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An Approach to Natural Image Classification based on Wavelet Transform and KNN

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Abstract—

Based on the shape, texture and color information, a new approach for image classification is presented. In this work, to extract the feature, three RGB bands of a color image in RGB model are used. Each image in database is spatially segmented into six spatial parts. Then Daubechies-4 wavelet transform and first order color moments are used to obtain the necessary information from each part of the image. K- Nearest Neighbor classifier is utilized in the proposed image classification system. Wavelet decomposition coefficients and Color moments from each part of the image are used as an input vector of KNN classifier. 150 color images of each category namely car, airplane and bike were used for training and 50 for testing. The best accuracy of 94% was obtained for training set and 86% for the testing set.

Keywords— Wavelet Transform, KNN, Image Classification, Color Moment

I. INTRODUCTION

In today world, the word knowledge has exchanged its meaning with information and hence to the data. In addition to it the rapid development in technologies in digital field and computing hardware makes the digital acquisition of information to be more in demand and popular. The term image classification refers to the categorizations of images into one of a number of predefined categories. Therefore, image classification challenge is also used for image-based CAPTCHA (Completely Automated Public Turing Test to Tell Computers and Humans Apart). To address image-based CAPTCHA problem and other problems like web searching, surveillance and sensor system, designing and implementing automatic image classification algorithms has been an important research field for decades. Consequently many digital images are being captured and stored such as medical images, engineering images, fashion images, sports images, cars, bike etc., and as a result large database are being created and used in many applications.

The human ability to analyze and classify objects and scenes rapidly and accurately is something that everybody finds highly useful in everyday. Thorpe and his colleagues found that humans are able to categorize complex natural scenes very quickly . In order to understand a complex scene, the first step is to recognize the objects and then recognize the category of the scene . In order to do this in computer vision, we use various classification algorithms that all have different characteristics and features. Classification algorithms typically employ two phases of processing: training and testing. In the initial training phase, characteristic properties of typical image features are isolated and based on these, a unique description of each classification category i.e. training class is created. In the subsequent testing phase, these feature-space partitions are used to classify image features.

For traditional machine learning algorithms, image classification from a database is particularly difficult because of the high number of images and many details that describe an image. For these reasons, traditional machine are unstable to classify images from a database. Furthermore, these machines take long time for classification. Existing image storing systems such as QBIC [1] and VisualSEEK [2] limit classification mechanism to describe an image based on texture, shape features or color information [3].

II. LITERATURE SURVEY

In [4], proposed a novel image representation to access natural scenes by local semantic description. They use a spatial grid layout which split the images into regular subregions. The techniques use both color and texture to perform landscape image classification and retrieval based on a two stage system. First the image is partitioned into 10×10 subregions and each one is classified using K-NN or SVM. An image is then represented by a so-called Concept Occurrence Vector (COV) which measures the frequency of different objects in a particular image. Given the image representation a prototypical representation for each scene category can be learnt. Image classification carried out by using the prototypical representation itself or Multi SVM approach. The advantage of this approach is that they it uses human meaning to classify the object and then image and able to classify image into big number of categories. The average classification accuracy is 71.1%. The disadvantage of this approach is that here image classification is based on object occurrence so a wrong object classification will result into erroneous image classification.

Shanmugam *et al*. [5], used extracting wavelet features for classifying war scene from the natural scene. By using After extracting wavelet features they are classified by using Artificial Neural Network and then Support Vector Machines (SVM). This paper also compares Artificial Neural Network and Support Vector machine and determining which one is best to classify war scene. First from the input image wavelet features are extracted and then that extracted features are given to normalization in order to maintain the data so that performance of classifier can be improved. Normalized features are given as input to Artificial Neural Network and also to Support Vector Machine. ANN classify the image using backward propagation algorithm and SVM classify the image using radial basis kernel function with p=5. In the case of SVM, it gives only 59% classification rate and in the case of ANN, it gives only 72.5% classification rate. Thus ANN provides good classification result in classifying war scene by extracting wavelet features when compared with SVM.

