+1}}{1-P_{st}},\ldots,\frac{P_{mn}}{1-P_{st}}; \quad (7)$$

Among them, s is the foreground gray threshold, t is the corresponding average gray value, $P_{st}=\sum_{i=1}^{s}\sum_{j=1}^{t} P_{ij}$. Thus the entropy of A is:

$$H(A)=-\sum_{i=1}^{s}\sum_{j=1}^{t}(P_{ij}/P_{st})\ln(P_{ij}/P_{st})=\ln P_{ij}+H_{st}/P_{st}$$

among them, $H_{st}=-\sum_{i=1}^{s}\sum_{j=1}^{t} P_{ij}\ln P_{ij}$. In the same way, the entropy of the background B is: $H(B)=\ln(1-P_{St})+(H_{mn}-H_{st})/(1-P_{St})$, therefore, global entropy: $\Phi(s,t)=H(A)+H(B)$.

When *(s, t)* take a value that$\Phi(s, t)$ is the largest, then the value *(s, t)* is the optimal threshold.

2.2.2 River extracted

Here we use the principle of binarization method to extract the river information on the map, namely:

$$I(i,j)=\begin{cases}1\ , & \text{if } g(i,j)=\text{Gray value of river}\\ 0\ , & \text{Other}\end{cases} \quad (8)$$

In fact, the operation of this step not only realized the extraction of the river, but also realized the processing of binarization, which is a good preparation for the future thinning and vectorization.

2.3 River thinning and vectorization

2.3.1 River thinning

Map image thinning is a process by which a certain algorithm can get rid of the edge points in order to get the skeleton. It is an important link in the two value image processing field, which is the basic technology of image analysis, information compression, feature extraction and pattern recognition. It requires the

complete preservation of the topological structure of the image, the main features and the original image is corresponding, in order to replace the original image for transmission and processing. Thinning for processing and analysis of the linear elements, note text skeleton line extraction is very meaningful.

Thinning method are many, the commonly used a template matching method, the image edge search coding method, the outer contour calculation method, the neural network method and mathematical morphology method, etc. From the processing process can be divided into sequential processing and parallel processing two types, when the current pixel is deleted or retained, the sequential processing method both to use the results of the previous treatment, but also to use the results of this processing; When the current pixel is deleted or retained, the parallel processing method only uses the result of the previous processing, and the obvious characteristic of the parallel processing method is to facilitate the hardware realization.

In this paper, we use mathematical morphology method to realize river image thinning. Mathematical morphology algorithm is a nonlinear filter, widely used in the field of computer and image processing. Based on the morphological, mathematical morphology is analyzed, according to different purposes, different types of structural elements are selected to interact with the target image, form the morphological transform of the image, so as to achieve the purpose of image analysis and feature extraction [4]. Specific implementation is briefly as follows:

Set X as river image, B as structure element. We can know from the knowledge of mathematical morphology, thinning of basic morphological operations (denoted as X○B),can be used to make x according to certain rules continue to shrink, and always maintain the X○B contained in X. According to this characteristic, we can by choosing appropriate structure elements, the X in the process of thinning connected properties remain the same, so as to realize the thinning of the rivers image. Among them, the structure element is not fixed in shape and size. It is designed with the algorithm of morphological transformation, and then it is designed according to the shape features of the target image and the required information. For different target images, different structure elements and processing algorithms are needed. The selection of structural elements is very flexible and changeable, and the shape and size of the structure element is appropriate or not, which will directly affect the thinning results of the target image. It can be said that the structure element is the mathematical morphology image thinning algorithm is superior to other image thinning algorithm. Here, we use two structural elements as shown in figure 1:

$$\begin{pmatrix} 0 & 0 & 0 \\ * & 1 & * \\ 1 & 1 & 1 \end{pmatrix} \qquad \begin{pmatrix} * & 0 & 0 \\ 1 & 1 & 0 \\ * & 1 & * \end{pmatrix}$$

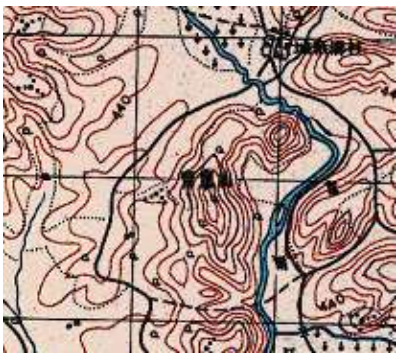
Fig. 1 Two kinds of structural elements B

2.3.2. River vectorization

When the vector of the river, we adopt the classic method of vectorization: contour tracking method [5], namely the linear object on the skeleton image (can also be understood as a thinning image) is regarded as a connected roads, the traversal of the connected roads is carried out to connect all the pixels on each connected path to form a chain type or a coordinate string. The basic idea is as follows: in front of an edge point information as a guide, based on the current edge point, the search forward, to find a complete contour curve. Accept an edge point, giving the direction signs, so that each edge point together.

3. Experimental Resultsand Conclusions

In order to verify the practicability of the binary extracted river method based on gray image, we have done experiments on the map of a certain area, and the experimental results are shown in Figure 2:



(a) Original image

(b) Extraction result

Fig. 2: River extraction

The binary extracted method based on gray image, the biggest characteristic is easy to implement, fast extraction. Using this method, the information of the river is extracted, and the binary processing is completed, which is a good preparation for the following thinning and vectorization. From the experimental results, this method is not only feasible, but also has a better extraction effect, that is, line positioning accuracy, good continuity, noise is very little.

4. References

[1] Haitao, BaoYuan lv, JiFang. Road Extraction based on the noise characteristics of color raster map [J]. Microcomputer and Application, 2004, 8: 50-52.

[2] Yang Shuying. VC++ image processing program design [M]. Beijing: Tsinghua University press. 2003. 284-286.

[3] Guo Hu. Research on preprocessing of scanned image of topographic map [D]. Shanxi: Master's degree thesis of Taiyuan University of Technology, 2002.20-24.

[4] Guo Ling, Zhou Xianzhong, Huang Zhitong. Pixel edge gradient algorithm is used for map image color separation [J]. Computer engineering and application, 2002,19：108- 109, 113.

[5] Zou Xiuming. Research on the vectorization key technology of raster map[D]. Nanjing: Master's degree thesis of Nanjing University of Science and Technology, 2001.41-43.