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Image Classification Algorithm based on Multi- Feature Extraction and KNN Classifier

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ABSTRACT:- *The classification is task of data mining where the algorithms are first trained on the patterns and then classified according to their past experience. The proposed image classification technique works in similar fashion, thus first the set of well-defined images with their classes are used to train the model and after training the model is used to identify the classes of the test set.In order to train and test the model multiple low-level features of image such as texture, colour and edges are used .The proposed algorithm uses local binary pattern for texture featureextraction, canny edge descriptor for edge detection and colour moment for colour feature extraction. These features are used with the KNN (k-nearest classifier) for finding the similarity of the domain specific images.The experiment results of proposed work show that multiple feature extraction techniques improve classification performance as compared to single local binary pattern feature extraction technique.*

Keywords-*KNN, local binary patterns, colour moment, canny edge detection, feature extraction, image classification*

1. INTRODUCTION

The classification of images is a task of data mining, and in this work image classification techniques and their working process is investigated. The proposed work is aimed to improve the classification performance in terms of classification accuracy using the feature based classification techniques. Image classification process classifies image according to its visual contents for example does image contain an elephant or not? Image classification is the task of assigning an input image to one class label from a fixed set of different class labels .for example an image classification model takes a single image and assign to it one of four class labels(elephant, rose, horses, dinosaur).

The task of recognizing visual content in an image and assigning it to one of class label is simple for humans but it is challenging from the perspective of a computer vision algorithm. Following are the problems that arise in image classification.

Rotation variation – image can be rotated in various ways. That makes it to difficult to classify.

Scale variation – Visual content in image can vary in their size.

Deformation –Objects in image can be deformed in extreme way.

Occlusion – Object in image is not visible properly.

Illumination conditions – Placement of light source can affect object appearance in an image.

Background clutter - It is difficult to focus only on object and ignoring the background.

Intra-class variation- Images of a single class may be varied based on their appearance.

A good classification algorithm must be invariant to all these variations.

Image classification plays important role in digital image analysis. This is done by using elements of visual interpretation. To identify the features occurring in an image is the main objective of image classification. Supervised classification and unsupervised classification are the two main image classification methods. In supervised classification, trained database is needed and also human annotation is required. In unsupervised classification, human annotation is not required and it is more computers automated [10]. The proposed image classification is a supervised feature extraction technique.Image classification procedure consists of following steps [3]:

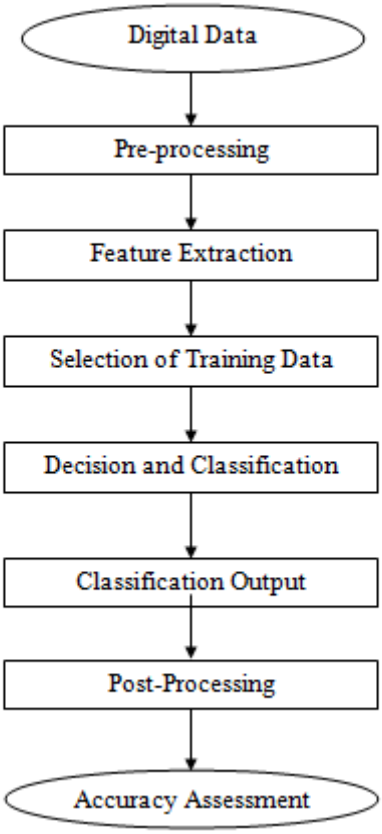

Fig.1 Procedure of image classification

• Pre-Processing – Pre-processing consists of geometric correction, noise removal, radiometric correction, geo referencing.

• Feature extraction – Feature extraction is a process of dimensional reduction of data that efficiently represents image.

• Selection of Training Data – Selection of attributes that best describe the image. Such as texture, edge, colour of an image.

• Decision and Classification –Images are classified into predefine group by using the method that compares image features with the target features. Examples of classifier are KNN classifier, SVM, ANN, fuzzy classifier.

