Application of Image Retrieval Techniques to Understand Evolving Weather

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Abstract— Multispectral satellite images provide valuable information to understand the evolution of various weather systems such as tropical cyclones, shifting of intra tropical convergence zone, moments of various troughs etc., accurate prediction and estimation will save live and property. This work will deal with the development of an application which will enable users to search an image from database using either gray level, texture and shape features for meteorological satellite image retrieval .Gray level feature is extracted using histogram method. The Texture feature is extracted using gray level co-occurrence method and wavelet approach. The shape feature vector is extracted using morphological operations. The similarity between query image and database images is calculated using Euclidian distance. The performance of the system is evaluated using precision

Keywords*:* Image retrieval, Tropical cyclones, Histogram, Cloud intensity, Euclidian distance

I. INTRODUCTION

Multispectral satellite images provide valuable information to understand the evolution of various weather systems such as tropical cyclones, shifting of intra tropical convergence zone, moments of various troughs etc., accurate prediction and estimation will save live and property. Meteorological satellites provide data and information contents in the form of images .With increased number of satellites the data volume and `information contents along with applications ranging from weather forecasting and navigation also significantly improved.

The types of clouds associated with tropical cyclones are cumulonimbus types of clouds. Understanding clouds for study require past images. A retrieval system can be used to study past images. Traditional methods cannot describe image contents such as clouds [1][2] and done after the classification of images. The limitation of them is that the retrieval is based on pre extracted objects. To overcome that we use independent features rather than of classes. Content-Based Image retrieval is based on low level features of the images which are colour, texture and shape. Texture and shape are important features for meteorological satellites.

The goal of this application is to enable user to retrieve cyclone images from meteorological remote sensing archives using gray level, texture, shape features and a semi automated method to find intensity of tropical cyclone.

The paper is organized as follows .Section2 provides the methodology for content based image retrieval and Section3 provides implementation and section 4 provides results. Section 5 gives conclusions

II. METHODOLOGY

This section is divided into four main phases. The first phase describes the database, the second phase describes the features extracted for CBIR. The third phase describes, the procedure for intensity estimation

A. Data and Software used

The meteosat series of satellites are geostationary satellites operated by European union[3].They provide images of full earth disc and data for weather forecasts. Figure 1 shows sample Infra Red image and many of such images belonging to various cyclones including Mala, Gonu, Sidr, Giri are used for feature extraction process and data base creation

B. Feature extraction:

1) Gray level Feature extraction:

In general colour histograms are used to compare images. Figure: 2(a) shows the histogram of the infrared satellite image. The image histogram shows the variations in gray levels from 0 to 255 .Since all these values cannot be used an feature vector, the histogram is sampled into number of bins to reduce the size of feature vector[4][5]. The generated histogram is shown in figure2(b).

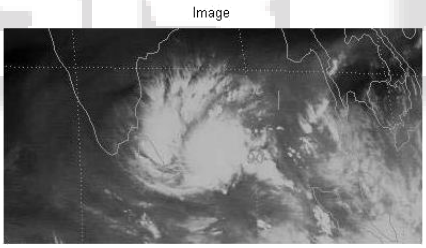

Fig. 1 : Infra red satellite image

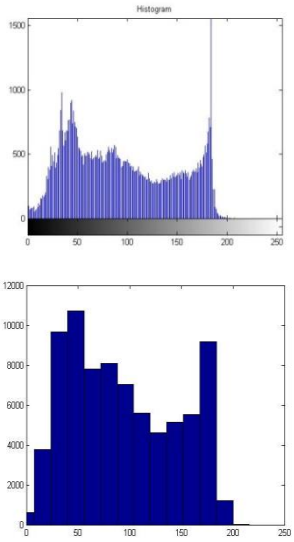

Fig. 2: Histogram of Infra red satellite image

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2) Texture feature extraction using GLCM method

GLCM is a statistical method of examining texture that considers the spatial relationship of pixels in an image. This method characterizes the texture of an image by calculating the presence of the specific pairs and spatial relationship of the pixels in an image. Four statistical features namely energy, contrast, entropy and correlation are obtained by using the means of all parameters

