Remote sensing image block segmentation and extraction based on the regionalized image segmentation algorithm

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Abstract: The quantity and quality of cultivated land in a country is the key to maintaining sustainable agricultural development. Satellite remote sensing images can be used to identify and extract cultivated land and conduct remote sensing mapping of cultivated land. Accurate distribution of cultivated land can provide important support for national decision-making departments. This paper uses a color model based on RGB and HSV conversion and uses MATLAB to extract non-cultivated land images for data binarization and denoising processing operations and introduces regional image segmentation algorithms, watershed algorithms, and clustering algorithms to solve the problem of unclear boundaries further. The C++ image processing algorithm is built based on Visual Studio and OpenCV, and the proportion of cultivated land is determined by calculating the proportion of black and white pixels of the annotated picture. The actual cultivated area is further estimated to achieve good results.

1. Introduction

The quantity and quality of cultivated land in a country is the key to maintaining sustainable agricultural development. Satellite remote sensing images can be used to identify and extract cultivated land and conduct remote sensing mapping of cultivated land [1]. Accurate distribution of cultivated land can provide important support for national decision-making departments. At present, the extraction of high-precision farmland information mainly relies on manual interpretation, which consumes a lot of manpower, financial resources, and low efficiency. Therefore, the research of farmland recognition algorithms for remote sensing images will provide important help for farmland remote sensing mapping.

2. Problem analysis

In order to extract arable land from the data, make arable land labels, and calculate the proportion of arable land, this paper adopts the method of image separation and color extraction to form the first layer of constraints, which separates construction land from land and removes it from the map [2]. The color difference is used to extract the cultivated land, and the cultivated land is distinguished from the non-cultivated land through the statistical color range value, forming the second layer of constraints and separating the cultivated area of the test map. However, the separated outline is not clear, so it needs to be corroded continuously, and finally, the label image is obtained. This paper proposes to process images based on HSV and RGB conversion color model, extract farmland, use regionalized image segmentation algorithm to advance boundary optimization, make better use of the information part of image color, and the processed image gradient is closer to the shape of the natural cultivated land [3].

Then calculate the arable land area of each map using the marked preview image obtained from the satellite remote sensing image map obtained by remote sensing technology. The marked map has been given in the contest question. We only need to figure out the proportion of white pixels—the proportion of cultivated land [4].

3. Establishment of the farmland segmentation model

In this paper, RGB and HSV conversion methods are used for farmland segmentation, and then regionalized image segmentation algorithms and watershed algorithms are used to clarify the boundaries further.

3.1 Convert color model based on RGB and HSV

Traverse each pixel of the image and distinguish between cultivated land and non-cultivated land by counting the color range values. Each value of RGB is between 0-255. When expressing colors, three numbers can be used to express: red: (255, 0, 0), green: (0, 255, 0), blue (255, 255, 255). After traversing the picture many times, collecting the different color point sets in the remote sensing image, the statistical results in Table 1 are obtained. (Including only part of the color range).

Table 1 Example data RGB color distribution of cultivated land

Area	Color	RGB value
Value farming area (Statistics are not made in non-farming areas)	Brown (dark color)	(70, 19, 82)
		(68, 15, 67)
		...
	Brown (light color series)	(8, 34, 137)
		(17, 28, 147)
		...
	Green (dark color)	(71, 55, 92)
		(77, 71, 72)
		...
	Green (light color series)	(65, 90, 127)
		(38, 25, 150)
		...
	Cyan and Black	(0, 3, 78)
		(10, 10, 79)
		...

This article uses MATLAB to show the matrix of each picture and generate a 600*500 matrix table. Use EXCEL for statistics. According to the statistics of 8 data graphs, get the range of different RGB data, as shown in Table 2.

