Satellite Cloud Image Processing And Information Retrieval System

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Abstract- **With the development of remote sensing imaging technology, the satellite information includes more abundant data, and the quality of satellite cloud image had achieved great progress. The satellite cloud images contain the valuable information for weather forecasting and early prediction of different atmospheric disturbances such as typhoons, hurricanes etc. The processing of content-based satellite cloud image has become one of the most important tasks for using the satellite cloud image information for continuous research. Content- based satellite cloud image processing and information retrieval is a very important problem in image processing and analysis field. In this research, a Content-Based Image Retrieval (CBIR) system has been developed using color, texture and shape as retrieval features from the satellite image repository. To extract the grey level/color properties of an image, histogram values have been used. Four functions of texture features have used such as (Entropy, Energy, correlation and contrast) and the shape features (area, perimeter and metric) have been extracted using the morphological operations. The images and the extracted feature vectors were stored in the database. Results obtained from the processing demonstrate the usability of proposed system.**

Keywords- Image processing; feature extraction; similarity Computations; Euclidean distance.

I. INTRODUCTION

The cloud layer information recognition from satellite cloud image is a valuable operation in many research fields which includes remote sensing, resource detect and weather forecast etc. If apply the CBIR in satellite cloud image retrieval, we could acquire better retrieval result than traditional retrieval system.

The traditional satellite cloud image search method is based on the file name and the sensor parameters of every image [1]. The disadvantages of this method are that it cannot describe the image contents such as cloud shape [2] and also leads to the inconvenience in content based retrieving images. Clouds are the dynamic phenomena of the atmosphere so its effect on the climate is not known. By the better understanding of the clouds, better models can be developed for the prediction of different atmospheric disturbances such as typhoons, hurricanes, dust storms and etc.

The better understanding of the clouds requires the study of the past images; a retrieval system can be used to study the historical patterns to study the current weather system [3]. Content-Based Image Retrieval (CBIR) is based on the low level visual features of the images. These features are color, texture and shape and spatial relation. Texture and shape are important features in the meteorological satellite images. Different types of clouds have different shapes. The different objects in the meteorological satellite images such as typhoons, hurricanes can also be described by the shape feature [4].

The research paper is an attempt to develop a system based on CBIR technique for the retrieval of the satellite cloud images from the meteorological satellite archival. This may be helpful for meteorologists to study & understand the temporal weather systems.

II. PROPOSED SYSTEM FOR CLOUD IMAGE RETRIEVAL

Satellite image retrieval system consists of a database construction part and an image retrieval part as shown in Figure 1. The database construction part is intended to ensure high retrieval efficiency by extracting a feature set for each of the images in the database at loading time and storing the feature set along with its corresponding image in the database so that when a query image is presented to the system, the system does not have to perform feature extraction on each database image.

To access the database, the user initiates the image retrieval process by providing a query image as input, and then the system starts by extracting the features from the

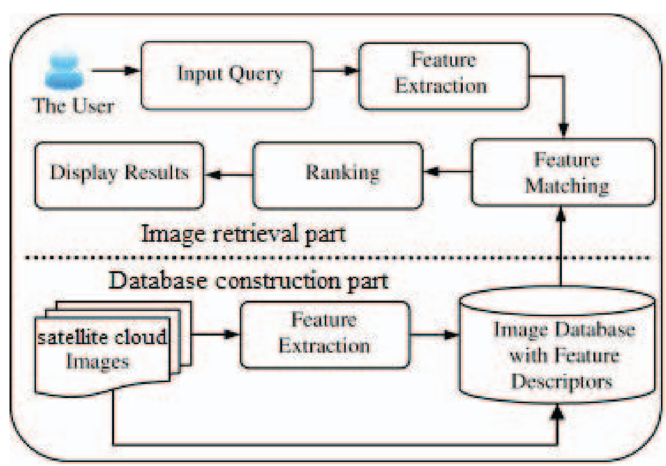


Figure1.The architecture of the proposed satellite image retrieval system

queried image. Afterwards, the system measures the similarity between the feature set of the query image and those of the images stored in the database. Finally, the system ranks the relevance based on the similarity and returns the results to the user.

