Digital Image Search & Retrieval using FFT Sectors of Color Images

H. B. Kekre, Dhirendra Mishra

Abstract- **This paper presents the method developed to search and retrieve similar images from a large database. The Fourier transform is used to generate the feature vectors based on the mean values of real and imaginary parts of complex numbers of polar coordinates in frequency domain. 8 mean values of 4 upper half sectors real and imaginary parts of each R, G and B components of an image are considered for feature vector generation. The algorithm uses 24 mean values of real and imaginary parts in total. Euclidian distances between the feature vectors of query image and the database images are considered. Images are retrieved in ascending order of Euclidian distances. The Average precision and Average recall of each class and overall average of all averages of each class are calculated as a performance measure.**

Keywords— **CBIR, Precision, Recall, Euclidian Distance, FFT sectors.**

I. IMAGE SEARCH AND RETRIEVAL

Digital image search and retrieval is very popularly known as Content-based image retrieval (CBIR)[1][2], also known as query by image content (QBIC) and content-based visual information retrieval (CBVIR) is the application of computer vision to the image retrieval problem, that is, the problem of searching for digital images in large databases. "Content-based" means that the search will analyze the actual contents of the image. The term 'content' in this context might refer to colors, shapes, textures, or any other information that can be derived from the image itself.[2].Without the ability to examine image content, searches must rely on metadata such as captions or keywords, which may be laborious, ambiguous or expensive to produce. There is a growing interest in CBIR because of the limitations inherent in metadata-based systems, as well as the large range of possible uses for efficient image retrieval. Textual information about images can be easily searched using existing technology,[2][3] but requires humans to personally describe every image in the database. This is impractical for very large databases, or for images that are generated automatically, e.g. from surveillance cameras. It is also possible to miss images that use different synonyms in their descriptions. Systems based on categorizing images in semantic classes like "cat" as a subclass of "animal" avoid this problem but still face the same scaling issues[5][6]. Potential uses for CBIR include: Art collections, Photograph archives, Retail catalogues, Medical diagnosis, Crime prevention, The military Intellectual property, Architectural and engineering design ,Geographical information and remote sensing systems

II. ALGORITHM

The method of image search and retrieval proposed here mainly focuses on the generation of the feature vector of search based on the real and imaginary parts of the complex numbers of the image transform generated by the Fast Fourier transform (FFT). Steps of the algorithm are given below.

Step1: Fast Fourier Transform of each components i.e. R,G and B of an RGB image is calculated separately.
Step2: The frequency domain plane of each color components i.e. R,G and B are divided into 8 equal polar sectors by calculating the angle theta of every element in frequency domain.
Step3: The real and imaginary parts of the Fourier complex numbers in each sector are calculated and their average value is taken as one of the parameter of the feature vector. For this purpose we have selected 4 sectors of upper half of complex plane.
Step4: The Euclidian distance between the feature vectors of query image and the feature vectors of images in the database are calculated.
Step5: The algorithm performance is measured based on the average precision and average recall of each class of images and their average across the class.

III. FEATURE VECTOR GENERATION

Every complex number can be represented as a point in the complex plane, and can therefore be expressed by specifying either the point's Cartesian coordinates (called rectangular or Cartesian form) or the point's polar coordinates (called polar form). A complex number x represented in cartesian coordinates as

$$x = a + jb$$

is represented as $Re^{j\theta}$

where $R= (a^2+b^2)^{1/2}$

and $\theta= \tan^{-1} (b/a)$

This helps us to generate eight components of a feature vector based on the complex plane as mentioned above. The real and imaginary parts of complex numbers of images generated by the Fast Fourier transform are checked for the angle of

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complex plane to allocate them to different sectors each of Π/4 radians. The real and imaginary parts of the complex numbers lying in the range of angles 0 to Π is taken into consideration to generate feature vector of dimension 8. The feature vectors are generated by taking mean of real and imaginary parts of the complex numbers in following ranges (0-Π/4 , Π/4-Π/2 , Π/2 - 3Π/4 , 3Π/4 - Π).[18]

IV. RESULTS AND DISCUSSION

Database of 170 images of 7 different classes is used to check the performance of the algorithm developed. Some representative sample images which are used as query images are shown in Fig.1.