An Noridayu *et al*. [6], proposed a new method for improving performance of object class recognition by combining different features with local features. In this, local features and boundary-based shape features are extracted from the image. The first type of feature is based on the interior information of objects while the second are based on the outline of segmented objects. Two features thus obtained are combined and then concatenating those features in a new single feature vector by using features fusion approach. Then features are classified by using Support Vector Machine(SVM). The classification accuracy was 70% is achieved.

Fei-Fei and P. Perona [7], proposed a method to classify natural scene. The images of scene are represented by a collection of local regions. These local regions are denoted as codewords. Then these codewords are automatically distributed to each local patch. Then identify a model that represents the distribution of these codewords in each category of scenes. In recognition, they first identify all the codewords in the unknown image. Then find in which category model distribution of these codewords of that particular image belongs to. Thus they classify images. In this classification scenes are categorized in the training phase itself so time will be less when recognizing unknown images and also here codewords are automatically distributed to each local patches that extracted from the image. The images are correctly classified at 76%.

In [8] Harr and a bank of perceptrons applied to image classification from a database of 600 images (300 for training and 300 for testing). They obtain 81.7% correct classification for training set and 76.7% for testing test. In [9], combination of wavelet transforms and neural networks applied to image classification. They report performances is near to 80%. In [10] Daubechies wavelet transforms are used to classification. 120 color images of airplanes were used for training and 240 for testing. The best efficiency of 88% was obtained. In [11], new approach to texture analysis and classification with neural network based on the wavelet transform is given and its good performance on the classification accuracy is demonstrated in the experiments. The proposed technique was verified using four classes of visually similar textured images, with a successful classification rate above 95%.

III. PROPOSED SYSTEM

The main objective of the system is to classify the images into three categories. The classifier used here is the KNN alongwith special feature extraction procedure. In the overall procedure, there are two phases of the system. Off-line phase and On-line phase *i.e.* the database creation phase and the actual classification of image using the above mentioned classifiers.

A. Off line process

All the images in the dataset are of random size, hence they are resize to 256*256.This resized image is then decomposed into R, G and B channel. Wavelet Transform is used to extract the describing features of the image. These features in the form of vectors are stored in the database. For the proposed method, three category each containing 150 images were considered and there feature vectors were stored in the training database. The features of all the images constitute the database for our system.

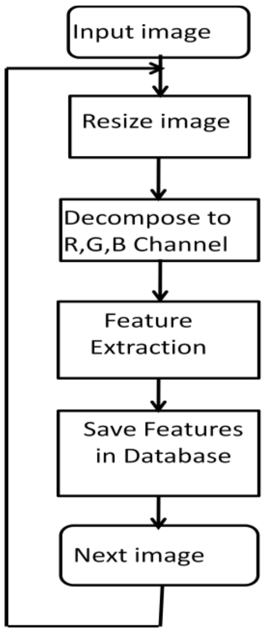


Fig. 1 Off line process

The table 3.1 shows the image category and image description belonging to each category along with the number of images.

TABLE I DATABASE OF IMAGES

Sr.	Category	Image Description	No. of Images
1	Category-1	Car	150
2	Category-2	Airplane	150
3	Category-3	Bike	150

Fig 2 shows some of the sample images of each category *i.e.* car, airplane and bike that were considered for creating the training database. The images below are part of the set of images that constitute the database for system.

(a) (b) (c)

Fig. 2 Images from the database (a) Car (b) Airplane (c) Bike

B. Online process

Fig. 3 shows the flowchart for image classification. The Query image is resized and decomposed into R, G and B channel. The features are extracted using db-4 wavelet transform. The extracted feature of query image is compared with the feature in training database. The K Nearest Neighbor technique classifies the query image into one of the predefined categories by comparing the extracted feature with the feature in the database.

