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Vector Quantization Method Based on Satellite Cloud Image

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Abstract

Automatic vectorization in the field of image processing and recognition is one of development direction. This paper does some relevant researches on satellite cloud image preprocessing, image segmentation, image vector quantization. To improve the effect of noise reduction and preserving image details, this paper puts forward an improved adaptive median filter algorithm; For increasing the speed of image segmentation, this paper puts forward automatic layering algorithm combined with color information. Finally, this paper puts forward automatic vector quantization algorithm based on satellite cloud images and we developed an automatic vector quantization prototype system of satellite cloud images. The research results suggest that our automatic vector quantization algorithm has satellite cloud information automatic extraction function, identification function and vector quantization function.

Keywords: *Satellite cloud image; Vectorization; Image segmentation; Edge detection; Feature point set*

1. Introduction

Satellite observation about Earth has become an indispensable source of information. Meteorological satellite remote sensing technology can provide meteorological satellite nephogram materials any previous detection means can't compare with, which makes meteorological satellite play an extremely important role in the field of analyzing weather forecasts and monitoring atmospheric environment. Meteorological satellite can identify some information in nephogram, such as, cloud species, attributes and precipitation, by analyzing and applying the features of shapes of satellite cloud images, their structures, their brightness and their textures.

At present, the main way of satellite cloud image analysis are still the traditions methods that the staff makes subjective judgment by taking visual look at these images, which easily influenced by subjective factors of analysts. The analysis mode makes it difficult to fully extract and maximum use all information contained in satellite images, which hinders the development trend of automated and quantitative production of weather forecasts.

Meteorological satellite is the most efficient way to acquire weather information and monitor changes in the weather. Based on satellite nephogram processing technology, meteorological satellite vectors satellite images, extracts characteristic information of the main target. Meteorological satellite plays a very important role in processing and analyzing the information on large-scale air environment and marine environment. Vectoring satellite images makes the analysis of satellite images be fast, accurate and scientific, develops qualitative development to quantitative development and accelerates the utilization of available satellite data, improving the application value of satellite images in meteorology, marine meteorology, forestry and other fields.

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At present, many researchers have been done on image vectorization at home and abroad, which create many scientific achievements. For example, Ailing De proposed a fusion method for image segmentation by jointly utilizing vector quantization and edge detection methods and SOM neural network adaptive vector quantization algorithm [1]. Pascal Barla researched two different categories of methods for producing vector gradients in his paper [2]. Ajalmar proposed a novel method, called Opposite Maps to train two vector quantization algorithms [3]. And, Zhang Xiangquan proposed the algorithm of boundary vectorization in binary images based on control points [4]. All of these analysis and researches have a good reference value. However, the object of those researches is mainly concentrated on the engineering areas of machinery, construction and electronics, such as, vectorization researches on engineering drawings, landform maps and electronic circuit diagrams [5-6]. While the vectorization based on meteorological images is rare.

Proceeding from the reality, the paper comprehensively analyzes available theories, strategies and methods on image vectorization based on the features of satellite images. It mainly researches raster image vectorization method based on the extraction of planar information and application technology, explores the causes of satellite image errors and proposes an improved adaptive median filtering algorithm. The paper analyzes color features of satellite image and proposes the automatic slicing algorithm combined with color information. Combining theory and reality, the paper proposes vectorization based on satellite images and develops automatic vectorization prototype system of satellite images.

2. Satellite Cloud Image Preprocessing

There exist various noises in original satellite images which seriously interfere with the analysis and processing of cloud charts. Gaussian noise and pepper-and-salt noise are two main kinds of these noises. If binarization processing is immediately taken on satellite images, extracted boundaries of target images will not only be jagged, have gaps or extrudes but also have breakages, adhesion, holes and noises after binarization processing will exert certain influence on subsequent recognition of satellite images. On this basis, if edge extraction is directly conducted, the edge will become irregular and there will be many little forks and rags around target edges. If there are holes in planer target, they will be regarded as marginal information in the subsequent edge extraction, which will not only make the result of edge extraction messy but also acquire many fake feature points, resulting in errors in evctorization.

Satellite image preprocessing mainly consist of denoising or filtering images in order to improve the quality of images. Current methods of filtering images or denoising are mainly median filtering, Gaussian filtering and offset median filtering, all of which are proved to be useful in image processing. However, they are far from perfect filtering, whose reason is that details of images such as boundaries, edges and lines are blurred and has no good effect while denoising. In order to make a compromise between denoising images and strengthening boundaries, this paper proposes an improved adaptive median filtering algorithm based on B-spline function to process images.

2.1. The Improved Adaptive Median Filter Algorithm

The filtering effect of median filtering algorithm is inhibited by the size of the filter window; the size of the filter window has a great influence on the performance of the median filter. When the window is small, the algorithm can protect the image detail, but the filtering performance is weak, cannot effectively eliminate the noise. When the window is larger, the algorithm will have strong ability of filtering, but can make the detail of the image is missed, damage some useful details of images.

To solve the contradiction between preserving image detail as much as possible and noise reduction, this paper combines the advantages of each window size, uses the noise density function $\rho(W_{i,j})$ from adaptation to determine the size of the filter window.

$$\rho(W_{i,j}) = \sum_{k=-1}^{1} \sum_{r=-1}^{1} N(i+k, j+r) \tag{1}$$

Where $N(i+k, j+r)$ is the noise sign of pixel point $(i+k, j+r)$. If $f(i, j)$ has been identified as noise pixels, we should adjust the filter window size $Filter\_W_{i,j}$ according to $\rho(W_{i,j})$. The rules are as follows:

$$Filter\_W_{i,j} = \begin{cases} 3 \times 3, if\ 0 < \rho(W_{i,j}) < 4 \\ 5 \times 5, if\ 4 \le \rho(W_{i,j}) < 7 \\ 7 \times 7, if\ 7 \le \rho(W_{i,j}) \le 9 \end{cases} \tag{2}$$

The process of adaptive adjust the size of filtering window is shown in Figure 1.