III. DATA AND SOFTWARE USED

The cloud images used in this research are Infra Red images which are sensed by Indian meteorological satellite Kalpana-1 and freely available at http://www.imd.gov.in/section/satmet/dynamic/insat.htm [5]. The dataset is provided in the JPG file format. These images can be imported in the Integrated GIS software for rescaling and exported to tiff file format for further processing. Figure 2 shows one Infra Red cloud sample image and hundred such images have been used for feature extraction process and database creation. MATLAB (R2009a) on Pentium(R) dual-core processor (2.1 GHz) with 2 GB of RAM have been used for image processing.

IV. FEATURE EXTRACTION

A. Grey level/Colour Feature Extraction

Color histograms are frequently used to compare the images. In this paper grey levels have been extracted using the histogram approach of image retrieval [6] [7] and [8]. The Figure 3 (a) shows the generated histogram of Infra Red cloud image as in Figure 2. The image histogram shows the variations of grey levels from 0 to 255. All these values cannot be used as a feature vector because of the large dimension to be stored or compared. The image histogram should be sampled into the number of bins to reduce the dimensions of the feature vector. Therefore, in this paper, the histogram has been sampled into 16 Bins for hundred images and the generated histogram of one sample image is shown in Figure 3(b).

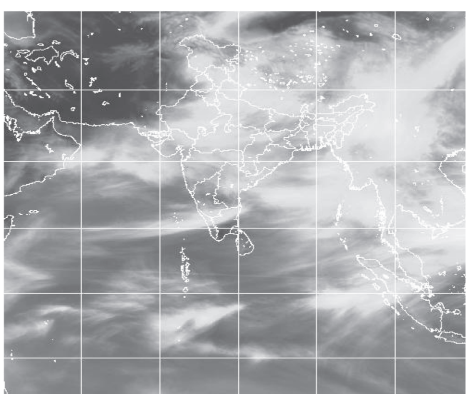
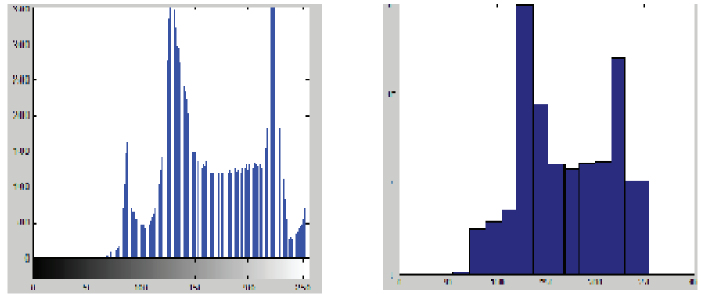


Figure 2 Infrared satellite cloud image of kalpana-1.



(a) (b)

Figure 3 Histogram of an infrared satellite cloud image

B. Texture feature extraction

There are varieties of techniques which are used for measuring texture such as co-occurrence matrix, fractals, gabor filters, and variations of wavelet transform [9] .In this research Grey Level Co-occurrence Matrix (GLCM) is used because of its significance in terms of image processing and simplicity in operation having two dimensional arrays.

Normalized probability density P (i,j) of the co-occurrence Matrices can be defined [11] as follows-

$$P(i,j)= \frac{\#\{(x,y),(x+d,x+y)|S|\ f(x,y)=i,\ f(x+d,y+d)=j\}}{\#S} \quad (1)$$

Where,

x, y = 0,1,…..N-1 are co-ordinates of the pixel

i, j = 0,1,…..L-1 are the gray levels

S is set of pixel pairs which have certain relationship in the image.

#S is the number of elements in S.

P(i,j) is the probability density that the first pixel has intensity value i and the second j, which separated by distance δ=(dx, dy).

The GLCM is computed in four directions for $\delta=0^0$, $\delta=45^0$, $\delta=90^0$, $\delta=135^0$.

Based on the GLCM four statistical parameters energy, contrast, entropy and correlation have been computed. Finally a feature vector was computed using the means and variances of all the parameters [10]. The steps for extracting texture features of image using GLCM which was followed can be given as below-

1) Separate the R, G, B planes of image.
2) Repeat steps 3-5 for each plane.
3) Compute four GLCM matrices (directions for δ=00, δ=450, δ=900, δ=1350) as given by (1)
4) For each GLCM matrix compute the statistical features Energy (Angular second moment), Entropy (ENT), Correlation (COR), Contrast (CON) [10] as follows-

Where P (i,j) is probability density.