• Accuracy Assessment – Accuracy of classification method is calculated to evaluate the performance of classifier. Recall and precision parameters are also used for accuracy assessment in classification algorithm.

2.EXISTING SYSTEM

Local Binary pattern operator is an efficient and simple texture classification method. In the traditional LBP algorithm, each pixel is compared with its neighbour pixel. The resulting vector contains numerical values that show the content of image. Before applying LBP operator an image must be converted into gray image. Gray scale image composed of shade of gray that vary from black to white. The classification of an image is performed using different texture classification method. First texture classification operator is classic LBP that uses 3*3 cells neighbourhood. Second classification operator is uniform pattern. The study shows that 90% of LBPs are uniform. The next method of LBP is circular neighbourhood, in which radius of circular neighbourhood is taken into account. The next method applied will be using a rotation invariant of LBP operator.

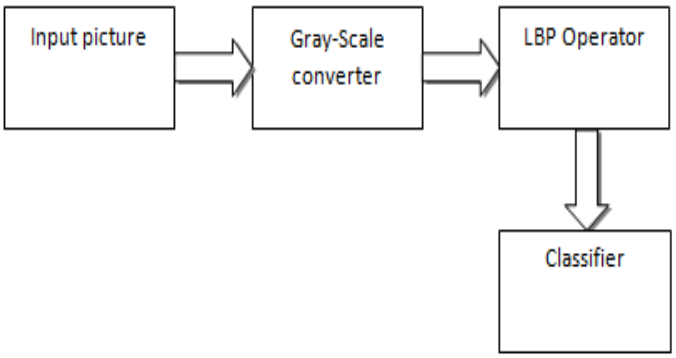

Fig. 2 Modules of LBP

The uniform LBP considers only uniform patterns while allnon uniform patterns are omitted. A uniform pattern is one that comprises at most two 0 to 1 or 1 to 0 change of states or transitions.

For basic LBP there are 2^p possible combinations while with uniform LBP there is p (p-1) +2 possible combinations. Thus uniform LBP reduce the size of feature vector. The uniform LBP considers only important textures such as spots, edges and corner.

The problem with uniform LBP pattern is that by using gray scale image, color information of image is lost. For handling color, new LBP must be combined with another visual method of color extraction to make the retrieval more effective.

The another problem is that uniform LBP does not have the capability of finding similar images, but it can be used to classify textured images from non-textured ones. Therefore, for accurate classification the LBP must be combined with another visual attribute like color and shape.

The main drawback of uniform LBP operator is that it is not invariant to rotation and scaling. If image is rotate or scale it cannot be accurately classified by the LBP classifier. To make LBP rotation and scaling invariant it must be combined with rotation and scaling invariant algorithms.

3. PROPOSED SYSTEM

The images define the real world objects using the pixels. these pixels are then organized on the basis of numerical values. But the images contain less information in text format to find the context of the images, in addition of that the associated tags are not much accurate to distinguish the image contents. Therefore, content based image classification technique is required to develop for more clearer and accurate classification. In the similar direction a novel effort using the LBP (local binary patterns) a classification scheme is found in [1]. Where first the image textures are extracted from the images during the training of system and then using the similarity between similar class images is measured to classify the images. This process is efficient and accurate for specific kinds of images. But if the different domain or context images have similar texture, the classification accuracy is affected. Therefore, a new technique with multiple low level features is used to classify the images.

The proposed technique uses the image content features shape, texture and the color of images for finding the context of the images. Therefore, to extract the shape features of images the canny edge detection algorithm is computed, similarly for recognizing the image texture the local binary pattern is computed, finally for the color features the grid color movement is used. After recovering the image features the class labels are also produced in the images, according to the training set. For organizing the training set the directories are considered as the class labels and these directories contain the domain specific images. These images are used during the training of the proposed classification system.

