A Method of Remote Sensing Image Retrieval Based on ROI

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Abstract

One of the features in JPEG2000 is ROI (region of interest) coding technique. Since the shape of interested region is manually optional in the coding process, the disturbance of uninterested regions to the retrieval process could be controlled to be very small if we retrieve images based on ROI content. This paper presents a novel and effective scheme for remote sensing image retrieval, which does not need to decode JPEG2000's code stream completely. We extract the spectral features of the objects based on the properties that objects would reflect different waves in different wave bands. The subsequent retrieval is based on this kind of spectral features. In addition, we design a new measurement scheme by which similarity between two images is computed and then the retrieval is realized based on the measurement. Experimental results show that our method is accurate and efficient. It also shows obviously that our method costs much less time than the traditional ones.

1. Introduction

Remote sensing image (RSI) is one kind of important images in present image resources. It is widely used in agriculture, mapping, water conservancy, geological reconnoiter and so on. However remote sensing image database is usually very huge in size and the data has been coming out ceaselessly. Thus how to browse, index and retrieve RSI information (for example, to check which regions have martial equip and which regions have residential area)from large database fleetly and truly is a key technique in RSI information system.

RSI contents abundant details and its data size is very large. To compress the original image data in advance is essential to transfer and store RSIs. However, only a small part of the RSI is useful to users. In JPEG2000 [1], people usually sketch the regions of interesting (ROI) of the images. ROI is a special region which is coded and transferred primely and precisely, so JPEG2000 is suitable for RSI. Since it can compress important regions without loss while compressing unimportant regions with loss, image information desired high fidelity is acquired and maintain a high compression ratio.

This paper presents a novel and effective scheme for RSI retrieval, which does not need to decode JPEG2000's code stream completely. In JPEG2000, the shape of the ROI can be manually selected and the disturbance of the background would be of little effect to the retrieval of the important regions. Firstly we get the code of the ROI from JPEG2000 coding stream, and restore the ROI into its original form. Then we extract the statistical spectral features of ROI based on the properties that objects in ROI would reflect different waves in different wave bands. The subsequent retrieval is based on the spectral features. Furthermore, we design a new measurement scheme by which similarity between two images is computed on which the retrieval is realized. The experimental results show that our method is accurate and efficient. It also has a series of excellent features such as robustness to rotation, translation and so on. In addition, it costs much less time than the traditional method.

2. Feature of Multispectral Remote Sensing Image

RSI would not be influenced by the environment of the earth. It can get information easily even in bad condition or in hard-exploring regions (for example: the enemy controlling regions). Multispectral RSI takes advantage of the characters that the object would reflect different waves in different wave bands. The same objects would show similar reflection when they

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are irradiated by the same wave band. So it is not difficult to figure out an object's spectral features by statistics and clustering and easy to find out the regions containing this object.

ROI of multispectral RSI is shown by figure 1. Since a region would reflect different waves in different wave bands, we can get a set of n-band images of that region (band 1, band 2……band n in fig.1). Especially spectral vectors refer to a set of reflection data when a spot is irradiated by different wave bands.

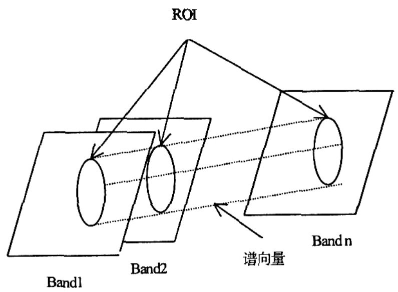
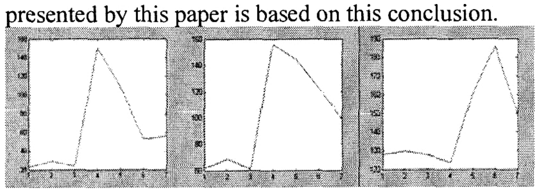


fig 1. ROI of RSI

We get a set of seven-band images of a region and calculate the spectral vectors. After clustering, the vectors of the city zone, the water area and the suburb area are shown as fig.2. The x-axis of the figure shows seven wave bands and y-axis represents the average reflection numerical value of each object corresponding to different wave bands. From fig.2, we can draw a conclusion that an object would be sensitive to some wave bands while unresponsive to the others. Therefore the RSI retrieval algorism presented by this paper is based on this conclusion.



Vector of the water area   vector of the suburb   vector of the **city** zone

fig.2 Reflection vectors of a region

3. RSI Retrieval Method Based on ROI

When remote sensing images have been transmitted to the earth, people usually make out ROI and compress the images into JPEG2000 coding stream. After we get the coding stream from Internet or image databases, we begin to restore the ROI and start the retrieval. We wipe off the nonsignificant data through statistics, keeping objects which have sizeable percentage in the ROI.