3) Contrast

Measures the local variations in the gray-level co-occurrence matrix. Contrast is 0 for a constant image. The contrast is given by

$$\sum_{i=1}^{k}\sum_{j=1}^{k}(i-j)^2 P_{ij} \longrightarrow \quad (1)$$

4) Correlation

Measures the joint probability occurrence ed pixel pairs. Correlation is 1 or -1 for a perfectly positively or negatively correlated image. . The correlation is given by:

$$\sum_{i=1}^{k}\sum_{j=1}^{k}\frac{(i-m_r)(j-m_c)P_{ij}}{\sigma_r\sigma_c} \longrightarrow \quad (2)$$

$$\sigma_r \neq 0\ \sigma_c \neq 0$$

5) Energy

Provides the sum of squared elements in the GLCM, Also known as uniformity or the angular second moment. Energy is 1 for a constant image. The energy is given by:

$$\sum_{i=1}^{k}\sum_{j=1}^{k}P_{ij}^2 \longrightarrow \quad (3)$$

6) Homogeneity

Measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal. Homogeneity is 1 for a diagonal GLCM computation of entropy.

Homogeneity is given

$$\sum_{i=1}^{k}\sum_{j=1}^{k}\frac{P_{ij}}{1+|i-j|} \longrightarrow \quad (4)$$

Steps for obtaining Texture feature vec.. are

(1) Load Image
(2) Convert RGB to gray image
(3) Calculate GLCM matrix in four directions with four distance vector from pixel of interest
(4) Calculate the texture measures contrast, correlation, homogeneity and energy for all GLCMs
(5) Calculate mean of all GLCM
(6) Obtain Texture feature vector

7) Texture feature extraction using pyramidal wavelet transform

Wavelet provides good multi resolution capability, good energy compaction, and good adaptability to human visual characteristics. Wavelets are finite in time and the average value of a wavelet is zero. A wavelet is waveform that is bounded in frequency and time

The computation of the wavelet transforms of a 2D signal involves recursive filtering and sub-sampling. At each level, the signal is decomposed into four frequency sub-bands, LL, LH, HL, and HH, where L denotes low frequency and H denotes high frequency[8]. For texture analysis here we use pyramidal structural wavelet transform. Figure3 shows a three level pyramidal wavelet decomposition of an image .During the first level of decomposition one low pass sub image (S_2) and three orientation high pass sub images (W_2^H, W_2^V, W_2^D)are created. In the second level of decomposition the low pass sub image is further decomposed into one low pass and three sub images(W_4^H, W_4^D, W_4^V).The energy of third level sub image is used as feature vector. The energy is given by

$$E = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}|X(i,j)| \longrightarrow$$

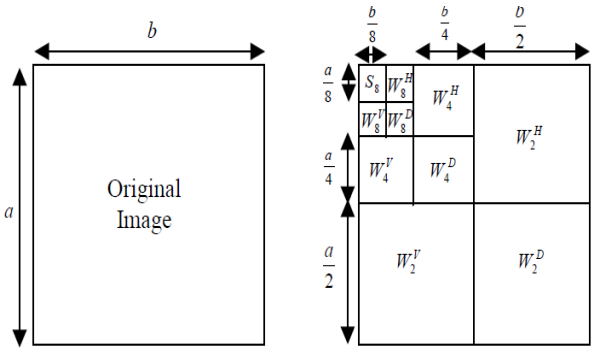

Fig. 3: Pyramidal wavelet transform of image

8) Shape feature extraction using morphological operations

In this paper, the image processing techniques and morphological operations have been used to extract shape feature vector.[9][10]

To extract shape feature following steps are followed.

(1) Convert RGB image to gray image
(2) Apply threshold value to more than 175 and convert to binary image
(3) Apply morphological filling operation to fill the holes of objects in binary image
(4) Apply morphological opening operation to extract cyclone shape
(5) Calculate shape parameters like area and perimeter to generate feature vector

Fig. 4: (a) Satellite image after converting to binary image

Fig. 4: (b) Satellite image after filling operation

Fig. 4: (c) Extracted image after opening operation

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Fig. 4: (d) Boundary extracted of cloud shape

The image has been converted to the gray scale image and then to binary image with threshold value of 175 to remove noise. There are two basic type of morphological operations namely erosion and dilation. The erosion operation removes the pixel from object boundaries and dilation adds pixels to the object boundaries .The adding and removing pixels depends on structural element to be processed. The image obtained after filling and opening operations is shown in figure 4(c) .The extracted boundary is showed in figure 4(d).

