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A Novel Approach to Content Based Image Retrieval Using Support Vector Machine

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***Abstract*-- In this paper, we propose content-based image retrieval method based on the SVM approach with efficient combination of histogram, color and edge features. Thus extending the work of the previous approach which used same set of features and the Euclidean distance measurement technique. As its histogram features, the extracted histogram bar values for each and every image are used. As its color features, the image is segmented into small pieces and then for each piece the red, green, blue values are used .As its edge features, Canny's edge detection technique is used to extract the maximum edge value of the image. After extracting the features, we use a machine learning technique called SVM (support vector machine) to find out the optimal result. Combining the features and classifying them using SVM and then finally comparing the results with the previous approach not only gives a better accuracy, but also evaluates the generalization ability under the limited training samples. The analysis of the proposed work is done using MATLAB R2007b simulator.**

***Index Terms*-- Color histogram, segmentation, edge detection, RGB color space, Machine Learning, SVM.**

I. INTRODUCTION

A. Support Vector Machine (SVM)

SVM was first proposed by Vapnik and is gaining popularity in field of machine learning due to many attractive features and to show practical performance [26]. It gives higher better performance in classification of image than other data classification algorithm. It is mainly used in real world problem like voice recognition, tone recognition, text categories, image classification, object detection, handwritten digital recognition, and data classification [26].

B. Content Based Image Retrieval (CBIR)

Today internet or World Wide Web has also become very popular for transferring data. So for that reason every data generated, analyzed, stored, transmitted and accessed through internet must be digitized and storing of alphanumeric data merely does not complete a system. For this efficient storage, access and retrieval the content based retrieval need to be developed in proper manner with its necessary attention. In this paper, we have given the prime importance to the image storage and retrieval. As image is one of the most widely used data besides text and also is the unit of video and other multimedia information, so content based retrieval of an image data also helps us to retrieve video and other multimedia information. This proposed approach is also a generalized approach to retrieval of other multimedia data.

II. Related Work

In past years, some paper has been presented for querying medium sized image collection. Some software are presented to store and retrieve primitive data and as well as complex data like images. Poulami Haldar and Joydeep Mukherjee [32] proposed such an approach where the image type, size, color and texture characteristics are extracted from the images and stored into the database. This type of software has its own content based retrieval module that allows users to build content based visual queries to the image level. All these are done by some background programming of the system. The image features are extracted from the original image and stored as metadata. And for the query image the same features are extracted from the image and compared with each other. But besides this offline approaches some online approaches [2] are also appreciable in this context. This approach has both higher level and lower level feature extraction. The higher level is just the refinement of lower level feature extraction. And with the introduction of finer features number of candidate images gradually decreases and search become more efficient.

Many approaches are available based on histogram extraction technique, but the color coherence vector [3] approach gave a new blow to previous histogram based approaches. This color coherence vector extracts not only the color distribution of pixels in images like color histogram, but also extracts the spatial information of pixels in the images. It gives us a more sophisticated approach towards histogram refinement. Use of multiple color coherence vectors gives much better efficiency than single one though it has higher computational

complexity. Some efficient work on histogram is done to detect image copy [4] also. In this scheme multi resolution histogram is used. It is almost same like the plain color histogram method. But it adds some extra feature like encoding of spatial information directly.

Most of the works related to the content based image retrieval is associated with the color extraction feature. Different approaches used different color spaces and different techniques to define color values. If the RGB color space is used in some approach then researcher gave high priority to the red, green and blue values. And in case of HSV color space, the hue, saturation and brightness takes the high priority level. For any other approaches different color values gets importance. Jagadeesh Pujari, Pushpalatha S.N, Padmashree D.Desai [5] used HSV and Lab color space to recognize an image and then compared it with grey and RGB approach. In their experiment Lab color space gives better result than other ones. But, Young Deok Chun, Nam Chul Kim and Ick Hoon Jang's [6] proposed approach is based on the HSV color space. They stored hue and saturation component for an image. And it gave a higher accuracy level than some other conventional methods though the feature vector matrix size was of the same size. In addition it also gave more retrieval accuracy for queries and target images of various resolutions. Some approaches also used the database to store the feature value of the images that stores color values as well as other features values. Finally the query image feature values are compared with each and every image's feature values. Then the final candidate images are retrieved. Xiang-Yang Wang , Yong-Jian Yu, Hong-Ying Yang[7] proposes a system that firstly cluster the image then predetermine them using fast color quantization algorithm. Then the dominant color values are obtained. Then these values are merged with the texture values and finally a robust system is presented.