We get the spectral vectors of a certain object using k-mean algorithm, which is a sort of clustering method based on E-distance. It can reach the center of an object by calculating the e-distance between the examples and the centers repeatedly. The algorithm is stated as follows:

1) Choose the center of each object randomly and remark the centers as $z_1(1)$ …… $z_k(1)$, k is the number of the objects.
2) Suppose S is the set of the samples and test each of the samples in S. x_n is one of the samples in S. If it satisfies the following condition:

$$|x_n - z_j(m)| < |x_n - z_i(m)|$$

i,j=1,2,3……k, i≠j

x_n would be supposed to belong to object j.

3) Calculate the new center of object j:

$$z_j(m+1) = \left(\sum_{x_x \in S} x_n\right) / N_j$$

N_j is the number of the samples which belong *to* object j. x_n is the vector of sample n.

4) If the center focuses to a constant, stop the clustering, or go to 2).

Since needs to compute the centers of the spectral vectors again and again until the centers reach to constants, k-mean algorithm seems to be very complicated. In our method, we use the spectral vectors of the objects in the query image directly. When the ROI of an image is restored, we calculate the distance between each pixel of the ROI and each object's center of the query image. If the smallest distance between a pixel and the centers is smaller than the criteria, the pixel would be supposed to belong to the object from which the distance is the smallest. All of the pixels can be divided into two parts: belonging to the objects of the query image or not. Count the pixels that don't belong to any object of the query image, and calculate the percent of such pixels in ROI. This percent is another index to measure the similarity between the query image and the images in database.

Our algorithm is shown as the follows:

1) Calculate the centers of the query image by means of K-mean algorithm. Choose K objects which have sizeable percentage and note their centers as $Z_1, Z_2 \ldots\ldots Z_k$.
2) Choose e-distance as the standard of clustering. E-distance's defined as:

$dis(x^1, x^2) = \frac{1}{m}\sum_{i=1}^{m}(x_i^1 - x_i^2)^2$. The smaller the dis is, the more similar the two examples are. x^1,x^2 are vectors of the two samples. M is the number of wave bands. We must choose every pixel from the ROI and calculate the distance between the pixel and query image's each center: $Z_1, Z_2 \ldots\ldots Z_k$.

3) If a pixel of the ROI satisfies the condition of $\min_j dis(x^i, z_j) > T$ in which T is the threshold of clustering, the pixel x^i doesn't belong to any object of the query image, or else it is taken into the object which it is the most similar to.

4) Suppose there are S_j vectors of ROI which satisfy the condition of $\min_j dis(x^i, z_j) < T$ and belong to the object j, and the vectors in the ROI belong to r objects of the query image, then the similarity between the images in the database and the query image is measured by the following equation:

$$D = \frac{1}{r}\sum_{j=1}^{r} a_j \left[\frac{1}{S_j}\sum_{m=1}^{S_j} dis(x^i, z_j)\right]$$

x^i represents the *ith* vector which belongs to the object j. a_j is a weight value. If the percent of the pixels which belong to the object j in ROI is similar to the percent of the object j in the query image, a_j would be a small number. However, if the percent of the object j in ROI is much smaller or bigger than that in query image, a_j would be a bigger number. In this way, we can exclude the images which only have a few pixels belonging to the objects of query image.

5) Count the pixels which don't belong to any object of the query image, remarking the number of the pixels as N_x . Suppose there is N pixels in ROI in total, then we calculate and remember the percent of $R = \frac{N_x}{N}$.

6) Get a reasonable threshold of percentage according to the query image, and note it as R_0. If $R > Ro$, the image doesn't match to the query image. If $R < R_0$ while $D > D_0$, the image doesn't match to the query image either. When $R < Ro$ and $D > Do$, then the image matches to the query image.

The flow chart of our algorithm is shown as fig.3:

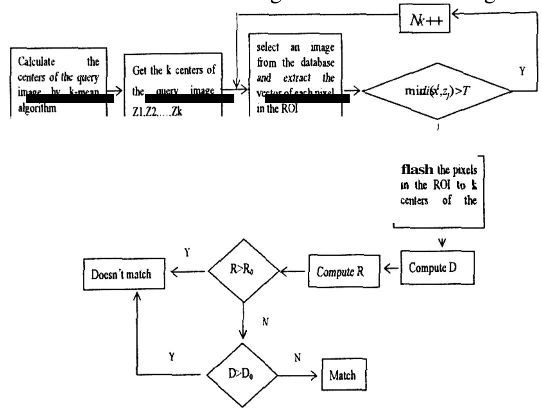
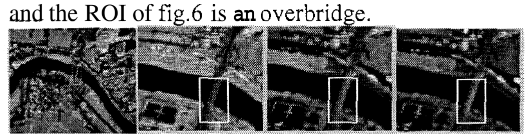


fig 3. **Flow of our retrieval scheme**

4. Experimental Results

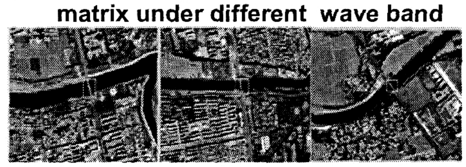
Diverse tests, based on sample query method, have been preformed on experimental database consisting of 100 varieties of seven-band remote sensing images. A sample image (query image), which is used to retrieve similar images from the entire database, is randomly selected from the database. Similarity is calculated basing on the algorithm shown as fig.3 and the system shows the top 3 images which are the most similar to query image according to D. In the following images, ROI is marked by the white circle.

