CBIR using Upper Six FFT Sectors of Color Images for Feature Vector Generation

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Abstract- In this paper we are using Fast Fourier Transform to generate the feature vector which considers the mean real and mean imaginary parts of complex numbers of polar coordinates in frequency domain. The method proposed here considers 12 mean values of 6 upper half sectors real and imaginary parts of each R, G and B components of an image. The algorithm proposed uses 36 mean values of real and imaginary parts in total. The proposed work experimented over a database of 249 images spread across 10 classes of images. 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. The cross over point of average recall and precision is 50% and it is 40% or above for all classes.

I. INTRODUCTION [1]

In many areas of commerce, government, academia, and hospitals, large collections of digital images are being created. Many of these collections are the product of digitizing existing collections of analogue photographs, diagrams, drawings, paintings, and prints. Usually, the only way of searching these collections was by keyword indexing, or simply by browsing. Digital images databases however, open the way to content-based searching. There are various technical aspects of current content-based image retrieval systems and number of other overviews on image database systems, image retrieval, or multimedia information systems have been published [1-6]. Functionality of temporary image retrieval systems in terms of technical aspects: querying, relevance feedback, features, matching measures[7], indexing data structures, and result presentation needs to be considered for CBIR[1] .Comparison of specific systems, rather than general architectures provides a basis for statements like "this or that system already does what your system does". It also is a thorough foundation for claims that most systems use low level features, and few use high level semantic meaningful features. A number of keyword-based general WWW search engines allow to indicate that the media type must be images. HotBot on Lycos website and NBCi are examples of these. A number of other general search engines are more specifically for images, such as Yahoo!'s Picture Gallery or the multimedia searcher of Lycos but they are still only keyword based. There are many special image collections on the web that can be searched with a number of alphanumerical keys. For example, Image Finder Berkeley University provides a list of such collections as a tool to help teachers locate historical photographs from collections around the world. AltaVista Photofinder is a search engine that allows content-based image retrieval, both from special collections, and from the Web. CBIR techniques have been implemented by many researchers to achieve the better results of retrieval from large image database. These work has been focusing on various methods like DCT [7], WALSH transforms for image feature vector generation. In this paper we have used FFT sectors as the mean to generate the feature database and feature vector of the query image.

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 12 equal polar sectors of 30^0 each . Elements in each sector in frequency domain are grouped together.

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 6 sectors of upper half of complex plane.

Step4: The Euclidian distances 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 $\theta= \tan^{-1} (b/a)$

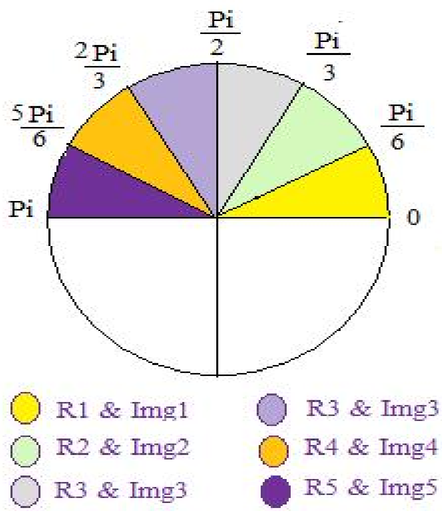

Fig.1: Illustration of use of upper half sector for feature vector generation

This is used to generate eight feature vectors based on the complex plane as mentioned above. The real and imaginary parts of complex numbers of images generated by the Fast Fourier transform is checked for the angle of complex plane to allocate them to different sectors each of Π/6 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 12. The feature vectors are generated by taking mean of real and imaginary parts of the complex numbers in following ranges (0-Π/6 , Π/6-Π/3 , Π/3 - Π/2 , Π/2 - 2Π/3 , 2Π/3 - 5Π/6 , 5Π/6 - Π) as shown in Fig.1 above.

IV. RESULTS AND DISCUSSION

Database of 249 images of 9 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.2.