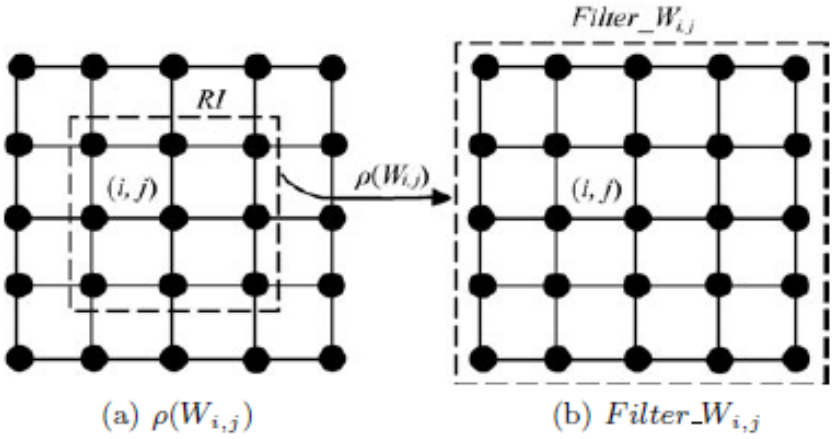


Figure 1. Adaptive Adjustment of the Process of Filtering Window Size

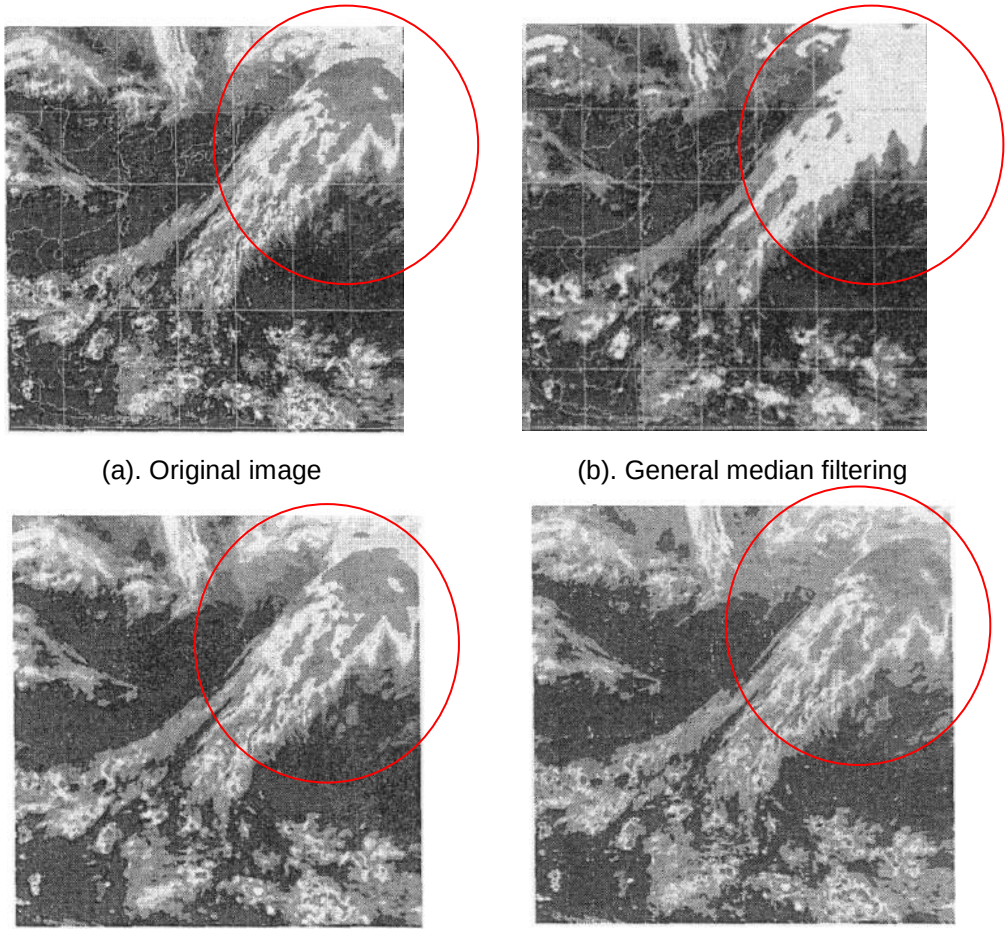
The steps of improved algorithms are as follows:

1. Based on B-spline discrete convolution and the human eye visual contrast sensitivity of the system, and noise sensitive coefficient is calculated for each point, and adaptively determine whether that point to the noise pixels.
2. According to the number of noise points in the sliding window adaptively adjust the size of filter window.
3. Using median filter, remove the obvious noise pixels.

2.2. Experimental Results and Analysis

In order to test the effectiveness of the algorithm, we experimented with satellite cloud pictures. Take Figure 2 as an example, Figure 2(a) is original image for the satellite cloud map; Figure 2(b) is the preprocessing denoising results after general median filtering method. Figure 2(c) is the map that obtained after median filtering based on B-spline function. Figure 2(d) is the map that obtained after filtering with the improved adaptive algorithm this paper proposed. After contrast, we can see that ordinary median filtering method processing images has faster calculation speed, can eliminate impulse noise, but it passivates the image details and reduces the quality of the image to a certain extent. And after median filtering based on B-spline function, all the noticeable noise in the original

map of the satellite cloud map have been filtered, and the image edge information is more clear than Figure 2(b). We can see that, from Figure 2(d), using the adaptive median filter algorithm processing image, not only filters a lot of noise, but also retains much more original image details than the Figure 2(c). This algorithm is suitable for the pretreatment of the satellite cloud image denoising.