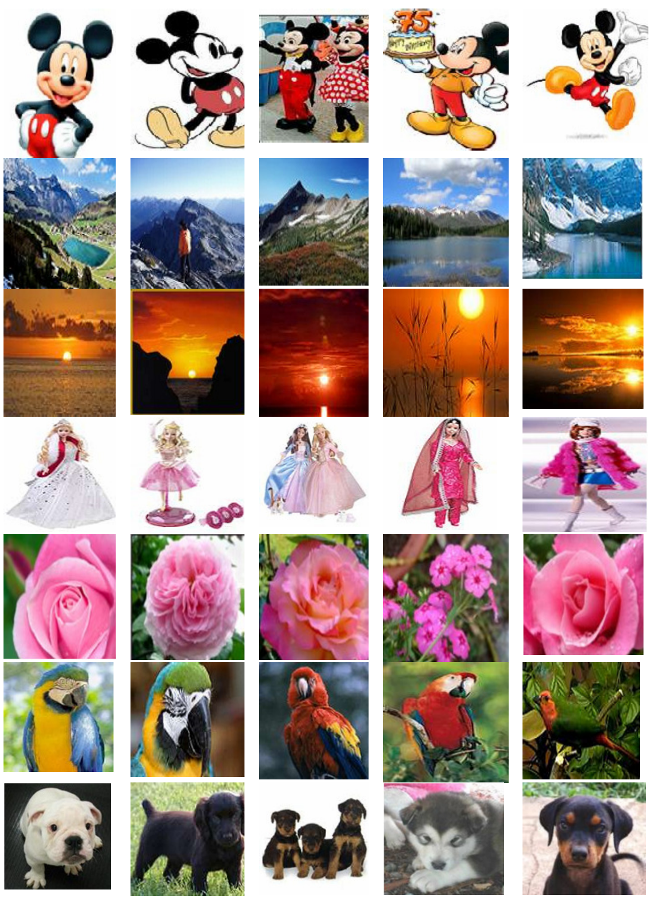

Fig. 1: Representative Sample Image Database

Once the feature vectors are generated for all images in the database, they are stored in a feature database. A feature vector of query image of each class is calculated to search the feature database. The image with exact match with the minimum Euclidian distance [6][7][8][9] is considered. The sorted Euclidian distance between the query image and the database images feature vectors are used to calculate the precision [14][15][16][17] and recall to measure the retrieval performance of the algorithm. As it is shown in the equation (2) and (3).

Once the query image of a class is taken The retrieved images are sorted in terms of increasing Euclidian distance between the feature vectors of the query image and the database images. Using equations (2) and (3) the precision and recall is plotted against the number of images retrieved.

$$\text{Precision} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of images retrieved}} \qquad (2)$$

$$\text{Recall} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images in database}} \qquad (3)$$

Precision[19]: Precision is the fraction of the relevant images which has been retrieved (from all retrieved):

Precision = $A / (A+B)$ (4)

Where, A is "Relevant retrieved" and
$(A+B)$ is "*All* **Retrieved** images"

Recall[19]: Recall is the fraction of the relevant images which has been retrieved (from all relevant):

Recall = $A / (A+D)$ (5)

Where, A is "Relevant retrieved" and
$(A+D)$ is "*All* **Relevant** images"

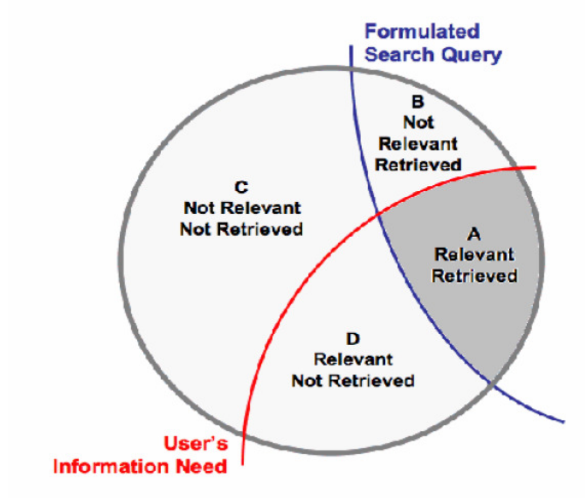

Fig.2 Four Possible Outcomes of CBIR Experiment[19].