Energy: (Angular Second Moment (ASM))
ASM =∑∑P2 (i, j). (2)
Energy measures textural uniformity.

Contrast (CON):
CON=∑∑ (i j) 2 P(i, j). (3)
Contrast indicates the variance of the gray level.

Entropy (ENT)
ENT = -∑∑P(i, j) log[P(i, j)]. (4)
This parameter measures the disorder of the image.

Correlation: (COR)

$$COR = \frac{\sum\sum ijP(i,j) - \mu x\ \mu y}{\sigma x, \sigma y} \quad (5)$$

Where μx, μy, σx, σy are the means and standard deviations of Px and Py respectively.
Px is the sum of each row in co-occurrence matrix
Py is the sum of each column in the co-occurrence matrix.
5) Compute the feature vector using the means and variances of all the parameters.
Thus, the feature vector f= {μASM, μENT, μCOR, μCON, σASM, σENT, σCOR, σCON } Where μ is mean and σ is variance of the parameters.
All the parameters were computed for hundred sample images and stored in the database.

C. Shape feature extraction

In this research, the image processing techniques and image morphological operations have been used to extract the shape feature vector from the cloud images. To extract the shape feature of cloud image, following steps were followed.
1) Convert the sample cloud image in binary image.
2) Apply morphological Opening operation to extract cloud shape.
3) Apply morphological filling operation on image on extracted cloud image.
4) Calculate region properties like area, perimeter and metric.

The sample image (Figure 2) has been converted into grey scale image which is shown in Figure 4(a). Then the grey scale image was converted into binary image to remove the noise. The appropriate value of 0.94 was chosen as a threshold value Figure 4(b).

There are two basic types of the morphological operations one is erosion and other is dilation. The erosion operation removes the pixels from the object boundaries and the dilation operation adds pixels to the boundaries of the objects. The number of pixels added in the dilation operation and removed in the erosion operation from the object boundaries depends on the structuring element to be processed on the input cloud image to produce the output

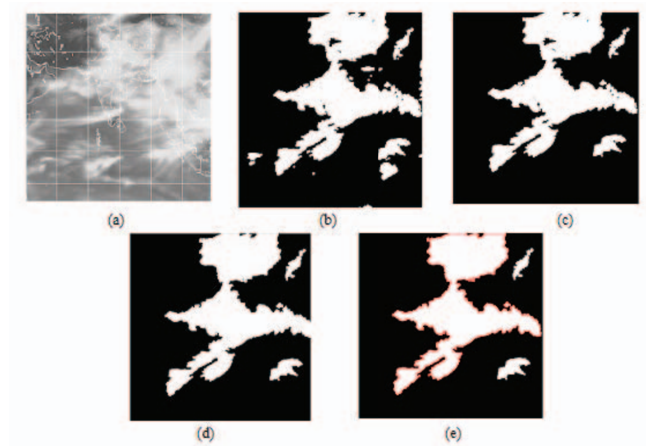


Figure 4 Image extracted results for morphological shape feature extraction

image. The image obtained after the morphological opening operations and morphological filling operations are shown in Figure 4(c) and Figure 4(d) respectively. The final extracted boundary of cloud shape (in red color) is shown in Figure 4(e).

V. IMPLEMENTATION

The discussed cloud image processing and retrieval methods have been implemented using MATLAB (R2009a) on Pentium(R) dual-core processor (2.1 GHz) with 2 GB of RAM. The proposed technique is tested on a database of 100 satellite cloud images to check the performance. All the images and its feature vectors are stored in Oracle 10g database.

Similarities between the images have been calculated using the Euclidean distance [12]. Gray levels similarity, Texture similarity, and shape similarity have calculated by the formula mentioned in the (6) (7) (8) respectively.

$$SimGR = \sqrt{\sum_{n=1}^{16}(QIn - DBIn)^2} \quad (6)$$

$$SimTEX = \sqrt{\sum_{n=1}^{4}(QIn - DBIn)^2} \quad (7)$$

$$SimSHAPE = \sqrt{\sum_{n=1}^{3}(QIn - DBIn)^2} \quad (8)$$

QI is the query image and
DBI is the database image.

The final similarity is calculated with the help of equation (9)

$$SimTOTAL=SimGR+SimTEX+SimSHAPE \qquad (9)$$

Where
SimTOTAL=total similarity between QI and DBI.
SimGR= gray level similarity.
SimTEX= texture similarity.
SimSHAPE= shape similarity.