III. IMPLEMENTATION

To check the performance of the system the techniques discussed are tested on a database of 150 satellite images .They are cropped to the area under study using photoshop .This work is implemented using MATLAB2012a

The similarities between images are caluclated using Euclidian distance .Gray level ,texture and shape similaritis have been clauclated using formulas shown below

$$Sim_{gr}(QI, DBI) = \sqrt{\sum (QI_n - DBI_n)^2} \quad (6)$$

$$Sim_{txt}(QI, DBI) = \sqrt{\sum (QI_n - DBI_n)^2} \quad (7)$$

$$Sim_{shp}(QI, DBI) = \sqrt{\sum (QI_n - DBI_n)^2} \quad (8)$$

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

IV. RESULTS

In order to check the efficiency of application the feature vectors for figure 1is shown below

A. Gray level feature vectors

The gray levels feature vector is represented by the frequencies of pixels that occur in each of the quantized bins and is presented in the Table 5-1

Table 4.1 Gray level feature vector

Bins	Frequencies
0-16	58953
17-32	48931
33-48	32119
49-64	30751
65-80	19270
81-96	16345
97-112	15171
113-128	15918
129-144	17166
145-160	17515
161-176	9484
177-192	3854
193-208	65
209-224	25
225-240	194
241-256	27

B. Texture feature vector

Texture feature vector is computed using GLCM and pyramidal wavelet transform method are presented below

Table 4.2 Texture feature vector using GLCM method

	Average value
Contrast	0.3686
Correlation	0.9177
Homogeneity	0.9013
Energy	0.1494

Table 4.3: Feature vector using pyramidal wavelet

	Energy
Average value	97.7062

C. Shape feature vector

The shape feature vector of the extracted TC from the infrared satellite image is presented in table 4.4

	Area	**Perimeter**	**metric**
Values	3903	269.9655	0.6730

Table 4.4: shape feature extracted

D. Similarity computation

The similarity between a query image and database images is computed and ten best results are displayed in the following table 4.5

Table 4.5 ten best similarity values with query image

	Similarity value
2000-01-01-18.jpg	1.1654
2000-01-01-21.jpg	2.6344
2000-01-13-18.jpg	3.1631
2000-01-02-09.jpg	3.1875
2000-01-01-15.jpg	3.4488
2000-12-24-03.jpg	3.6422
2000-12-23-18.jpg	3.6672
2000-01-02-00.jpg	4.1658
2000-12-25-03.jpg	4.2154

Images are ranked and retrived based on similarity values and the first ten images retrieved as shown in figure 5

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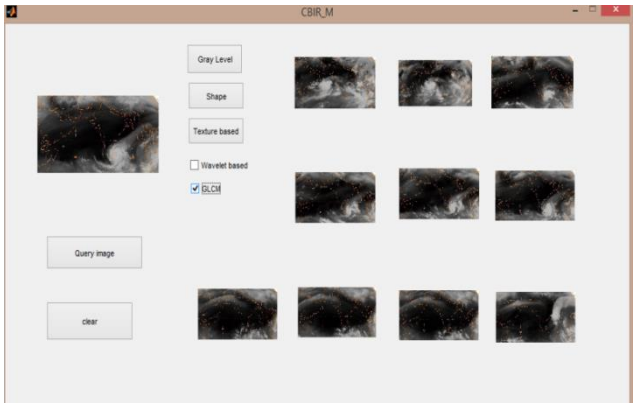

Fig. 5: Retrieved images based on gray level feature

E. System performance

Precision is used to evaluate the performance of the application. It is defined as the ratio of number of relevant images to the number of images retrieved

$$\text{Precision} = \frac{\text{Number of relevent images retrieved}}{\text{Total number of images retrieved}}$$

Figure 6 will show the plot between precision and number of images retrieved

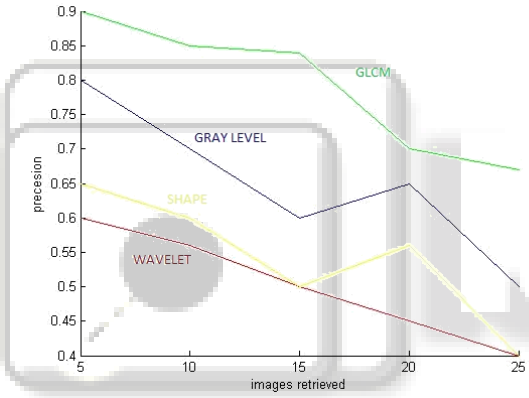

Fig. 6: Precision vs number of images retrieved

V. CONCLUSIONS

Understanding weather phenomena such as cyclone requires past images. Search for relevant images has become a challenging task .The methods presented in this paper for meteorological satellite image retrieval are fairly food for most of query images. The performance can be further improved by adding relevance feedback.

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