(a). Original image (b). General median filtering

(c). Median filtering based on b-spline function (d). The adaptive median filter

Figure 2. Image Filtering Experiment

3. Satellite Cloud Image Segmentation

The purpose of image segmentation is detecting and measuring for interested target in the image and isolating specific part from the image background. Image segmentation is the process of dividing an image into different features and each other is not the area of overlap, and the process of extracting the required parts (foreground). Actually, it is a process of marking the image.

3.1. Satellite Cloud Image Background

In a satellite cloud image, the prospect that the image segmentation required is the surface shape information of clouds each layer, and the rest are background. Satellite cloud image segmentation firstly separates the prospect cloud information from the mainland background ocean area. The article adopts the method of threshold segmentation to separate the background of satellite cloud image [7].

Threshold segmentation method is a kind of spatial segmentation technology based on space of image region. It divides the set of image pixels into several groups by setting

different fixed threshold. This method can be used for a contrast image between foreground and background, and its basic rule is: all the images whose grayscale value less than or equal to the threshold value's image pixel are prospect targets, and all images whose grey value is greater than the threshold value's pixel belongs to set of background. Threshold segmentation method, as long as chooses the correct threshold, it will generate a better segmentation effect to the images that have lager contrast. And the computational process is simple. This method has a better effect only for the images which foreground and background in image gray value contrast is big.

But in general, grey values of the background in satellite cloud images are not fixed, and the contrast between clouds targets of the prospect and background also exists certain change, at this time will not be able to use a fixed threshold of image segmentation, because this threshold may be in the area of the image can get good effect, but it does not apply to the image of other areas. In order to solve this problem, we can change fixed threshold into a variable, which can be expressed as a function to the threshold value, and this function is slowly changing as the image position, that is, according to the different characteristics of each region, to choose different thresholds. This is the adaptive image threshold segmentation method.

More mature image segmentation methods in recent years based on adaptive threshold which is proposed by Quoc Bao and Byung Ryong [8]. This method is using the gray distribution of image to get adaptive threshold of images, the specific ideas is that the whole image is divided into several equal subarea, which do not overlap each other, then the best threshold corresponding to each subareas is calculated by these image gray histograms, then the threshold of whole image segmentation is calculated through threshold deviation calculation. This method takes the local information of image into consideration while determining the threshold, so its effect is obviously better than the effect of the fixed threshold segmentation method.

In this paper, the above algorithm was improved for image segmentation and separating the background on satellite cloud pictures. The main way of the algorithm is as follows. Firstly, the satellite cloud image is divided into $N(N = 4n, n = 1,2,3,\ldots)$ mutually disjoint sub image. Then, calculate the mean of all the pixels in each sub image and set this mean as point threshold of the corresponding subarea. Finally, separately for each sub image area use the corresponding point threshold for image segmentation.

Specific steps of the algorithm are as follows:

1. To block the satellite image. The satellite cloud image is divided into a mutually disjoint sub image.

2. Each sub image points threshold. All pixels in each sub image area's average for their respective point threshold.

3. According to their respective points for each sub graph segmentation threshold, separate the structures with the background. Because each pixel mean of every graph is different. In order to improve the accuracy of image segmentation, we need to make image segmentation for each sub image with their respective point threshold.

The advantage of improved adaptive threshold image segmentation algorithm is: it not only takes the image grey value of pixels itself into account, but also takes the characteristics of pixels around the neighborhood into consideration. Both concerning about the global image features and concerning about local characteristics, which is a kind of integrated adaptive threshold segmentation algorithm. In the algorithm, with the increase of the number of the sub image, the segmentation will be more and more sophisticated, the better the satellite cloud image segmentation effect will be. But with the increase of N, the amount of calculation of the algorithm also becomes larger.

Considering the efficiency and real-time performance of the algorithm, the general take more appropriate.

3.2. Satellite Cloud Image Hierarchical Rules

Because the resulting satellite cloud picture processed by the vector quantization needs to include hierarchical information of clouds, so the clouds will be divided into several orders of magnitudes, that is, we need extract the corresponding information from the original gray image.

In the basic processing of satellite cloud images, there is a pseudo color processing for satellite cloud pictures. Pseudo color processing of satellite cloud picture is in order to make the human eye can observe more information from the satellite cloud image, is the image of the grey value and several kinds of color to form a kind of corresponding relation. The color of each pixel is not decided by each primary component values directly, but rather the pixel values as color lookup table (color look - up table, CLUT) table entry address, to find a display image used in R, G, B value intensity, find out the R, G, and B strength values of color is called pseudo color.

We don't need to pseudocolor processing of satellite cloud pictures, but the purpose of clouds stratified information extraction is the same with pseudocolor processing's purpose which gray level of image can be divided into several levels and each layer with a certain value. Different pseudocolor processing will be specific to represent the color value for each level, and hierarchical information extracted from the clouds layer is represented with a certain the gray value of each level, that is, the pixel values as a grayscale value of an item from a lookup table entry address, to find a display of image grayscale values.

We can take advantage of the pseudocolor processing rules define the satellite cloud image clouds stratified rule: rank according to the weather, with temperature below zero, every level is one degree, with temperature above zero, 20 degrees for every level, in addition, density stratification for the infrared satellite cloud.