Table 2 Data RGB color distribution of cultivated land

Color representation	R	G	B
Green Land	18-74	54-255	60-201
Brown Land	0-29	20-117	78-179
Cyan and Black Land	13-150	32-255	2-65

Perform binarization denoising processing. Create a white base image, extract the color of the cultivated land division of the picture according to the requirements, and copy it on the white base image. Part of the non-cultivated land area is extracted in Figure 1. After the initial extraction, it was found that some cultivated land was extracted, the result was not accurate enough, and the boundary processing was not apparent.
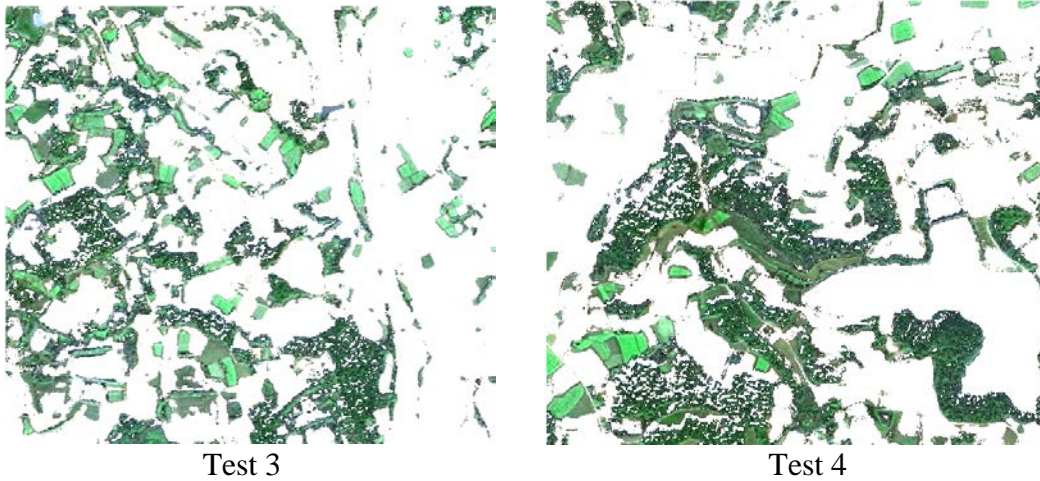
Test 3   Test 4

Figure 1 Preliminary extraction of land features

3.2 Regionalized image segmentation algorithm

For the binarized and denoised image after the land extraction, the difference between cultivated land and non-cultivated land cannot be distinguished, so this article uses a regionalized image segmentation algorithm. To better present the extracted image, the original image is first created to split the original image to form different sub-datasets. Then the color of the cultivated land of the picture is extracted according to the requirements for boundary extraction, and the picture is finally displayed and saved.

The regionalized segmentation algorithm is used in the color space. It is more practical for image segmentation than threshold classes and clustering, and it is relatively simple. This article carries out the image corrosion operation based on the conversion method of RGB and HSV color space.

The corrosion formula is:

$$\varphi_n(E)(a,b) = min\{ E(a + a_0, b + b_0)|(a + a_0, b + b_0) \in O_1; \} \qquad (1)$$

While, $(a_0, b_0) \in F_n$.

The color characteristics of each pixel:

$$C(x,y) = \sqrt{\vartheta_1 H(x,y)^2 + \vartheta_2 S(x,y)^2 + \vartheta_3 V(x,y)^2} \qquad (2)$$

Among them,$H(x,y), S(x,y), V(x,y)$ represent the components of H, S, and V, and represent the weight coefficient.

After we use Arcgis pro to read the tif-format picture, we get the three-band picture effect, and the grayscale picture is shown in Figure 2.
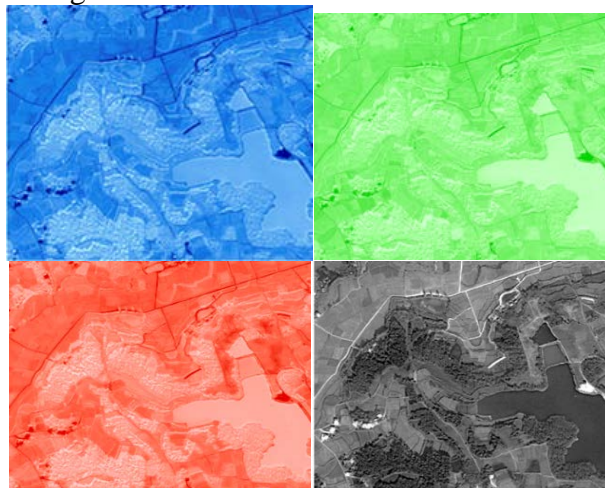