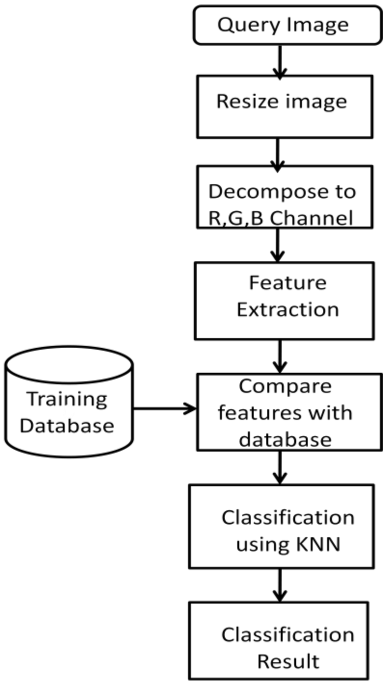


Fig. 3 Online process for Image classification using KNN

IV. IMAGE FEATURE EXTRACTION

The accuracy of the system behavior is majorly depends on the features used for training of classifier and the classifier structure itself. In this work, the effort is made to present the novel feature extraction method which computes the unique ninety nine features for each image. These features are stored in the database which is used to compare with features of query image for the classification. Fig. 4 elaborates the complete feature extraction methodology used in this approach.

The images available are of different sizes, at first all such images are resized to 256*256 RGB image format. After this, the resized image is then split into three color bands namely R, G and B.

Each of these channels is decomposed to level 1 by db4 wavelet transform to the approximate, horizontal, vertical and diagonal components. Among this, the energy of only horizontal, vertical and diagonal components belonging to each channel is calculated which constitutes (3*3) nine features with the formula given as

$$E = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} p(i,j) \qquad (1)$$

After this each channel is spatially divided into six parts. Now, for each of these six parts, the color moments are calculated from the formula given as

$$CM = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} p(i,j) \qquad (2)$$

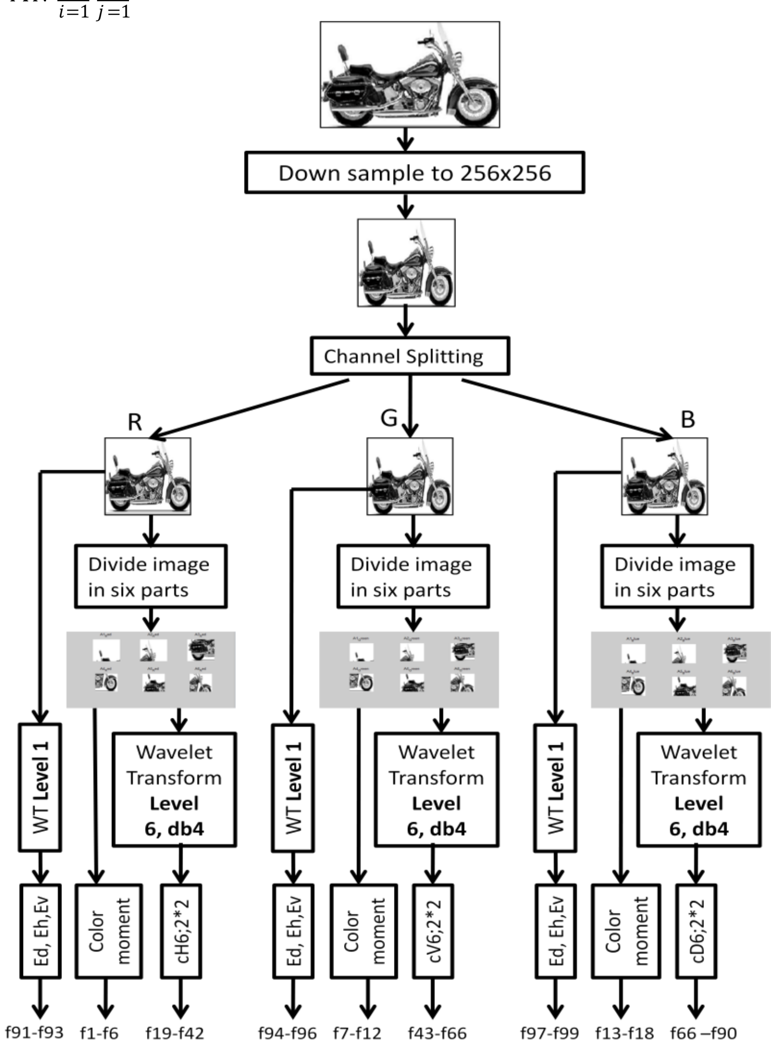


Fig. 4 Image feature extraction methodology

These color moments constitutes (6*3) eighteen features of an image. The next step is successive wavelet decomposition of each of the six parts. Each part is decomposed to six levels by db4 wavelet transform. Here, after each decomposition the size of the image gets halved. Therefore starting at 256*256, six level decomposition leads to final image of size 2*2. Thus, this procedure gives the 2*2 matrix of horizontal, vertical and diagonal components for each part of each channel after six level decomposition.