Fig.5 and fig.7 are the retrieval result of the query images shown in fig4 and fig.6. The last three images in fig.4 and fig.6 present the band 1, band 3 and band 5 of the ROI. In fig.5 and fig.7, A,B,C are the retrieval result ranked by similarity. The ROI of fig.4 is a bridge and the ROI of fig.6 is an overbridge.



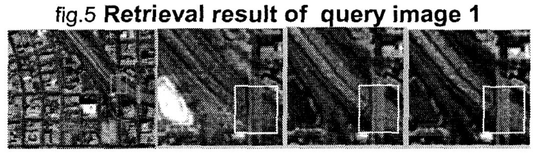
query image 1 band1 band3 band5

fig.4 **Query image 1 and ROI's reflection matrix under different wave band**



A B C

fig.5 **Retrieval result of query image 1**



query image 2 band1 band3 band5

fig.6 Query image 2 and ROI's reflection matrix under different wave band

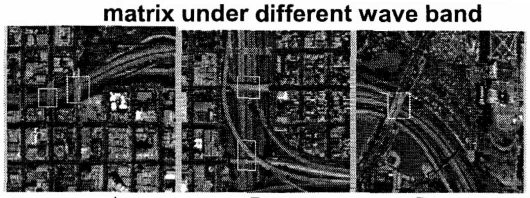

A B C

fig.7 **Retrieval result of query image 2**

Though the query images of fig.4 and fig.6 are both bridges which are both made of reinforced concrete, we get different retrieval results. Of course, the component of bridges and overbridges may be different, but another important reason to this phenomenon is that the objects in fig.4 is a bridge under which is the water while the main objects in fig.6 is the overbridge under which is the road.

From the retrieval result of fig.5 and fig.7, we can come to a conclusion that our method also has the excellent features of robustness to rotation, translation and so on. Because the spectral feature is worked out by statistics which wipes off the spatial distribution information of objects, our method would not leave out the images that have the same objects but don't have the same spatial location with the query image.

In [2] RSI retrieval is realized using the color feature of the images. The method first converts the image's color space from RGB to HSV. Then wavelet decomposition is used upon the images. The low-frequency component of N-level wavelet decomposition is then used to measure the similarity between the image and the query image. If the result is satisfied, the high-frequency component of N-level is picked out for the future measurement.

We choose the color-based retrieval method mentioned in [2] to compare with our approach to see how we can improve the retrieval performance in term of precision. In our test, 50 images are randomly selected and used as query images. The top 3 images which satisfy the threshold and the most similar to the query images are returned. The average precision of our retrieval processes is 90.24% while the precision mentioned in [2] of color-based retrieval processes is 65%. In [2], similarity is measured by the corresponding pixels of two images, so the retrieval result only includes the images which have the same objects and the objects have the same spatial distribution. Furthermore, the color feature is based on N-level wavelet decomposition which can't represent the whole character of the image. Our method, due to its statistical nature that doesn't take into consideration the spatial distribution information of the objects, has robustness to rotation and translation. At the same time, the spectral feature is acquired in ROI's original situation, ensuring that the information is perfect.

We use the centers of the query image to classify the pixels of the images. In this way, we save the time of clustering the pixels of the images by K-mean algorithm, and the speed of retrieval improves rapidly. In another test, we cluster a set of seven-band images whose sizes are 300*400. It costs 43 seconds to make the centers converge to constants by the method of k-mean algorithm. However, if we change a way, the speed improves greatly. First, we choose a quarter of the image and cluster by the method of k-mean algorithm, calculating the centers of the objects in the quarter image. And then calculate distance between the pixels of the other 3/4 part of the image and the centers. We suppose the pixels belong to the object of the smallest distance. This method of clustering costs 10 seconds, which only 0.25% of the pixels classified differently from the result of k-mean algorithm.

5. Conclusion

We propose a novel and effective RSI retrieval approach which make good use of the character of JPEG2000. We can acquire the coding stream of the ROI easily, and since the shape of ROI is manually optional in the coding progress, the influence of uninterested region would be very small. Thus, we can calculate the spectral feature of the ROI. Furthermore, we design a new measurement scheme by which the similarity between two images **is** computed and then the retrieval is realized. The experimental results show that our method is accurate and effective. In addition, it costs much less time than the traditional method and this is very important in the retrieval of large image databases.

References

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