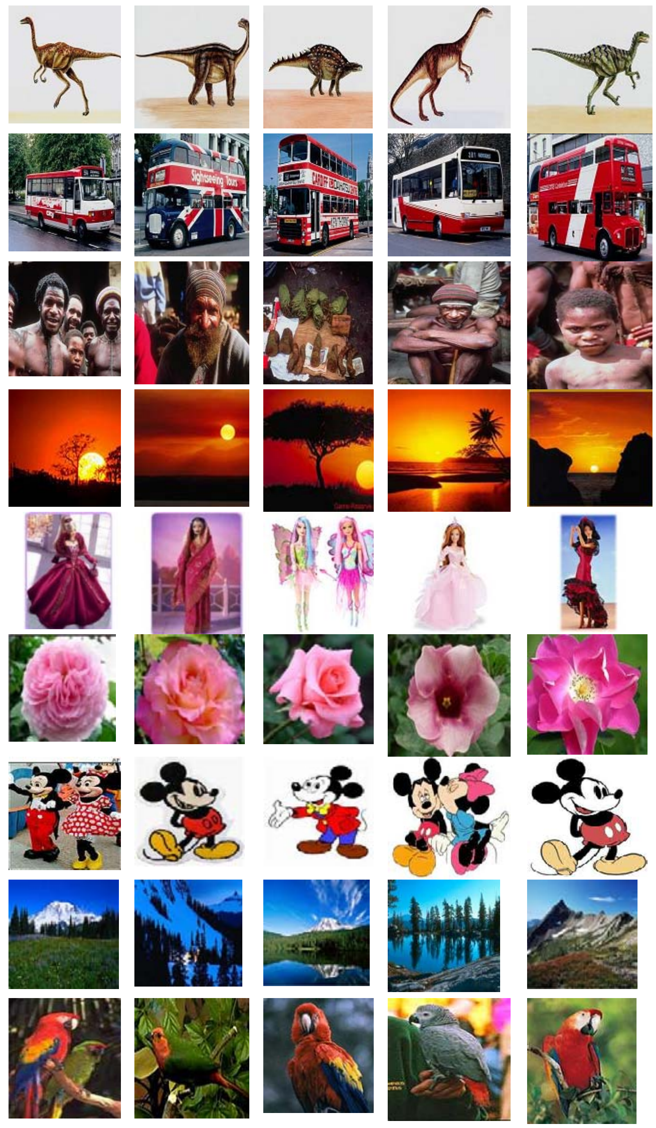

Fig. 2: Representative Sample of Image Database

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 [8-13]. The sorted Euclidian distance in ascending order between the query image and the database images feature vectors are used to calculate the precision [14-18] and recall to measure the retrieval performance of the algorithm as shown in the equations (2) and (3).

Once the query image of a class is taken The retrieved images are sorted in terms of increasing Euclidian distance [19][20] 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[20]: Precision is the fraction of the relevant images which has been retrieved (from all retrieved): Refer Fig.3.

$$\textbf{Precision} = A / (A+B) \qquad (4)$$

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

Recall[19][21]: Recall is the fraction of the relevant images which has been retrieved (from all relevant):

$$\textbf{Recall} = A / (A+D) \qquad (5)$$

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

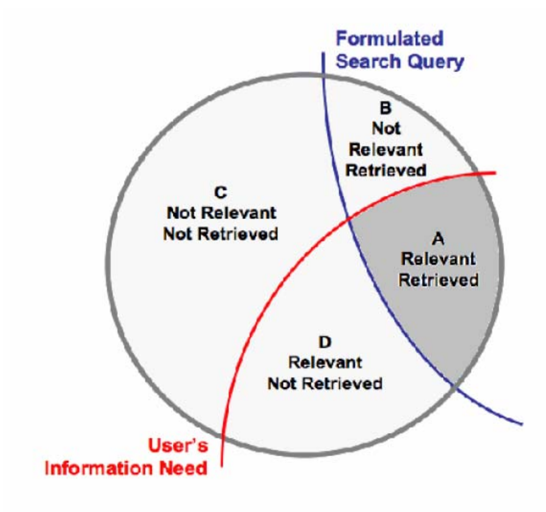

Fig.3 Four Possible Outcomes of CBIR Experiment [19].