Shape detection of an image is an important feature for object recognition. Shape description or representation of edge is an important issue in classification also. Nanhyo Bang and Kyhyun Um[8] proposed an extraction method of logical shape to detect structure of an image. They generated some pattern segment matrix that is composed of curve's type which helped them to find most similar curve sequence. As per their proposal they demanded that their system have global characteristic like the structural feature and also local characteristic as an adaptive feature of shape. This approach reduces computational complexity and retrieval cost. Zheng-Yun Zhuang, Ming Ouhyoung [9] proposed a new type of image retrieval approach that associates both with shape detection and color value extraction. Their system has two types of matrix i.e. „shape metric" and „color metric" to store the color values. This approach also gives good accuracy as two features are used efficiently here. N. Senthilkumaran and R. Rajesh [21] have done a comparative study in different edge detection techniques. They have used the soft computing approaches namely, fuzzy based approach, Genetic algorithm based approach and Neural network based approach. In their research it is seen that Robert method is better than both Sobel and Prewitt method. But by our experiment we can come to an conclusion that for our system the Canny method gives more accuracy than the Robert method.

SVM does not hypothesing number of neurons in the middle layer or defining the centre of Gaussian function in RBF. SVM uses optimal linear separating hyper planes to separate two set of data in feature space. Optimal hyper planes are produced by maximum margin between the two set [28]. If we plot the data about X and Y axis and to classify it, we see that there are many hyper planes which can classify it. But to choose which one is the best or correct solution is very difficult task. For removing this type of problem SVM used [27]. The main feature of SVM is to construct a hyper planes or a set of hyper planes with the help of support vectors in a higher dimension space [31]. These are mainly used for classification. It separate the space into two half space. A 'good separation' is achieved by hyper planes that have the largest distance to the nearest data points. Here good separation means larger the separation between two hyper planes gives lower generalization error. That's by it is called maximum margin classifier [26], [28], [29], [30]. Two parallel hyper planes are constructed on each side of the hyper planes that separate the data. If geometric gap between hyper planes high than classification error is low [26], [28].

III. OBJECTIVES & OVERVIEW OF THE PROPOSED SYSTEM

A. Objective

In this paper we extend the approach proposed by Poulami Haldar and Joydeep Mukherjee [32] for image store and retrieval methods based on different extracted features like image histogram analysis, extraction of color values from segmented image and logical shape detection of an image, by classifying them using SVM.

B. Overview of the proposed mechanism

Our first approach on feature extraction is image histogram analysis. For this we have used some functions that extracted histogram bar values for each and every image. The generated image histogram is almost like a bar graph and that bar values varies from image to image depending on the color, intensity and many other things related to that

image. After extraction of histogram bar values of an image, the different bar values are stored in a 1D array. This process is repeated for every image in the database.

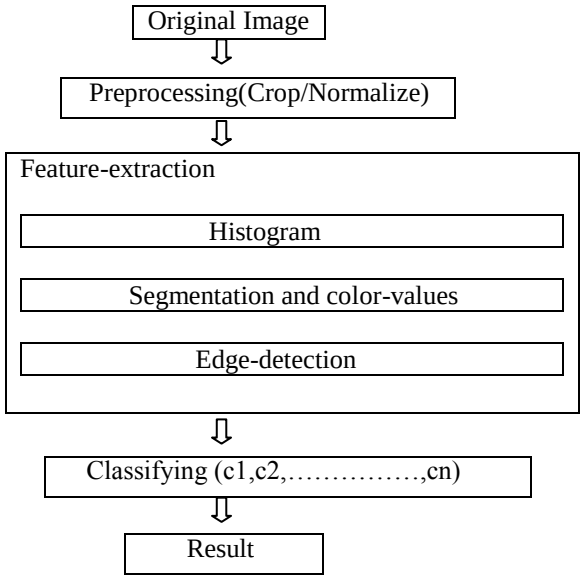


Fig 1: Flow Chart

Our second approach in feature extraction is to extract color values from an image. For this we segmented one image into many small pieces and then for each and every piece the red, green and blue color values are extracted. After this process we took an average of red, green and blue values for one small image. So after this process we get three color values (red, green and blue) for each small part of our main storable image. This color values are also stored in three 1D arrays.