The cartoon image shown in the Fig.3 is taken as the query Image to search the given image database. The algorithm applied to generate feature vector of complex numbers for each image in the database and the query image.

Fig. 3: Query Image

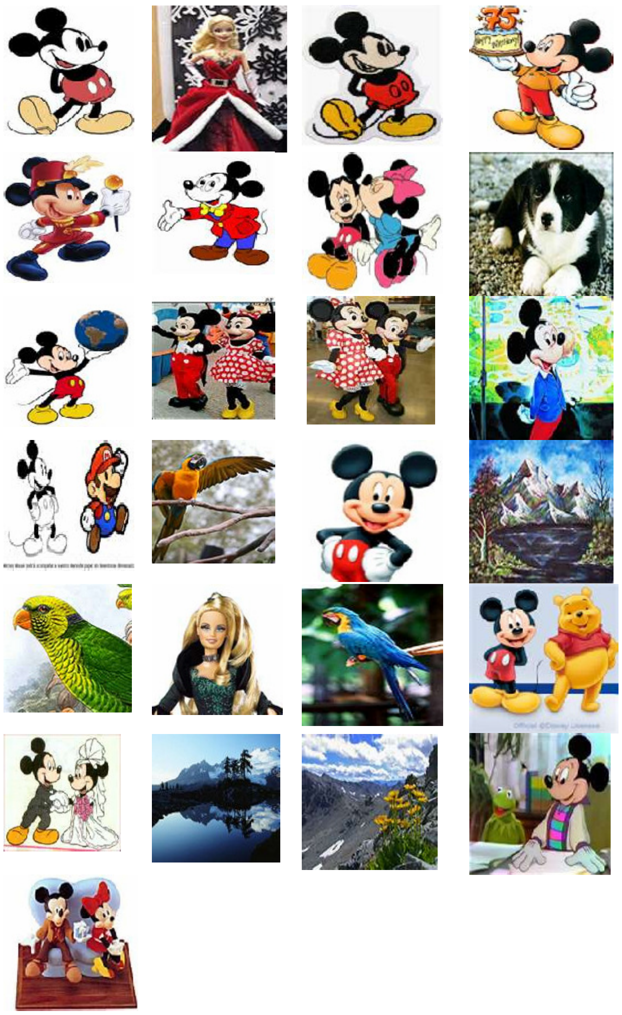

Fig 4:. Images Retrieved against the Query Image shown in Fig. 3.

This algorithm has produced good results as it can be seen in the Fig. 4 where 12 images retrieved are of cartoon class among first 15 images retrieved and the first image is the query image itself. Average Precision and Average Recall Performance of these retrieved images is shown in the Fig. 5. The Following graphs show average precision and average recall plotted against the number of images retrieved. The graphs are plotted by randomly selecting a 5 sample images from each class. Results of cartoon, sunset, Barbie and scenery, flower, birds and dogs are shown in Fig.5 to Fig.11.

The overall average performance of the algorithm with respect to all classes is shown in the Fig.12. It shows the good outcome of the algorithm with very smooth curve of precision and recall with cross over point of 40% retrieval.