Fig. 4: Query Image

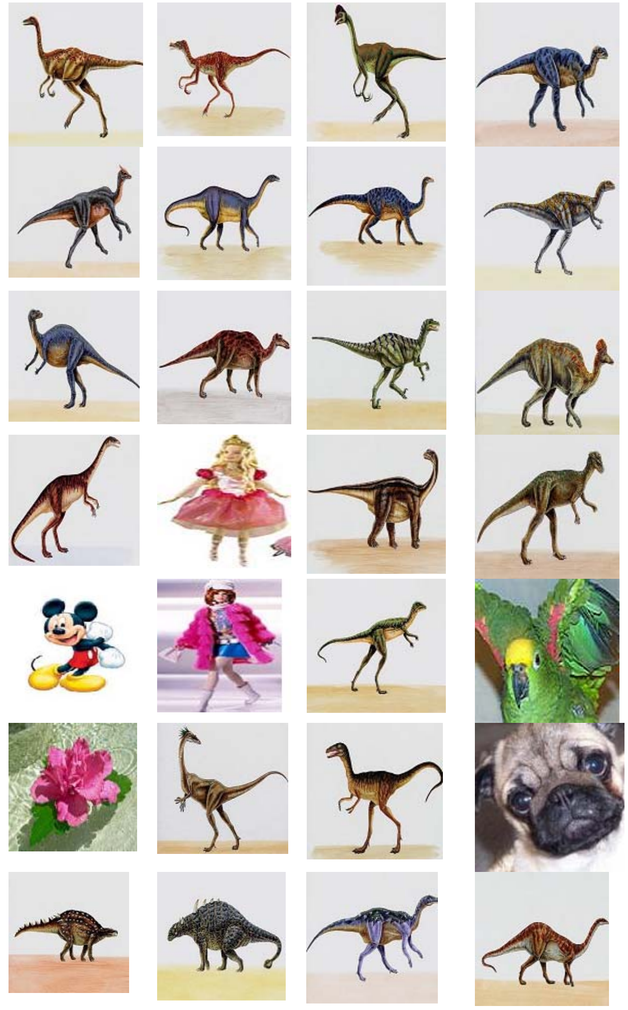

Fig 5: Images Retrieved against the Query Image shown in Fig. 4.

The dinosaur image shown in the Fig.4 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. This algorithm has produced very good results as it can be seen in the Fig. 5 where first 13 images are of dinosaur and 22 images retrieved are of dinosaur class among first 28 images retrieved. The first image is the query image itself if it is in the database. Graph of Average Precision and Average Recall Performance of these retrieved images of dinosaur class is shown in the Fig. 6. The Following graphs show average precision and average recall of various classes plotted against the number of images retrieved. The graphs are plotted by randomly selecting 5 sample images from each class. Results of dinosaur, bus, people, sunset, Barbie, flower, cartoon, scenery and birds are shown in Fig.6 to Fig.14. The overall average performance of the algorithm with respect to all classes is shown in the Fig.15. It shows the good outcome of the algorithm with smoother curve of precision and recall with cross over point of 50% retrieval. The proposed method provides the better outcome of retrieval for all classes which are 40% and above.

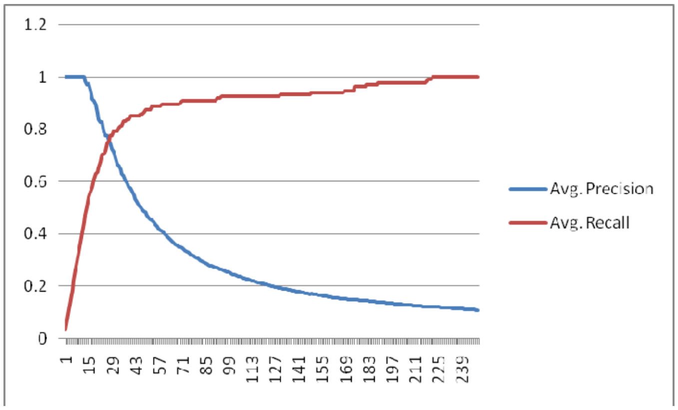

Fig 6: Average Precision and Average Recall Performance for dinosaur class of images.

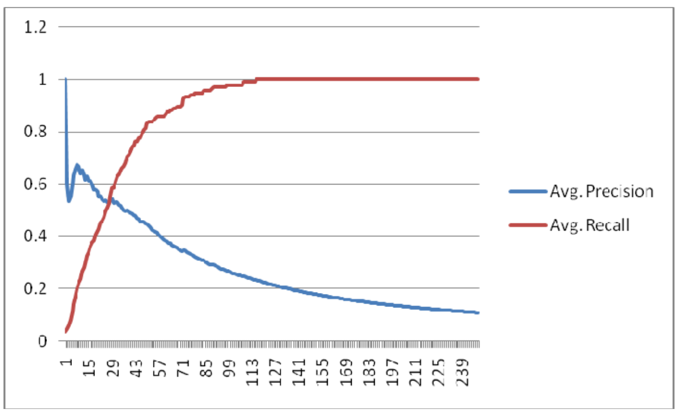

Fig 7:. Average Precision and Average Recall performance for Bus class of images.