The proposed concept of the image classification is demonstrated using the fig. 3 in this diagram, the entire components of the system are presented.

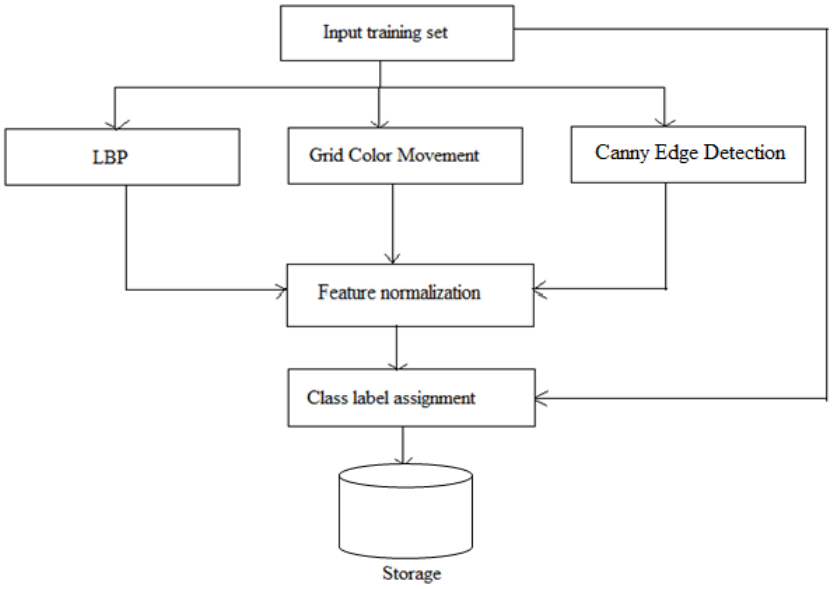

Fig. 3 Model Training

The design of the proposed classification technique is performed in two main modules first the training and second testing.

3.1 Training and Testing set

For training the proposed system and testing of the proposed model the datasets are prepared. In the training dataset, the classes are defined by the directory names and the patterns are defined by the images stored in these directories. Therefore, the entire data contains a number of directories and similarly each directory consists of a number of similar domain images. Similarly for creating the test data set a set of randomly selected images from the different domains are developed in a single directory. During the classification the single directory data is produced for classification and their class label identification.

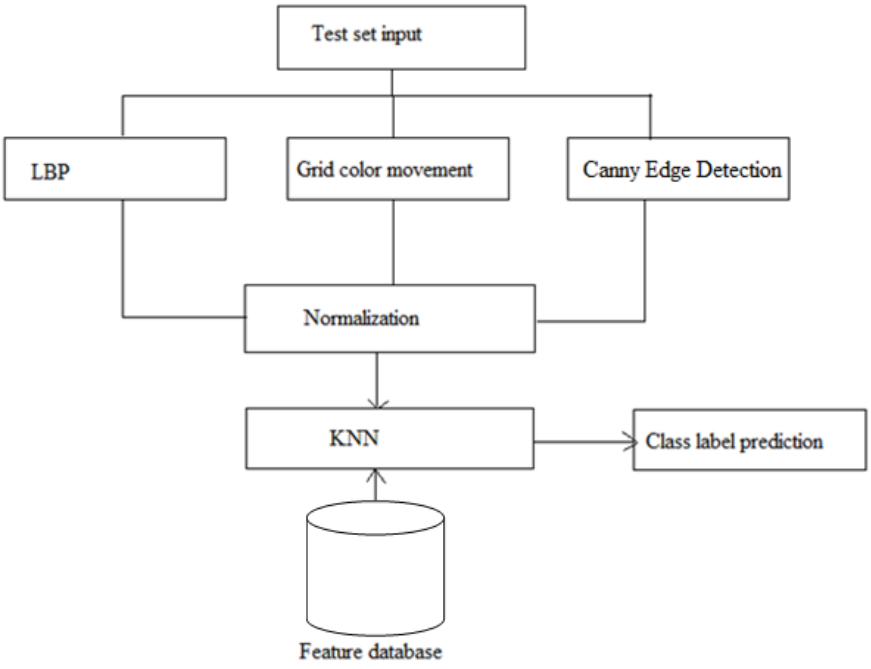

Fig.4 Testing Model

For extracting the low label features form images three main features are used all the features are computed in the following manner.