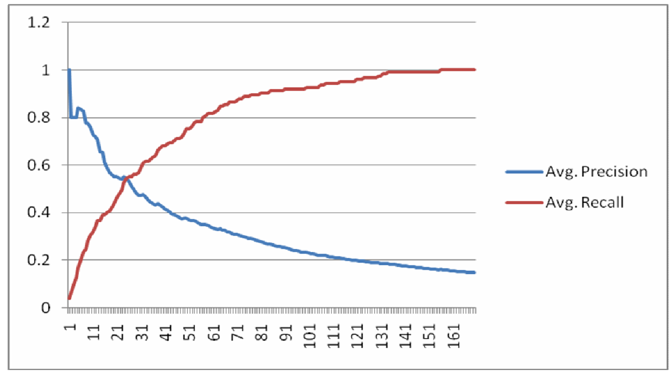

Fig 5: Average Precision and Average Recall Performance for cartoon class of images.

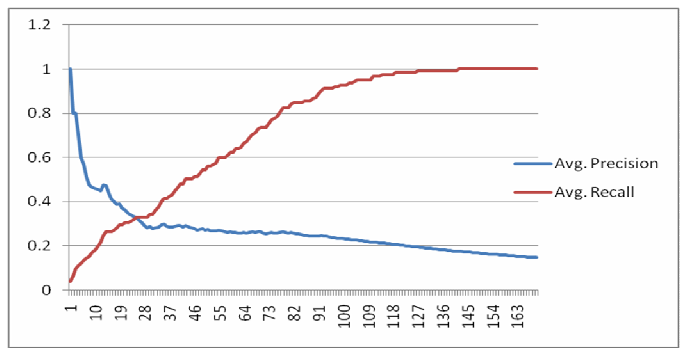

Fig 6:. Average Precision and Average Recall performance for Scenary class of images.

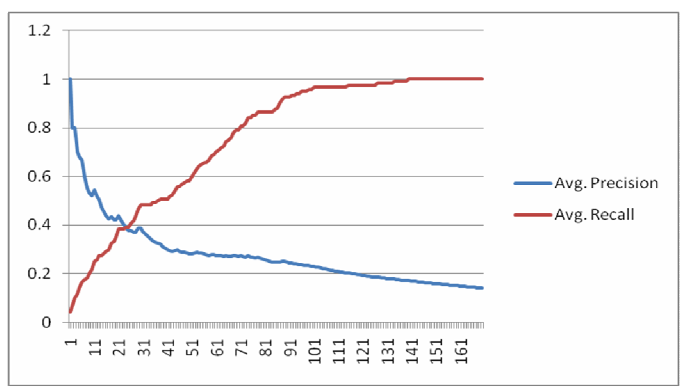

Fig 7: Average Precision and Average Recall performance for sunset class of images

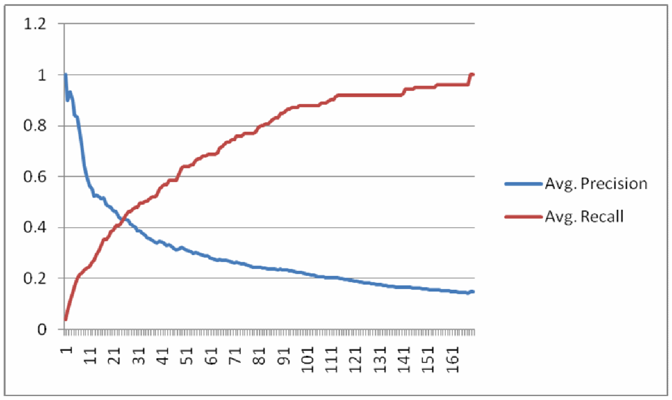

Fig 8: Average Precision and Average Recall performance for Barbie class of images

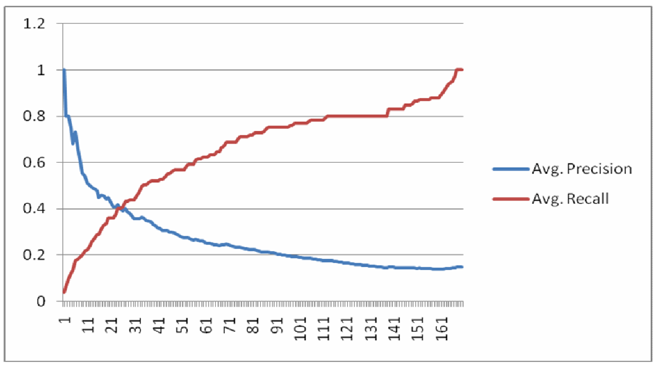

Fig 9: Average Precision and Average Recall Performance for flower class of images.