3.3. Layered Algorithm of Satellite Cloud Image

If based the gray level statistics properties of the satellite cloud image directly, or only consider satellite cloud image color information is very difficult to get the right relief map layered results. Previous image color separation algorithm is only in view of the image pixel color information [9-11], and si-yuan wang [12] is just put forward a serial algorithm that modified the picture with mathematical morphology after colors of image are layered. But, there exist the image color error, so these algorithms need to be improved in the practical application. According to the characteristics of the satellite cloud image layering and difficulties, this paper proposed a new image layered thought: because of the large amount of satellite cloud image data, the operation is very time consuming, so in the process of image segmentation, not only should consider the effect of image segmentation, at the same time also need to improve the speed and efficiency of the algorithm. Before the clustering processing, all the pixels in the image will be divided into several subsets which with color consistency. And because of the pixel number of these subsets is less than number of image data, using the fuzzy subsets and the center of the data clustering, will greatly improve the speed of segmentation algorithm, but also use clustering validity analysis to determine the clustering number of image data.

Image pixel grayscale classification have larger fuzziness, as in the image of each layer overlap, it is difficult to explicitly pointed out that it belongs to which layer, so this paper adopts the fuzzy c-means clustering algorithm for color. For image color clustering, it also conforms to the human eye to color information to identify the actual situation.

For the problem of color segmentation for the satellite cloud image, due to its composition of gray levels and the rough range are known, which meet the insufficient that clustering is difficult when FCM under the condition that clustering number is

unknown. In addition, in order to improve the distribution features of the membership degree of FCM algorithm, improve the precision of the algorithm, this paper puts forward the improved FCM algorithm. Different from previous image segmentation, the algorithm is the satellite cloud tutu pixel spatial relation information and image grayscale combining algorithm.

3.3.1. FCM Improved Algorithm: The basic idea of general FCM algorithm is that there is a limited data set with n samples located in the feature space, C is the number of class needed to divide. Define the objective function as $J_m(U,V)$. Through iterative calculation getting fuzzy membership degree μ_{ik} and the clustering center v_i , can get the minimum of objective function. Finally, obtain the final fuzzy partition matrix U and matrix clustering prototype center V . The FCM algorithm is an iterative optimization method of operation that requires repeated calculation u_{ik} and v_i until the algorithm convergence. So, when this method is applied to image segmentation, because of the large amount of image sample n (a picture of 256 x 256 images $n = 65536$), the algorithm's convergence speed is very slow, which will lead to huge computational cost and storage space, thereby reducing the efficiency of segmentation algorithms.

For satellite cloud image, the sample size of the grayscale is a fixed value that has nothing to do with the image size. According to a certain similarity criterion, the point set of the whole image is divided into n_p subsets $S_k (k = 1, 2, \ldots, n_p)$. Because the number of pixels of these subsets is less than the number of image data, we conduct fuzzy clustering on this subset, which will greatly improve the speed of clustering. The specific method is: image from pixel space is mapped to the gray-level histogram feature space, according to the hierarchical rules of satellite cloud image previous mentioned, the image is divided into several subsets. Because the stratified sample of satellite cloud image is less, we can greatly improve the speed of the algorithm.

Because gray levels of pixels in each subset S_k are similar, the distance of $\forall x_l \in S_k$ to the center v_i is equal to the distance that from the center x_k^c of S_k to v_i .

$$d_{il}^2(x_l, v_i) \approx d_{ik}^2(x_k^c, v_i) = \left\| x_k^c - v_i \right\|_A^2 \tag{3}$$

So after the substitution, the size of the fuzzy matrix U is changed from the original $n \times c$ to the $n_p \times c$. Bringing new distance calculation formula into of the formula for calculating the membership degree, a new calculation formula of clustering center is changed

$$v_i = \frac{\sum_{k=1}^{n_p} (\mu_{ik})^m x_k^c D^c(x_k^c)}{\sum_{k=1}^{n_p} (\mu_{ik})^m D^c(x_k^c)}; i = 1, 2, \ldots, c \tag{4}$$

The iteration formula of objective function turns to:

$$J_m(U,V) = \sum_{k=1}^{n_p} \sum_{i=1}^{c} (\mu_{ik})^m d_{ik}^c(x_k^c, v_i) D^c(x_k^c) \tag{5}$$

Among them, $D^c(x_k^c)$ represent the size of subset, that is, the number of data in subsets.

After the algorithm was convergent, it use the clustering center have obtained to recalculate U , and the image segmentation can be conducted as the following rules. If $\mu_{ik} = \max\{\mu_{1k}, \mu_{2k}, ..., \mu_{ck}\}$, then $x_k \in i$ class.

4. Satellite Image Vector Quantization Research

4.1. The Basic Idea of Vector Quantization Algorithm

Satellite cloud image is a typical planar image. So we used the vector method to extract the image planar information. For the satellite cloud image after image segmentation, this paper adopts the following method: vector quantization boundary.

1) Extract the boundary of the polygon area of the same layer.
2) Mark the start-point of the same type of polygon.
3) From the start-point of edge information.
4) Tracing the edge of the area connected to form vector graphics.
5) Return to step (3), for the next edge connected area extraction processing, until all the complete type layer connected region extraction, execute the next step.
6) Return to step (1), for the next type extracting polygon area boundary layer, and until all the categories of the layer are processed, vector quantization process is over.

4.2. Gray Image Binarization Processing

In the satellite cloud image after isolated points in the image of each layer, image of each category is a gray image with 256 classes. In order to reduce the amount of data and facilitate subsequent purification and vector processing, we disposed each category of image by using binarization.

This article uses the whole threshold method for image binarization processing. This method algorithm is simple, fast, also won't artifacts phenomenon in some parts of the picture. The main idea of this algorithm is: first of all, apply gray histogram processing to the whole image, then, find the peak values of foreground and background from the image histogram, next, take the mean of two highest peak of the foreground and background as the best segmentation threshold for image binarization processing, finally, using this threshold value for image threshold segmentation, image binarization results were obtained eventually.

4.3. The Edge of the Satellite Cloud Image Feature Extraction

Image edge detection is the image processing method to make the image more prominent. It is a kind of important regional processing technology. Before the image feature extraction, generally the need for edge detection, edge detection will highlight the edges of the image, and on the edge of the image outside the zone will be weakened or be completely removed.