3.2 Grid Color Moment

Color feature is the most widely used feature in image retrieval. Color is invariant of scaling rotation and translation of an image. The key component of color feature extraction consists of color space, color quantization and the similarity measurements [11].

Many color descriptors are used for color feature extraction such as color moment, color histogram and color coherent vector. The proposed algorithm uses color moment for feature extraction. Color moment measures color distribution in an image. There are several color models. Three color moments are computed per channel (9 moments, it the color model is RGB and 12 moments, if the color model is CMYK). Color moment is computed in same way as probability distribution. The algorithm of color moment is consists of following steps [12]:

- Read image from RGB color model
- Uniformly divide the image into 3x3 blocks.
- Compute its mean color

The mean value represents average color per channel in the image.

$$x' = \frac{1}{N}\sum_{i=1}^{N} x_i$$

Where N is the number of pixels within each channel, x_i is the pixel intensity in R, G, B channels.

- Compute its standard deviation

The standard deviation is calculated by taking the square root of the variance of color distribution.

$$\sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(x_i - x')^2$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - x')^2}$$

- Compute its Skewness

It measures how asymmetric color distribution in color model.

$$\gamma = \frac{\frac{1}{n}\sum_{i=1}^{N}(x_i - x')^3}{(\frac{1}{n}\sum_{i=1}^{N}(x_i - x')^2)^{3/2}}$$

That can also be computed using the following formula

$$\gamma = \sqrt[3]{\frac{1}{N}\sum_{i=1}^{N}(x_i - x')^3}$$

3.3 Local Binary Pattern

Image Texture classification has many potential applications, for example industrial surface inspection, biomedical image analysis and remote sensing. The major problem with texture classification is that the textures of real world are often not uniform due to orientation, scale and translation. In addition to that, the computational complexity of most proposed texture classification algorithm is too high. Therefore, a powerful texture measure with low complexity and invariant to transformation of image is required. LBP based image classification is one of the most efficient methods in texture analysis.

The LBP operator transforms and labels the pixel of an image into decimal number. These labels (decimal number) describe the characteristics of original image at lower level. Most known LBP operator is applied to a gray-scale image [21].Red, green and blue all component carry single intensity value in RGB space for gray scale image. In LBP, for each pixel a code will be computed. For a cell of 3*3 pixel the intensity of centre pixel is compare to intensity of each surrounding pixel. The difference between the intensity of centre pixel and neighbour pixel is computed if the sign of difference is negative 0 value is taken and if the sign is positive 1 value is taken. The resulting value is binary number. The Binary number converted into decimal number and store into database [23].