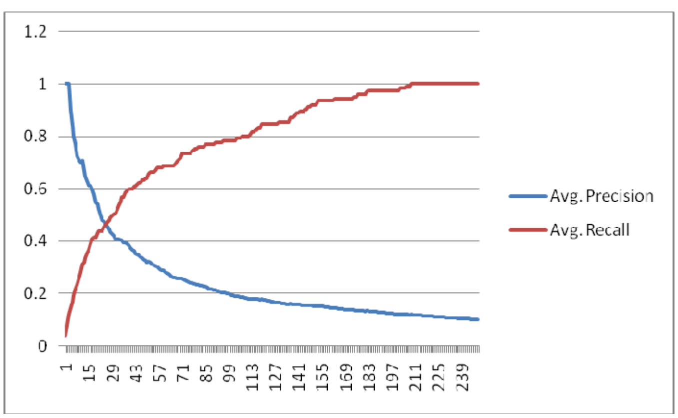

Fig 8: Average Precision and Average Recall performance for people class of images

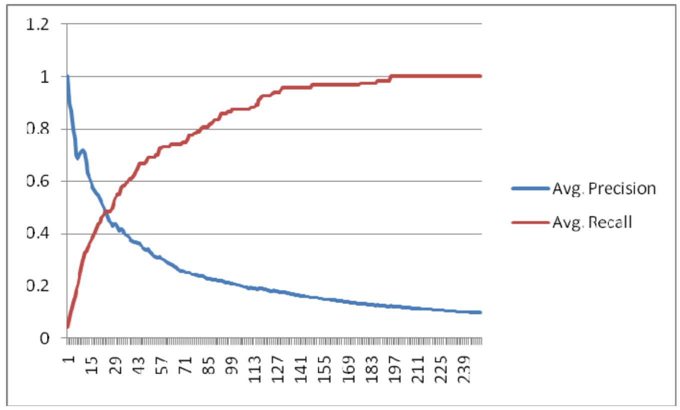

Fig 9: Average Precision and Average Recall performance for Sunset class of images

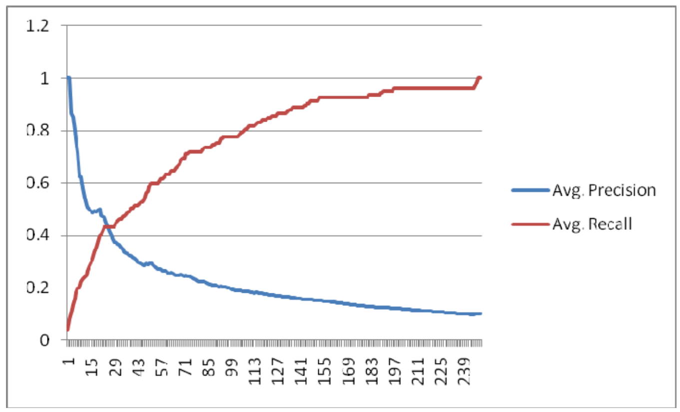

Fig 10: Average Precision and Average Recall Performance for Barbie class of images.

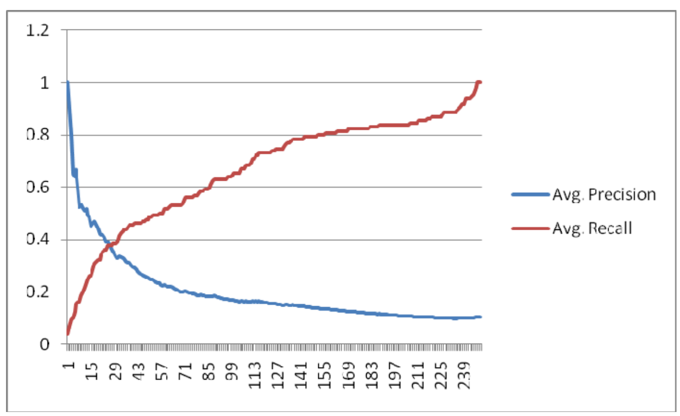

Fig 11: Average Precision and Average Recall Performance for Flower class of images.

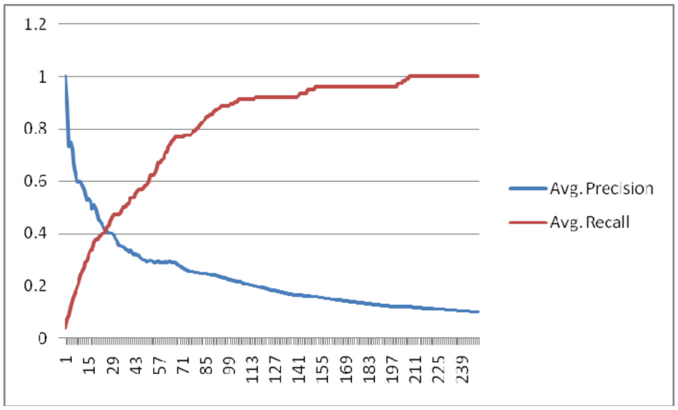

Fig 12: Average Precision and Average Recall Performance for Cartoon class of images.