Figure 2 Three-band and pixel gray average picture display (take Test4 as an example)

On the basis of the corrosion operation, the image is binarized, and the denoising process is performed to obtain the label image, as shown in Figure 3.
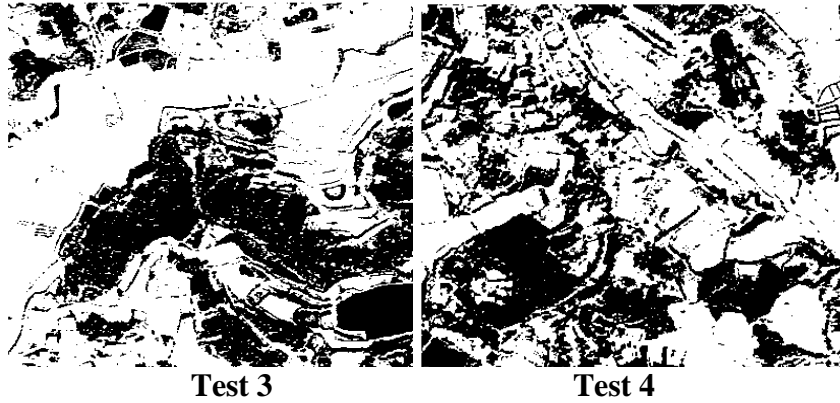

Test 3   **Test 4**

Figure 3 Binarization and noise reduction image

3.3 Watershed algorithm

Based on the regionalized image segmentation algorithm, this article uses the watershed algorithm to optimize. That is, the entire landform is put into the water, the low-height area will be submerged, and the buildings and forest areas will be highlighted, forming a catchment basin. It is good to delineate the boundary area between cultivated land and non-cultivated land [5].

The general assumption is that an image $R(x, y)$ is used to represent the gradient map of the color image $C(x, y)$ to be segmented. Let $Q_1, Q_2, Q_3,\dots$ denote the set of coordinates of each local minimum point in the gradient image $R(x, y)$, use $U(O_i)$ to denote the set of coordinates of all pixels in the catchment basin 1 that are connected to the local minimum point, and use $A(u)$ to denote the set of coordinates (m, n), of which

$R(m, n) < u$.

$$A(u) = \{(m,n)|R(m,n) < u\} \tag{3}$$

Let $U_u(O_i)$ denote the set of coordinates of all pixels in the catchment basin, then in the u stage $U_u(O_i)$ can be regarded as a binary image, which is

$$U_u(O_i) \cap A(u) \tag{4}$$

Let $U(u)$ denote the collection of pixels submerged by water in the first stage of the catchment basin.

$$U(u) = \bigcup_{i=1}^{K} U_u(O_i) \tag{5}$$

Let $U[max + 1] = \bigcup_{i=1}^{m} U(O_i)$ denote the collection of all catch basins.

At the beginning of the algorithm, assume $U[max+1]=A[max+1]$, and then the algorithm enters the recursive call cycle. It is assumed that $U[u-1]$ has been built in step u, let N be the set of connected components in $A(u)$, use structural elements of size 3×3 to expand $N \cap U[u-1]$ and limit the expansion to N Within, high spots can be formed. Because this will affect the previously processed image after corrosion and denoising, the resulting boundary area will be covered. There are three errors: one is that the segmentation algorithm used does not have a precise boundary location, and the other is that the non-cultivated area will be treated as a cultivated area. It is not separated, and the third is that a new area is added to the divided image. Therefore, clustering can be used to combine to reduce the impact of the watershed.