Our third approach in feature extraction is logical shape detection of image. Logical shape detection is also well known as edge detection technique. For edge detection we have many different techniques available that have been proposed times before. We used Canny's edge detection technique as most of the experiments have proved that this technique gives most effective result for our proposed system.To apply this technique we have to convert our image to a grey scale one. Though the color values of the image is lost but that makes our edge detection more efficient. After conversion and edge detection is done we have taken the maximum edge value for one column of the image and stored it into a 1D array.

Our fourth approach is finally after all the feature values are extracted and stored for one image we get five 1D arrays for one image. For the query images also the same procedure is followed. Then we load the dataset and use support vector machine to classify the dataset to get the optimal result.

IV. Efficient Content Based Image Retrieval System

Our proposed methodology involves study of three features image histogram, segmentation, RGB color values and edge detection techniques which are basically taken from the previous approach [32]. It is used for the implementation of CBIR using histogram, color and shape descriptor approach and then finally classifying these features using SVM.

A. Image Histogram Analysis Method

An image is a function of two variables. It is simply represented by a 2D matrix after the digitization is done. If a pixel in that image is black then the pixel value is assigned to zero and in case of a white pixel the pixel value is assigned to one. For other pixels some other values in between one and zero is assigned. Color histogram of an image is a type of bar graph and these acts as a graphical representation of the tonal distribution in a digital image. The number of pixels is plotted for each tonal value. An image viewer can understand the entire tonal distribution of an image by looking at the histogram bar graph. In mathematics a histogram is a function $\boldsymbol{m_i}$ that counts the number of observations that falls in each of the category (bins). Thus, if $\boldsymbol{n}$ is the total number of observations and $\boldsymbol{k}$ is the total number of bins, the histogram $\boldsymbol{m_i}$ meets the following conditions:

$$n = \text{sum}(m_i) \text{ when } i=1 \text{to } k$$

In our proposed approach image histogram feature is extracted by converting an image to grey color space and applying this formulae.

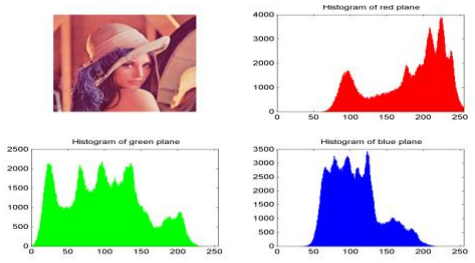


Fig 2: Image histogram representation of an Image

B. Image Segmentation and Color Values Analysis Method

Image segmentation is a modular approach to get color values of image more accurate. Segmentation of an image means, to divide an image into many small parts. The goal of segmentation is to simplify the representation of image into something that is easier to analyze and access. The segmented images collectively represent the whole main image. By

segmentation the different characteristics such as color, intercity, texture etc. of an image can be accessed, manipulated and computed easily. A color image is represented by three 2D matrices after digitization in RGB color space. One matrix is for red and two are for green and blue. So for a color image we get three 2D matrix of same size as the image size in pixels. After segmentation also for every small part we get same size matrix as image size in pixels. And as segmented image color manipulation is more easy and accurate so color values we get is more accurate if we do any computation over them. For every small image we get three color values after computation.

C. Edge Detection Method

Shape of an image describes more or less each and every object presented in an image. Edge extracted from an image tells us about the full content of an image. There are various techniques of edge detection available i.e. Prewitt method, Sobel method (Fig 4), Robert method etc. But in our proposed system Canny's method is used. It is proposed by John Canny. He derived optimal smoothing filter algorithm by giving criteria of detection, localization and minimizing multiple responses to a single edge. He used a filter that is well approximated by first-order derivatives of Gaussians. Though it is an old approach, but it is still hard to find an edge detection technique better than this.