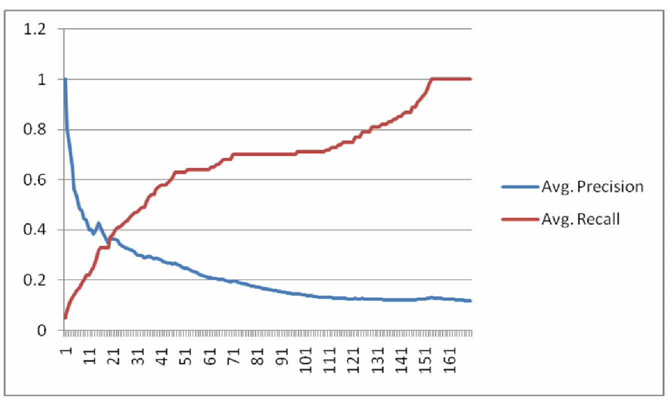

Fig 10: Average Precision and Average Recall Performance for Birds class of images.

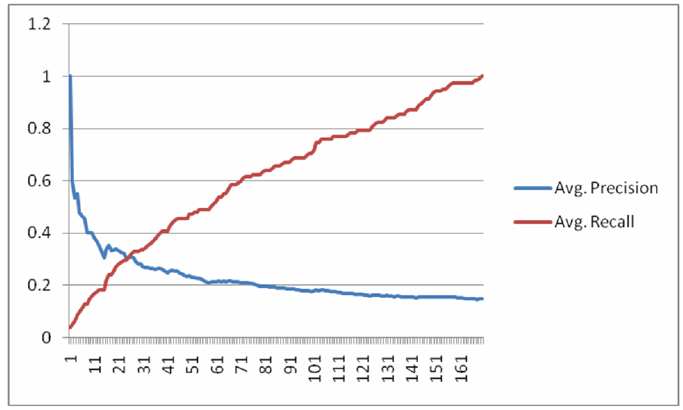

Fig 11: Average Precision and Average Recall Performance for Dog class of images.

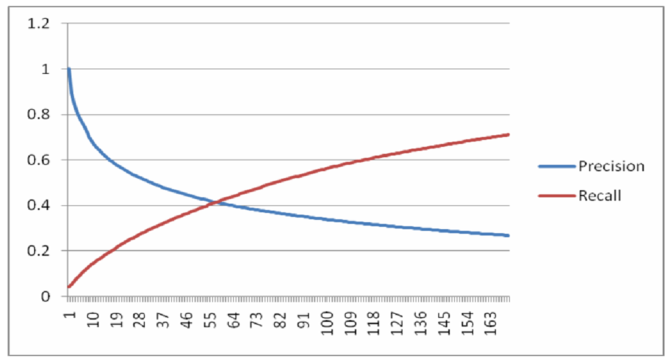

Fig 12: Average Precision and Average Recall Performance for Average Precision and Average Recall of all classes as shown in Fig..5 – Fig. 11.

V. CONCLUSION

We have presented a new algorithm for digital image search and retrieval in this paper. We have used Fast Fourier Transform of each R,G and B component of images separately which was divided into 8 sectors of which only top 4 sectors are used to generate feature vectors of dimension 8 which is a very small number as compared to using full transform as a feature vector. In all 24 components i.e. 8 components of R, G and B are considered for feature vector generation. Thus the algorithm is very fast as compared to the algorithms using full transforms which may have 128x128 components. The result of the algorithm shown in the form of average precision and recall of each class and overall average performance of precision and recall of each class as shown in Fig. 12 which is good performance.

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BIOGRAPHIES

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