- For Red channel, each value of 2*2 matrix of horizontal component for each of six parts is stored as feature values. (6*4)
- For Green channel, each value of 2*2 matrix of vertical component for each of six parts is stored as feature values. (6*4)
- For Blue channel, each value of 2*2 matrix of diagonal component for each of six parts is stored as feature values. (6*4)

This process provides (6 parts * 4 values) 24 features for Red, 24 features for Green and 24 features for Blue channel. The total no. of features that are obtained after this complete procedure is ninety nine. All these features are stored as a column vector associated with the category specified corresponding to each image presented to the system for training purpose. Hence this feature extraction process is novel and which supports the classifier to improve the performance.

V. Performance Evaluation

In this chapter we are going to analyze the performance of the proposed method. The project dataset consist of three categories mainly airplane, bike, car. All the images in the dataset are color images of size 256*256 pixel. For training purpose we have considered 150 images of each category and for testing we have considered 50 images of each category.

TABLE II Category description Table

Sr	Category	Image Description	No. of Images for Training	No. of images for Testing
1	Category-1	Car	150	50
2	Category-2	Airplane	150	50
3	Category-3	Bike	150	50

The above Table II, contains three categories and the image description for each category. It also shows the number of images considered for training and testing.

TABLE III Performance matrix for KNN classifier for Training images (150)

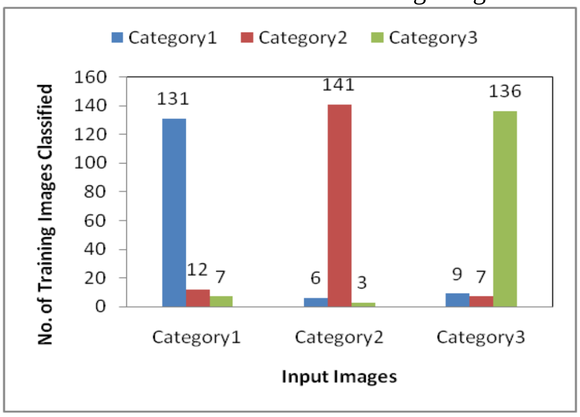
		Classification Result		
		Category 1	**Category 2**	**Category 3**
Input Image	Category 1	131	12	7
	Category 2	6	141	3
	Category 3	9	7	136

The above Table III, shows the distribution of classification performance of KNN classifier. Here, 150 images belonging to each category were provided as a training image to system. Car, Airplane and Bike belongs to category 1, category 2 and category 3 respectively. The Table III shows the distribution for correctly classified images for each category. From Table III it can be concluded that among of 150 images of car the KNN has accurately classified 131 images in category 1 and wrongly classified 12 images in category 2 and 7 images in category 3. For category 2, the KNN has classified 141 images correctly in category 2 and wrongly classified 6 images in category 1 and 3 images in category 3.Similarly for category 3, 136 images were correctly classified and 9 images were classified in category 1 and 7 images in category 2.Thus the above table presents the overall classification performance of KNN classifier for 150 training images.

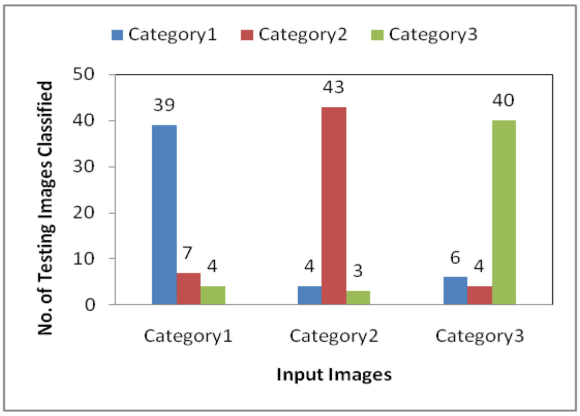
TABLE IV Performance matrix for KNN classifier for Testing images (50)