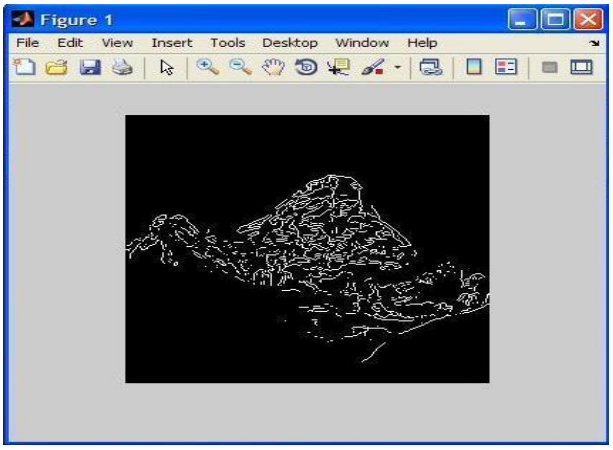


Fig 3: Edge detection by Sobel's method

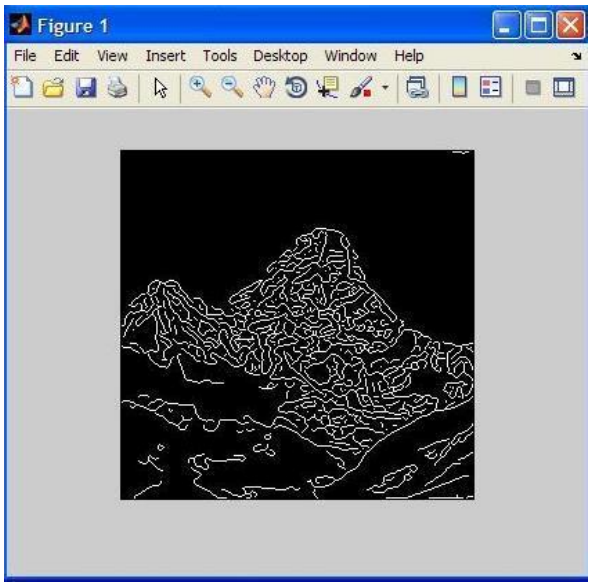


Fig 4: Edge detection by Canny's method

D. Classification using Support Vector Machine

Here we use SVM as a classifier for the classification of image and apply this classification process to all the features of image which are extract from feature extraction step. It is mainly used to find maximum margin hyper planes in a high dimensional feature space. It divides the feature set into arbitrary groups and classifies them to return the best optimal result.

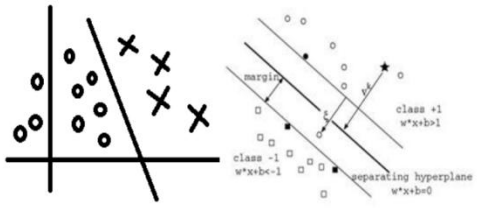


Figure 5: (a) A separating hyper plane. (b) The maximum margin separating hyper plane.

V. FEATURE EXTRACTION

As mentioned earlier, our proposed approach uses three feature extraction methods i.e. image color histogram extraction, segmentation and image color values extraction in RGB space and image edge detection using Canny's edge detection technique.

A. Histogram Feature Extraction

Our proposed algorithm to find the histogram of a color image is following:

Step1: read the image file.

Step2: convert the color image to a grayscale one (fig 6).

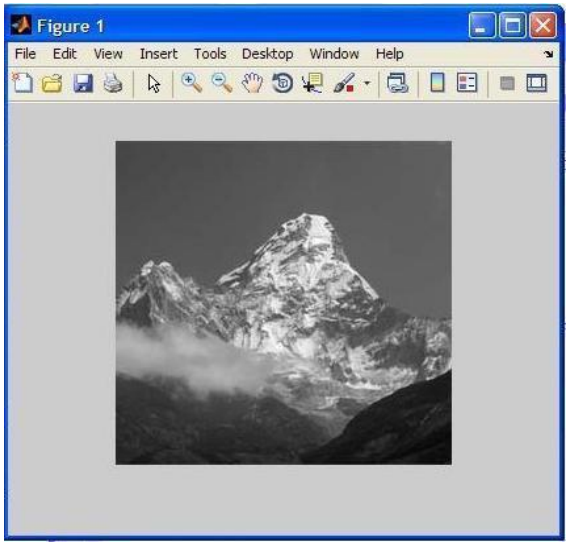


Fig 6: Grey scale image (after conversion)