Assuming that there are m homogeneous regions after the watershed, with parameters ε_0 and probability λ_0, it is the mixed parameter estimation of step n. After calculating the nth iteration process, the probability that a certain area i is classified into j category is $P_{ij}(n+1)$

$$P_{ji}^{(n+1)} = \frac{\lambda_j^{(n)} f(\bar{x}_i; \varepsilon_j^{(n)})}{\sum_{k=1}^{n_1} \lambda_k^{(n)} f_k(\bar{x}_i; \varepsilon_k^{(n)})} \tag{6}$$

$$\lambda_j{}^{(n+1)} = \frac{1}{m} P_{ji}{}^{(n+1)} \tag{7}$$

$$\eta_j{}^{(n+1)} = \frac{\sum_{i=1}^{m} P_{ji}{}^{(n+1)} \cdot \bar{x}_i}{\sum_{i=1}^{m} P_{ji}{}^{(n+1)}} = \frac{\sum_{i=1}^{m} P_{ji}{}^{(n+1)} \cdot \bar{x}_i}{m \, \lambda_j{}^{(n+1)}} \tag{8}$$

$$\psi_j{}^{(n+1)} = \sqrt{\frac{\sum_{i=1}^{m} P_{ji}{}^{(n+1)} \cdot (\bar{x}_i - \eta_j{}^{(n+1)})^2}{\sum_{i=1}^{m} P_{ji}{}^{(n+1)}}} = \sqrt{\frac{\sum_{i=1}^{m} P_{ji}{}^{(n+1)} \cdot (\bar{x}_i - \eta_j{}^{(n+1)})^2}{m \, \lambda_j{}^{(n+1)}}} \tag{9}$$

In each iteration process, the energy value of the regional feature is solved, and the *above formula: obtains the n+1th energy expression*

$$E^{(n+1)} = \sum_{i=1}^{m} (-\log(\sum_{j=1}^{n} P_{ji}{}^{(n+1)})) \tag{10}$$

In this process, when parameter ε approaches a certain minimum value, its change trend is shown in Figure 4.
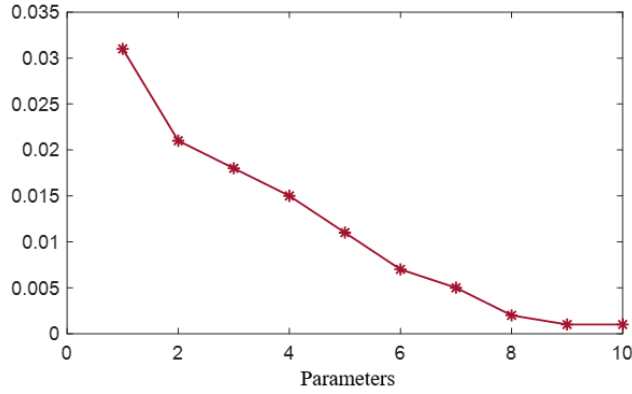

Figure 4 Parameter change trend

3.4 Test Results

After getting the segmentation results, we need to fill the holes to make the edges clearer and smoother. The following figure 5 is the final processing result we got.

Figure 5 Test label diagram

Import and run the annotated reference preview image based on OpenCV-based c++. This article uses an Image Processing (imgproc) image processing module to calculate the proportion of white pixels. Configure the environment first, then create a new project and run the code. The implementation code is:

Mat element = cv::getStructuringElement(MORPH_RECT, Size(3, 3));

The configuration environment is Windows10, VS2015community. After configuring the environment, place the marked picture in the corresponding program folder of the running program. After reading the picture, go through all the pixels, and the computer records the black and white pixels of the picture. The number of points, respectively, output the number of black, white, and total pixels,

calculate the proportion of each pixel, and finally, the proportion of white pixels is the proportion of cultivated land [6].

Table 3 Data details

project	Number of white pixels	Number of black pixels	Total number of pixels	Percentage of white pixels	The proportion of cultivated land
Test3	206383	93617	300000	68.79	68.79
Test4	175240	124760	300000	58.41	58.41

4. Conclusion

In this paper, the initially extracted cultivated land data is binarized and identified. After inverting the color of the picture, the cultivated land appears white, and the non-cultivated land appears black, but the outline of the cultivated land and the non-cultivated land is not clear. The difference between cultivated land and non-cultivated land cannot be clearly distinguished for the binarized image after extracting the land. We use MATLAB to corrode the image to make the outline clear. After introducing the watershed algorithm, the result obtained is more accurate.

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