		Classification Result		
		Category 1	**Category 2**	**Category 3**
Input Image	Category 1	37	9	4
	Category 2	6	40	4
	Category 3	7	5	38

The above Table IV shows the distribution of classification performance of KNN classifier on testing. Here, 50 images belonging to each category were provided as a testing image to system. From Table IV, it can be concluded that among of 50 images of car the KNN has accurately classified 37 images in category 1 and wrongly classified 9 images in category 2 and 4 images in category 3. For category 2, the KNN has classified 40 images correctly in category 2 and wrongly classified 6 images in category 1 and 4 images in category 3.Similarly for category 3, 38 images were correctly classified and 7 images were classified in category 1 and 5 images in category 2.Thus the above table presents the overall performance of KNN classifier for 50 training images.



(a)



(b)

Fig. 5 Performance of KNN classifier for Images (a) Training images (b) Testing images

Fig 5 (a) shows the graph for performance of KNN classifier for training images. For category 1 the highest peak (blue color) shows the correctly classified images for category 1 where as the two low peaks (red & green) shows wrongly classified images of category 1 in category 2 and category 3 respectively. For category 2 the highest peak (red) shows the correctly classified images for category 2 where as the two low peaks (blue & green) shows wrongly classified images of category 2 in category 1 and category 3.Similarly for category 3(green) shows the correctly classified images for category 3 where as the two low peaks (blue & red) shows wrongly classified images of category 3 in category 1 and category 2 respectively.

Fig 5(b) shows the graph for performance of KNN classifier for testing images. For category 1 the highest peak (blue color) shows the correctly classified images for category 1 where as the two low peaks (red & green) shows wrongly classified images of category 1 in category 2 and category 3 respectively. For category 2 the highest peak (red) shows the correctly classified images for category 2 where as the two low peaks (blue & green) shows wrongly classified images of category 2 in category 1 and category 3.Similarly for category 3(green) shows the correctly classified images for category 3 where as the two low peaks (blue & red) shows wrongly classified images of category 3 in category 1 and category 2 respectively.

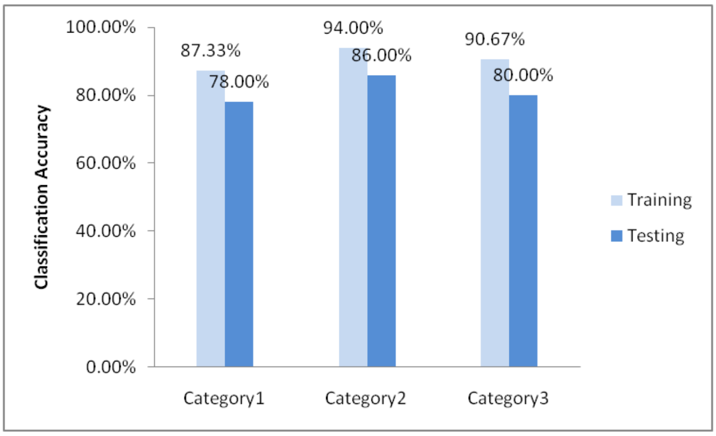


Fig. 6 Classification accuracy of Testing Images for KNN

Fig 6 shows the classification accuracy of KNN classifier for training and testing images. The graph shows the maximum classification accuracy of KNN classifier achieved for training images is 94.00% for category 2(Airplanes) and for training images is 86.00% for same category. While the mimimum accuracy is obtained is 87.33% for training and 78.00% for testing images.

VI. CONCLUSIONS

In this paper, a novel technique for image classification using wavelet transform and KNN classifier is introduced. To describe texture and shape features of images Wavelet transform is used and to extract the color information color moments are used. The three RGB bands of a color image in RGB model are used to extract the describing features. Each of the image in image database is divided into 6 parts. Then the first order color moment is applied and Daubechies-4 wavelet transform to extract the input vector of neural network. The KNN classifier with K=1 for image classification is used . The best accuracy of 94% was obtained for training set, and 86% for the testing set .

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