VI. RESULTS

The feature vectors values for sample image shown in Figure 2 are computed.

A. Grey level feature vectors

Histogram is sampled into 16 bins; the computed values are shown in table I and image histogram shown in Figure 3.

TABLE I. GREY LEVEL FEATURE VECTORS

Bin range	*Value*
0-16	0
17-32	0
33-48	3
49-64	171
65-80	2994
81-96	40530
97-112	23898
113-128	80643
129-144	144849
145-160	70197
161-176	58326
177-192	59214
193-208	62133
209-224	95352
225-240	69147
241-256	846

B. Texture Feature Vectors

GLCM matrix computes to find out texture features, computed values are shown in table II.

TABLE II. TEXTURE FEATURE VECTORS

texture features	*Values*
Contrast	0.68897446
Correlation	0.79522605
Entropy	0.87397502
Energy	0.14863173

C. Shape feature vectors

The shape feature vector details of satellite cloud image as shown in Figure 2 is presented in Table III.

TABLE III. SHAPE FEATURE VECTORS

Shape feature vectors	*Values*
Perimeter	3289.64
Aria	51157
Metrics	0.059404

D. Similarity Computation

The similarity between the query image and the images are computed by (9).The ten similarity values for query images are presented in Table.

TABLE IV. SIMILARYTES VALVE BETWEEN QUERY IMAGE AND DATBASE IMAGE

Image name	*Similarity value*
'K1VHR_01AUG2012_AVGSEC_IR.tif'	1.6231340
'K1VHR_02AUG2012_AVGSEC_IR.tif'	1.6815297
'K1VHR_05JUL2012_AVGSEC_IR.tif'	1.9860595
'K1VHR_04JUN2012_AVGSEC_IR.tif'	1.9235649
'K1VHR_05JUN2012_AVGSEC_IR.tif'	2.0476009
'K1VHR_06JUN2012_AVGSEC_IR.tif'	2.0587183
'K1VHR_06JUN2012_AVGSEC_IR.tif'	2.0696172
'K1VHR_03JUN2012_AVGSEC_IR.tif'	2.0737246
'K1VHR_03AUG2012_AVGSEC_IR.tif'	2.0812518
'K1VHR_07AUG2012_AVGSEC_IR.tif'	2.0835677

Figure 5 shows the 10 best matching cloud images out of hundred images to queried image. Cloud images were ranked on the basis of its similarity values. Result1 is showing most similar image to query image and then result 2, result3 and likewise upto result10.

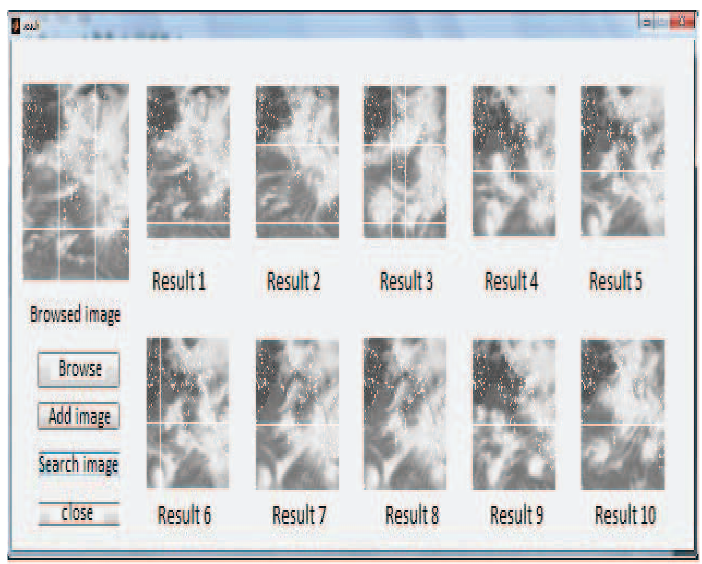


Figure 5 Retrieved clouds images which are similar to queried image

VII. CONCLUSION

This paper has proposed a model for the Satellite Cloud Image Processing and Retrieval System. This model can extend the current retrieval paradigm, which is mostly limited to cloud image retrieval by file name and the sensor parameters of every image. The results are quite good for most of the query images and it is possible to further improve by fine tuning the threshold and adding relevance feedback.

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