This paper proposes a method combined with Sobel edge detection algorithm, mathematical morphology method and the theory of natural mimicry. The experimental results show that the method can effectively extract the complete closed outer boundary of the image, and the boundary is identifiable graphics, vector quantization for the subsequent processing to lay a good foundation.

4.3.1. The Improved Edge Detection Algorithm: The basic idea of Sobel edge detection algorithm is: the Sobel operator is a kind of image edge detection algorithm based on first order differential, and image gray gradient is a measurement for function change, an image can be equated to the array composed by the sampling points obtained by the image gray continuous function. Because the edge of image is the region that the grey values of

image change significantly, so they can make use of the discrete approximation function of gray gradient to detect the image edge.

It uses horizontal template and vertical template (as shown in Figure 3) for image convolution respectively, convolution templates can be expressed as follows:

-1	0	1
-2	0	2
-1	0	1

1	2	1
0	0	0
-1	-2	-1

Figure 3. The Traditional Sobel Operator Template

Finally selected a fixed threshold, if the pixel point is greater than this threshold value we consider this pixel point as the edge points.

4.3.1.1. Increase the Sobel Operator Direction Template: The traditional Sobel operator does not take the image characteristic into account, easily affected by noise, the edge it detected may contain false edge, and in the algorithm it is also need to determine a suitable threshold. Determining appropriate threshold often is a very difficult process, if the threshold is too high, processing process will be lost some necessary edge; but if the threshold is too low, processing process will produce a lot of false edge. Especially because the satellite cloud image quality will be affected by instrument, environment and other factors, so determining an appropriate optimal threshold is more difficult, which will lead to boundary discontinuity. After the boundary was extracted, closed boundary is obtained by linear extension methods. However, because the straight line extension has directional, extension after the common boundary extraction will lead confused border.

Traditional Sobel operator only has horizontal and vertical these two templates, the four templates with four directions here we use to improve the quality of the image. There are eight adjacent pixel points around with a pixel point that is in the middle of image. That is, there can be four direction (0°, 45°, 90°, 135°) in 8-neighborhood of a point, as shown in Figure 4.

135°	90°	45°
0°	x	0°
45°	90°	135°

Figure 4. Pixel Pattern

Each point in the image convolve with the four template respectively, let the maximum income as the output of convolution between Sobel operator and the image, and record the corresponding template direction as the direction of the point. Four directions templates are as shown in Figure 5.

2	1	0	1	2	1	0	1	2	-1	0	1
1	0	-1	0	0	0	-1	0	1	-2	0	2
0	-1	-2	-1	-2	-1	-2	-1	0	-1	0	1

Figure 5. Four Directions of Sobel Operator Template

From the four directions, respectively using Sobe1 gradient detection operator for line segment detection with a single direction, the resulting boundary line is based on the all directions. Because border line extracted from each direction is not cross with each other, so it will not affect the subsequent processing. But as to the threshold value method is adopted to image boundary judgment, so the retrieval results will cable segment of discontinuous. Aiming at this problem, this paper used a mathematical morphology method based on directional for reprocessing to solve the old problem of fuzzy boundaries with Sobe1 algorithm. The main idea of this method is: the boundary line segment for each direction, respectively use corresponding mathematical morphology connection template for straight line connection. This kind of the straight line method, which can change the discontinuous border line segment into a continuous line set. After the directional gradient boundary processing and mathematical morphology processing, each directional image only contains the set of line segments on their own direction; Then cover processing to the four directions figure, which merged the four directions boundary figure into a whole, the merged boundary of the image won't has the problem of fuzzy boundaries and has better effect than traditional Sobe1 gradient detection operator.

4.3.1.2. Based on the Edge of the Sobel Operator Refinement: Sobel operator introduce the local average weighted factor, which has certain smoothing effect on the random noise in image; Because it is the difference between the two rows or columns of pixels, get rid of some of the false edge, smooth the actual edge, so the edge on both sides of the element has been enhanced, the edge width, usually for at least two pixels. But on the edge of the image measurement also needs to make accurate positioning, you need to rough edge image obtained by the above elaboration, single pixel edge.

Effective thinning algorithm based on Sobel operator is as follows. Make a Sobel operator edge detection on the rough edge of image t1 got by edge detection for the first time again, get t2 images. Let the difference figure between the former the latter figure as t3 and change the negative point in t3 to 0 to remove the t3 diagram points, at the edge of the lateral edges thinner diagram is obtained. For the edge of a steep part can be directly got smooth, continuous and close to the edge of the single point wide, for edge fuzzy part of the process can be repeated many times, is conducive to capture more direction of edge information, make the refine edge positioning more accurate.

4.3.1.3. Outside the Closed Boundary Algorithm: There are still more boundary discontinuity in the complex boundary image got by the previous step, and the boundary potentially be in the closed region is meaningless which should be removed. Here this paper presents a mimic water features closed outer boundary algorithm. The characteristics of the water is: firstly, flowing from high to low, when encounter obstacles it will change its direction; Secondly, erosion function, when water surrounded the obstacles (such as soil ridge) which eroded by water; Finally, it has certain characteristics of surface tension, when obstacles when there is a certain gap, if small gap to a certain degree, water will not flow into its principle as shown in Figure 6.