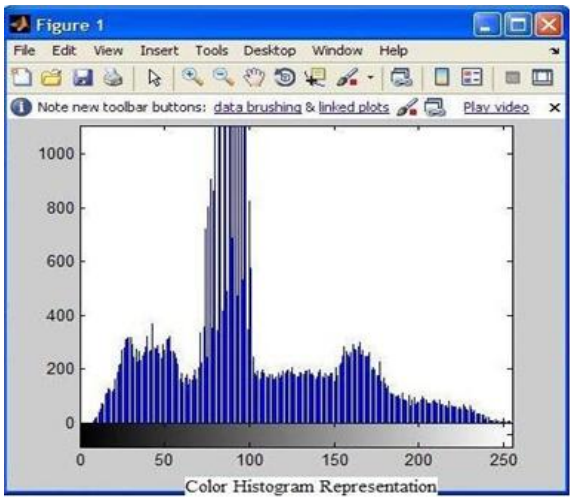


Fig 6: Generated color histogram

Step3: find the image histogram by Matlab's own histogram computational method.

Step4: find the relative frequencies of colors inside the image.

Step5: store the values in a matrix.

B. Image Segmentation and Color Values Extraction

Proposed algorithm to segment an image and extract red, green and blue color values from it is as follows:

Step1: read the image.

Step2: segment the image into small parts by some computational method. The number of segmented small image is not fixed. Any number of images can be generated. For our system main image size is 256X256 and small parts are of 16*16 size (fig 7).

Step3: for every small part red channel, green channel and blue channel color matrices are generated.

Step4: the average of red matrix is taken for one small part and the same process is repeated for both green and blue matrix.

Step5: now finally we get one red color value as well as green and blue color values for one small image part.

Step6: store these values in a matrix.

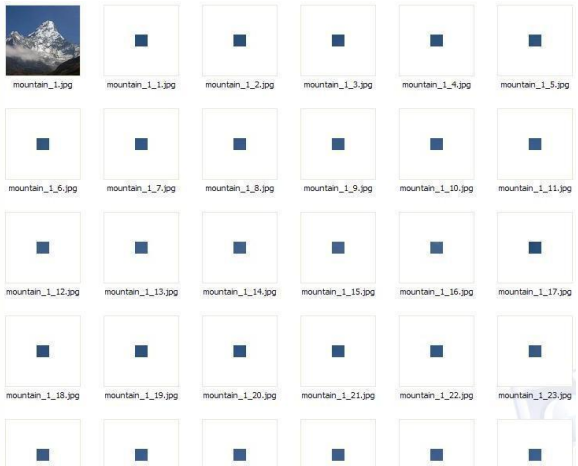
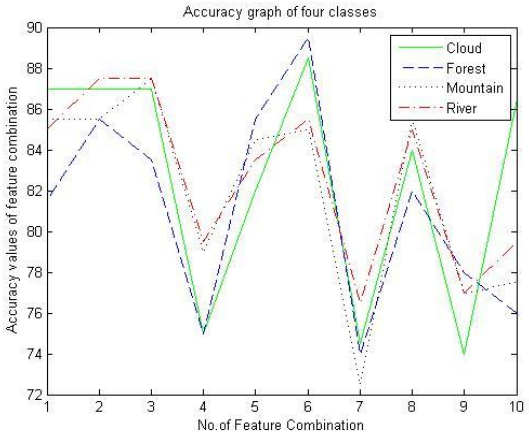


Fig 7: Main image with its segmented parts

C. Edge Detection and Values Extraction

Our proposed algorithm to find the edge of a color image is as follows:

Step1: read the image.



Step2: convert the image into a grey scale image because Matlab supports edge detection only after conversion the image into grey scale one.

Step3: apply Canny's edge detection technique to detect the edges and store it into a 2D matrix.

Step4: the maximum value of each column is taken from the generated matrix.

Step5: store the values in a new matrix.

D. Classifying using SVM

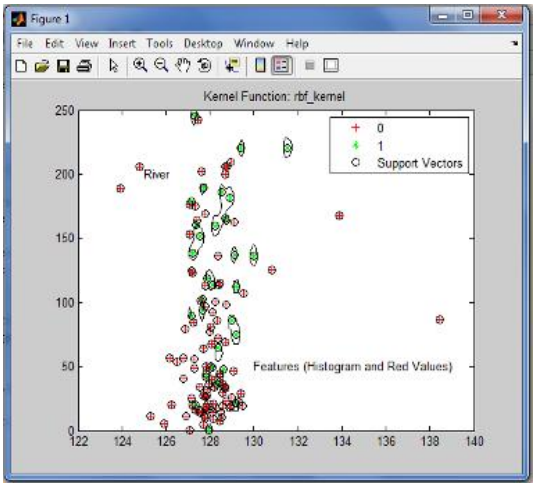
Now all the features are extracted from image and stored into different matrices. But for classifying we need to accumulate all the data into one single matrix i.e., we need to form the dataset. After that we propose our algorithm for classifying the dataset which is as follows:

Step1: Load the dataset.