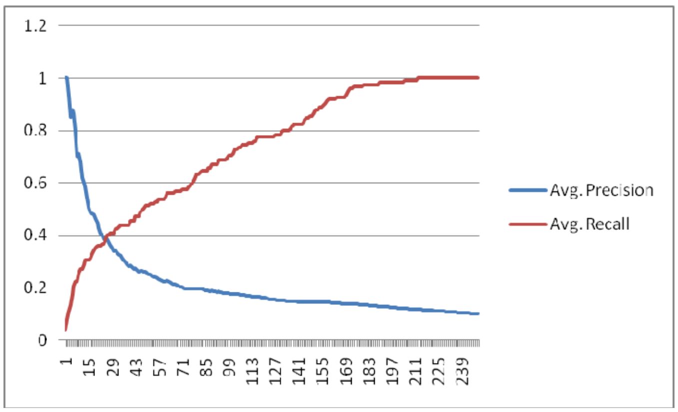

Fig. 13 Average Precision and Average Recall Performance for Scenery class of images.

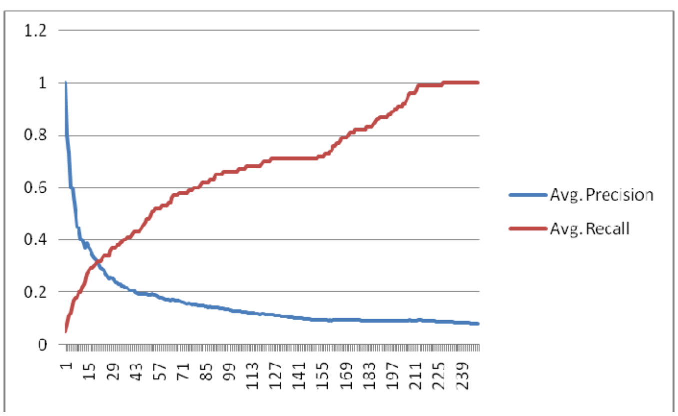

Fig. 14 Average Precision and Average Recall Performance for Birds class of images.

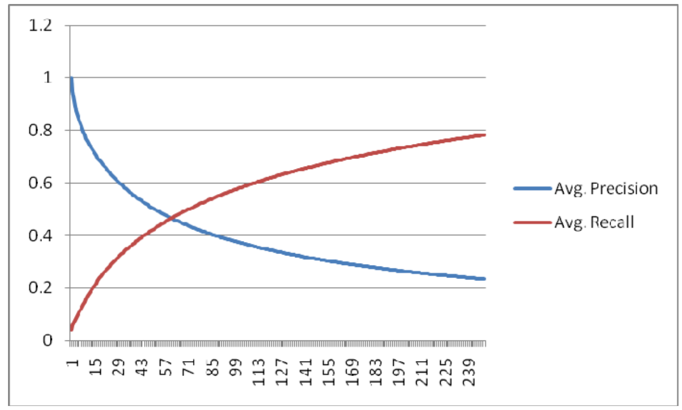

Fig 15: Average Precision and Average Recall Performance for Average Precision and Average Recall of all classes as shown in Fig..6 – Fig. 14.

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 12 sectors of which only top 6 sectors are used to generate feature vectors of dimension 36 which is a very small number as compared to using full transform as a feature vector. In all 36 components i.e. 12 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 Fig.6–Fig.14.and overall average performance of precision and recall of each class as shown in Fig. 15 which has cross over point at 50% which is a good performance.

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BIOGRAPHIES

Dr. H. B. Kekre has received B.E. (Hons.) in Telecomm. Engg. from Jabalpur University in 1958, M. Tech (Industrial Electronics) from IIT Bombay in 1960, M.S. Engineering (Electrical Engineering) from University of Ottawa in 1965 and Ph.D.(System Identification) from IIT Bombay in 1970. He has worked Over 35 years as Faculty and H.O.D. Computer science and Engineering at IIT Bombay.He has worked as a professor and Head in Dept. of Computer Engg. at Thadomal Shahani Engg. College, Mumbai for 13 years. He is currently working as Senior Professor at Mukesh Patel School of Technology Management and Engineering, SVKM'.s NMIMS University vileparle west Mumbai. He has guided 17 PhD.s more than 150 M.E./M.Tech Projects and several B.E./B.Tech Projects. His area of interest are Digital signal processing and Image Processing. He has more than 250 papers in National/International Conferences/Journals to his credit .Recently six students working under his guidance have received the best paper awards. Currently he is guiding 10 PhD. Students

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