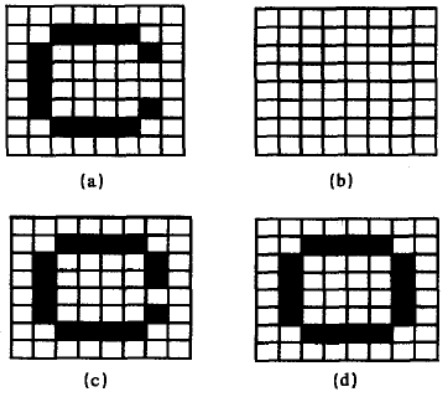


Figure 6. Principle of Water Erosion

We can see from the figure that in Figure 6 (a) the gap is bigger, so all of them been eroded away (Figure (b)); And in Figure 6 (c), the gap is very small, in the final result we can see that not only the original border is retained and the gap was filled in, as shown in Figure (d) the black squares. Assumed the tension width of water is 1 (square). By water erosion, isolated segment and points can be eliminated, and the line set of a closed area cannot be formed. At the same time, the surface tension characteristics also can close many gaps. During the processing of image boundary figure, can consider the boundary has been obtained as an obstruction set that able to be eroded. By water erosion, erosion is a background sections are eroded and the rest is closed area.

4.4. Satellite Cloud Image Feature Point Extraction

Usually, the points got by using edge detected are much more. Apply vector quantization to re-painting the edge which obtained by using all of detected points, which spend a lot of computational cost. In order to reduce the amount of calculation, boundary samples, must be selected on the border of the feature points to represent the boundary.

4.4.1. Contour Point Search Rankings: Because the contours of the border of the satellite cloud image classification map is closed, avoid the two-dimensional curve, and on the same level layer exist a number of disjoint contour line. The edge points set edge detected is a disorderly combination of some discrete, independent and unrelated boundary contour points, which must firstly obtain orderly combination of pixels on each contour line. This paper chooses the method of contour tracking to sort the contour points.

1) Progressive scanning whole image from the beginning, we set the first target boundary point searched as the starting point.

2) According to the 8-neighborhood search rules to search the next adjacent point of starting point, and set the adjacent point as a current point, continue to search.

3) Until the search returns to the starting point, it shows that we have searched a closed 2D curve, and record the starting point of the contour line and the boundary chain code, then, contour lines are removed from the image, repeat step 1, search the next contour line, until the whole image of contour lines are searched out.

4.4.2. Based on the Feature Point Extraction Method of USAN Area: This paper chose a simple and effective detection method that a feature point extraction method based on USAN area.

First of all, the definition of USAN is: in the absence of texture image, we will define the circular area whose center can be any pixel of image as a dense region. If the grey values of inner pixels in this area have a certain similarity, which such areas are defined

as USAN area. Figure 7 shows three kinds of expression form of USAN area, the figure (a) said that the processed pixels is not at the edge of the image, figure (b) said it is in the edge of the image, figure (c) said it's on the corner of the image. In order to more accurately obtain USAN area Angle information, we do not take the case that multiple edges through the center into consideration.

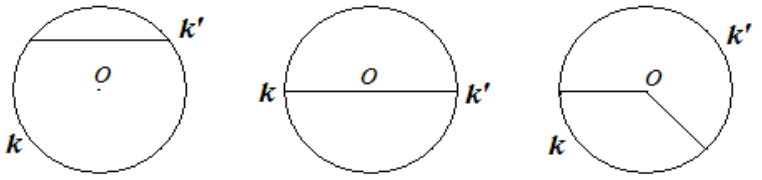


Figure 7. USAN Three Forms of Expression

As shown in Figure 7, the purpose of the feature point's extraction algorithm is detecting the image of the inflection point, namely the Figure (c) the center O (turning point); we also need to calculate the Angle of the turning point and the direction of the edge. Therefore, we should follow the pixel to be detected USAN area of the circular arc edge scanning, find grey value change point, strong as a circular arc edge curve and image edge point, the point and the center O attachment as candidates for the corner edge.

The retrieval algorithm based on USAN area can cause local details be slight change, in order to suppress this interference, this paper uses a feature point detection method based on USAN area. In the algorithm is introduced into a local average function:

$$g(i,\ j) = \frac{1}{N_m} \sum_{\Omega(i,\ j, M_g)} f(k, l) \tag{6}$$

In formula (6), $\Omega(i,\ j, M_g)$ represents a USAN area which is a circular area with center is the pixel point $(i,\ j)$ and the radius is M_g ; N_m represents the number of pixels in this USAN area.

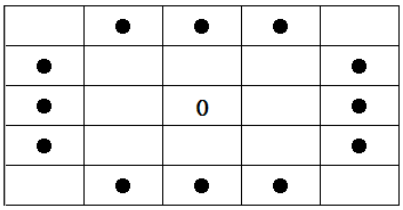


Figure 8. Discrete Arc Radius of 2

In the algorithm, we define an approximate circular curve based on the discrete area, as shown in Figure 8. The specific steps of feature point detection algorithm are as follows:

1. Select a starting pixels ($i_1 = i,\ j_1 = j + R_n$), set R_n as a radius of the USAN area, then in turn, make serial number for pixels according to counterclockwise, getting a set of pixels: $C_{R_n} = \{(i_1,\ j_1), (i_2,\ j_2), \Lambda, (i_l,\ j_l)\}$.

2. In turn, calculate $f(i_1,\ j_1) - g(i,\ j), \Lambda, f(i_l,\ j_l) - g(i_l,\ j_l)$, which defined as N_c . When the sign changed, record the position of the change point (if the edge points of grey value is bigger, the record number change before and after the position of the point with a positive difference).

3. When $N_c = 2$, Received two intersection points between the edge of USAN area and corner O, refer as (i_a, j_a) and (i_b, j_b) respectively. Calculating the Angle among (i_a, j_a), (i, j) and (i_b, j_b) these three points (less than 180°), determining whether it within a certain range (can be set to $45^\circ \sim 135^\circ$). If so, it will be as a candidate at a corner, and record the size of the Angle; otherwise, this is not a corner, delete.

4. Along the anticlockwise direction from the Angle of the starting edge, as shown in Figure 3 (c), for the starting Angle of side, and will start edge as a point in the direction of the edge direction.