Step2: Prepare new data from the dataset.

Step3: Then create two groups to classify the data.

Step4: Randomly select train and test set.



Step5: Train the SVM classifier.

Step6: Test the classifier.

Step7: Find the performance of the classifier.

VI. EXPERIMENTAL RESULTS

A. Classification Results

We test the proposed approach using our dataset that contains 400 images which are divided into 4 classes cloud, forest, mountain and river. Radial-basis kernel function is used for SVM learning. Here we have used ten feature combinations i.e., taking two features at a time (like histogram and edge value) for each of the 4 classes .Fig8-9 depicts the plot of training and testing of the classifier for a specific class. Now we compare the accuracy result with the approach proposed in [32].

Fig 8: Training the classifier for Class River

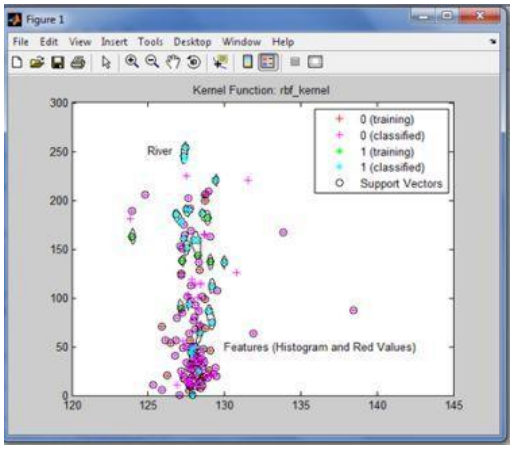
Fig 9: Testing the classifier for Class River

B. Final Accuracy Graph Plotting

After training and testing phase is over, we have calculated the accuracy for the four classes for the feature combination. The final accuracy graph is given below (fig 10).

In fig 10 Cloud denotes class 1 value, Forest class 2 values, Mountain class 3 values and River class 4 values.

Fig 10: Accuracy Graph



C. Accuracy Table

Table 1. Accuracy table for all features combinations for the 4 classes

	HR	HG	HB	HE	RB	RG	RE	BG	BE	GE

Cloud	**87**	**87**	**87**	**75**	**82**	**88.5**	**74.5**	**84**	**74**	**86.5**
Forest	**81.5**	**85.5**	**83.5**	**75**	**85.5**	**89.5**	**74**	**82**	**78**	**76**
Mountain	**85.5**	**85.5**	**87.5**	**79**	**84.5**	**85**	**72.5**	**85.5**	**77**	**77.5**
River	**85**	**87.5**	**87.5**	**79.5**	**83.5**	**85.6**	**76.5**	**85**	**77**	**79.5**

Now comparing the final accuracy of the four classes for both the approaches.

Table 2. Accuracy table for 4 classes

	Cloud	**Forest**	**Mountain**	**River**	**Total Accuracy**
Euclidean	**95**	**90**	**90**	**50**	**81.25**
SVM	**81.55**	**81.95**	**81.05**	**91.40**	**83.98**

VII. CONCLUSION

After comparing the two approaches we find that SVM gives an optimal result as compared to the first approach. We can say that for our implemented system, the image classes used by us give very good image retrieval accuracy. Our system performance is quite reasonable as per the accuracy graph shown above. At the same time the accuracy is uniform for all the classes making SVM a better choice.

VIII. FUTURE SCOPE

In our proposed approach we worked with image retrieval from some stored images. Properly maintained database storage instead of MATLAB file may give better accuracy level and also can reduce the time and computational complexity.

This approach concentrates only on retrieving of image files, but in future this work can be enhanced to retrieve the audio and video file by using these features or modifying them. Also here we have done only binary classification using SVM; we can extend it further using Multi-class SVM and classify more features at a time.

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