The algorithm of diagonal point detection is certain rotation invariance. That image $f'(x, y)$ is the result of the image $f(x, y)$ rotation Angle, in using the algorithm to detect two images, the angular point information is basically the same. Because this algorithm USES approximate circular arc USAN area, so the calculated two images of local average function $g(x, y)$ and $g'(x, y)$ is approximately equal to that end up with two symbols change frequency N_c is basically the same, so the angular point results detected by basic won't change with the rotation of the image.

4.5. Based on the Feature Points of Curve Fitting

Gets the edge feature points, and finally apply border fitting for feature points. Curve fitting curve is obtaining a set of feature points by sampling for those known or unknown curves, recycling, this set of feature points by interpolation or approximation method, constructs the corresponding curve, to get the curve of some design requirements, and try to approximate the original curve, namely to minimize the fitting error. This article selects the least squares method of B-spline curve fitting to get the initial fitting curve. When the number of feature points is fixed under the premise of this kind of method of fitting error is smaller.

5. System Design and Implementation

This paper analysis and research on the characteristic of satellite cloud images and puts forward the satellite cloud image preprocessing, image segmentation, processing, and a series of vector quantization algorithm. On Visual C++ platform to develop a set of relatively complete satellite image vector quantization of the prototype system, and use of satellite cloud picture more comprehensive experiment was carried out.

5.1. The Overall Function of the System

The main functions of the prototype system of satellite cloud image vector quantization is as follows:

1. Satellite cloud image preprocessing.
2. The background of satellite cloud image segmentation.
3. Satellite cloud image level segmentation of clouds.
4. Satellite cloud image edge information extraction of clouds.
5. Satellite cloud image feature points extraction of clouds.
6. The satellite cloud image automatic vector.

5.2. System Software

This system mainly includes image preprocessing module, image segmentation module, vector quantization processing module and curve fitting module. And each module is composed of multiple sub-module, such as, vector quantization processing for

one level module which is handled by binarization, edge extraction and feature point extraction those sub-modules.

According to the process of image processing, the system design of the main menu for preprocessing, image segmentation, vector processing and curve fitting. Among them: pretreatment menu is to deal with the noise of image features; Image segmentation menu includes image background separation and stratification two big functions; Deal with menu includes vector quantization is closely related to the process of vector quantization of binary processing, edge extraction algorithm and feature point extraction function; And the function of curve fitting menu is changing the feature points have got into vector graphics.

5.2.1. Satellite Cloud Image Preprocessing Subsystem: The main function this system module achieved is as the followings:

1. Read and display satellite cloud images, support *. BMP and * JPG format file.

2. According to the algorithm mentioned in 2.1, it conducts filtering denoising on the satellite cloud image to improve the quality of satellite cloud images.

5.2.2. Satellite Cloud Images Layered Subsystem: According to the spatial information and color information of the combination of image segmentation principle, the subsystem realize of satellite cloud image segmentation. First separate the background information from the satellite cloud image to extract the target clouds, then, hierarchical processing is conducted on the whole clouds target, laying the foundation for the next step that make vector quantization on the cloud information.

5.2.3. Vector Anti-fuzzy System: This subsystem mainly through the clouds for binarization, edge extraction and feature point extraction, processing and finishing of satellite cloud picture each cloud information extraction. Features include:

1. Each level of the clouds category image binarization processing, respectively.

2. After the binarization processing category per level image for edge extraction respectively.

3. To the edge of the extraction of feature points extraction respectively.

5.2.4. Curve Fitting Zygote System: This subsystem conduct curve fitting on the feature point set that obtained by vector quantization, which is a least square fitting method based on b-spline curve fitting, finally shows the vector graphics.

5.3. Experimental Effect

We used a variety of experimental data of satellite cloud picture to test the system's functions. The following is the vector quantization effect picture of satellite cloud image.

Figure 9 is a satellite image of the original image. From the figure we can see that the shape and edge of cloud image are fuzzy and the cloud hierarchy is not clear.

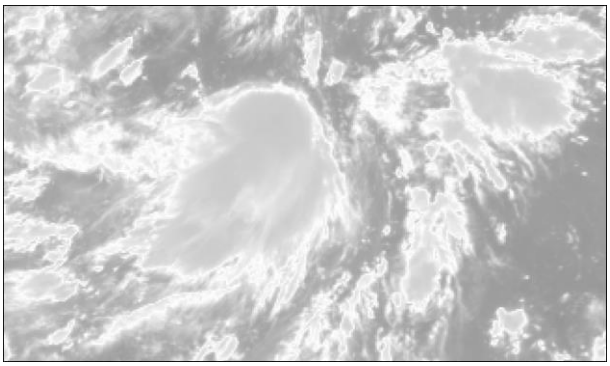


Figure 9. The Original Image of Experimental Data

First, image segmentation algorithm is used to remove the background from the image, getting the resulting picture in which the backgrounds are separated and stratified. As shown in Figure 10.

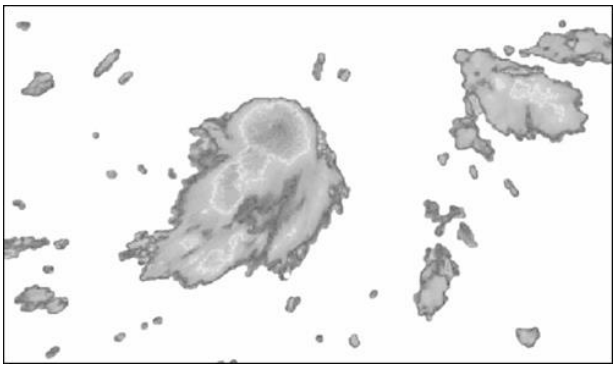
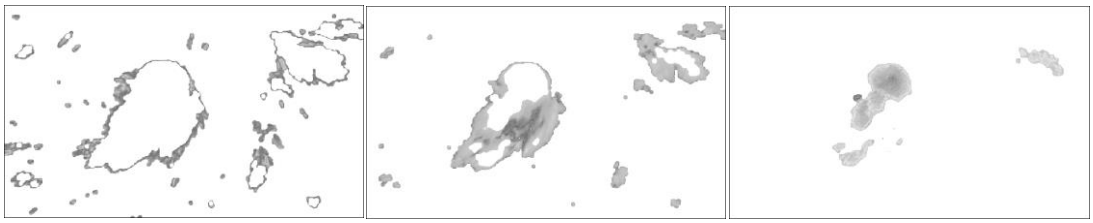


Figure 10. Background Separation and Stratification Results

Figure 11 is extracting the different levels of the clouds respectively. According to the rules of clouds of stratification, the infrared cloud image is mainly can be divided into 3 levels, the measured temperature of 230 k, 230 k and 230 k respectively, and each layer of the grey value 127, 94 and 63 respectively; Finally using the improved FCM algorithm segmentation, for each level clouds to graphics, the edge of the clouds and at all levels become clear. As shown in figure 11, Figure (a) is the first level cloud with grey value 127; Figure (b) is the second clouds of grey value 94; Figure (c) is tertiary clouds based on grey value 63.

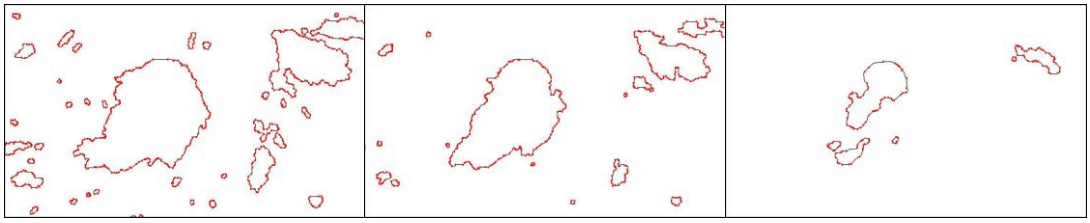


(a). 1 level of the clouds of 127 grey value (b). 2 level of the clouds of 94 grey value
(c). 3 level of the clouds of 63 grey value

Figure 11. Image Stratification Results

Figure 12, respectively, each layer to extract edge and the result of the feature point information. Figure (a) is the extraction results from first clouds; Figure (b) is the extraction results from second clouds; Figure (c) is the extraction results from tertiary

clouds. See from the diagram, using the outside edge extraction algorithm can extract the target's external borders, and based on edge feature point extraction algorithm can achieve good results, for the back of the curve fitting procedures laid a good foundation.



(a).edge and feature points of 1 level clouds (b).edge and feature points of 2 level clouds (c).edge and feature points of 3 level clouds

Figure 12. Edge and Feature Point Extraction Results

Figure 13 is the results of vector quantization fitted according to the feature point information. Deal with the overall results of vector quantization of satellite cloud picture makes in the cloud, a cloud of boundary and hierarchical information becomes clear intuitive, the satellite cloud image from the subjective fuzzy qualitative recognition is transformed into the clear and accurate objective quantitative recognition.

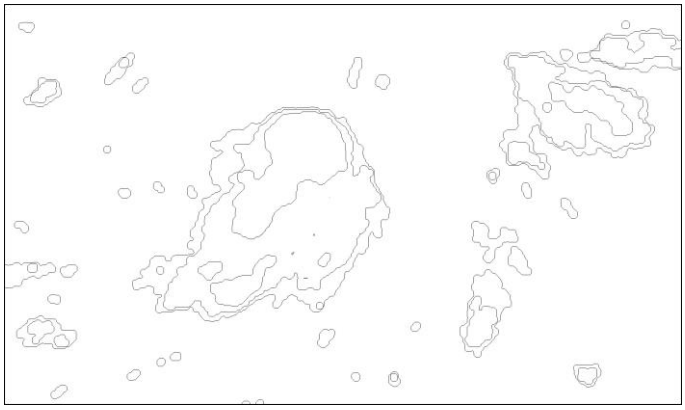


Figure 13. The Results of Vector Quantization

6. Conclusion

This paper studies the technique of vector quantization of meteorological satellite cloud image feature extraction and its implementation. According to the characteristics of the satellite cloud image, combined with image processing technology, we carried on the thorough research from the satellite cloud image preprocessing, image segmentation, image vector quantization.

Adaptive median filtering denoising method is proposed to effectively reduce the noise of the satellite cloud image and improve the quality of satellite cloud images. On the basis of analyzing the color characteristics of satellite cloud image, we proposed the improved FCM image segmentation method. This paper puts forward a kind of automatic layering algorithm combined with color information, effectively improving the speed of image segmentation, for the satellite cloud information vector quantization hierarchical recognition and automatic laid a good foundation. And this paper proposes vector quantization algorithm based on satellite cloud images, treated with binarization, edge extraction, feature point extraction, steps, such as curve fitting and get the final vector graphics. Satellite cloud image automatically vectorized prototype system is developed, using real satellite cloud picture data, verify the feasibility of this design idea and the

validity of algorithm, around the extracted image features and cloud area of interest, for meteorological work personnel to the structure and evolution trend of observation and analysis of cloud to provide effective basis.

But, we need further modify and perfect the automatic vector quantization system. For example, in this paper, the satellite cloud layered image segmentation method only uses the color information of satellite cloud image graphics, while not uses the spatial information of image; Therefore, if we process hierarchical cloud pictures according to the color and space these two information of image, the layered effects of satellite cloud pictures will be better.

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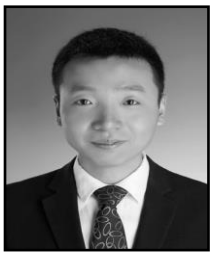

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