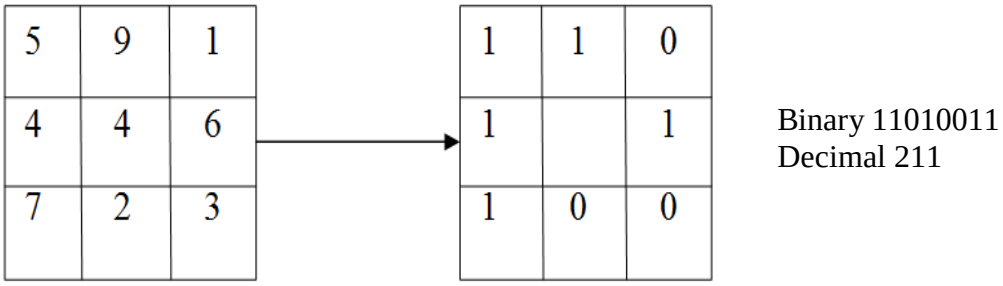

Fig.5 Example of the basic LBP operator

Due to the statistical properties of local binary pattern, uniform LBP achieves better performance as compared to basic local LBP. Experiments carried out on large image database showed that images contain 90% of uniform pattern while the remaining small percentages are non-uniform. Large number of histogram bin is required for this small number of non uniform pattern which is not reliable. A uniform pattern is a pattern in which there are no more than two transactions from "0" to "1" or vice versa. For example binary pattern 00101101, has 5 transactions, is not uniform and binary pattern 00001000, has 2 transactions, is uniform [1].

For p neighbour, the number of uniform LBP is given by p(p-1)+2. In computation of LBP histogram, the histogram has a separate bin for each uniform pattern and a single bin for all non-uniform patterns. Uniform LBP reduces the length of feature vector by eliminating the non-uniform binary patterns.

3.4 Canny Edge Detection

Shape is most powerful and an important feature of image classification. Shape information is extracted by using histogram of edge detection. Shape representation can be either edge or region based. Shape provides numerical information of an image, which doesn't change even when the position, size and direction of objects are changed. Edges in image are area of strong intensity contrasts. The edge information in image is obtained by using canny edge detection. The canny edge detection algorithm runs in 5 separate steps-

Step 1: Smoothing – Smooth the image with Gaussian filter for removing noise.

Step 2: Finding gradient – find out gradient of the image have larger magnitudes. The gradient magnitude at each point can be found using the formula:-

$$|G| = |Gx| + |Gy|$$

Gx and Gy are the gradients in the x- and y- directions respectively. The images of the gradient magnitudes indicate edge but edges are broad and not indicated properly. For indicating edge properly the direction of the edge is determined by using the formula:-

$$\text{theta} = \text{invtan}\ (Gy / Gx)$$

Step 3: Non-maxima suppression – Once the direction of the edge is inferred, then it gets allied with an attributable direction in the image. Like the name suggests, this step reduces all non-maxima gradient values to zero. This suppression results in a value which provides the location of the most intense value.

Step 4: Double thresholding – Since edge pixels have a range of gradients, these values can be exploited to distinguish edge pixels as either strong or weak. To achieve this, two fixed values are considered namely, high and low threshold. The gradient value of strong edge pixels is greater than high threshold. Similarly weak edge pixels have gradient values greater than low threshold. If pixel value is smaller than the lower threshold value, they will be suppressed.

Step 5: Edge tracking by hysteresis – The source of extraction of weak pixel can be from the true edge or from the noise. To trace edge connection, blob analysis is applied by observing the weak edge pixel and the eight surrounding pixels related to it. As long as there is one strong edge pixel involved in the blob, that weak edge point can be identified as one that should be preserved [25].

3.5 Normalization

Feature normalization is a method used to standardize the range of feature vector and is generally performed during pre-processing step. If one of the features has a broad range of value than without normalization feature with large values have stronger influence on the cost function .By feature normalization, value of all features will be in predetermined range.

3.6 Class label assignment

In this phase during training the image features are labeled with their directory name for example E_f, C_f, L_f is the feature of image which is placed under nature directory then the label of the feature is "nature". Further the classification of the extracted patterns is performed using the KNN classifier defined as in next section.

3.7 K-nearest neighbour

The K-nearest neighbour (KNN) classifier is a non parametric classifier because it makes no underlying assumptions about the statistical structure of data. The KNN algorithm measures the distance between a test query features and a set of training data features that store in the database.

The distance between these two feature vector is estimated using a distance function d(x,y), where x, y are feature vector can be represents as [18].

$X = \{x_1, x_2, x_3, \ldots.\}$

$Y = \{y_1, y_2, y_3, \ldots.\}$

Two distance functions can be used in KNN are:

Absolute distance measuring

$$d_A(x,y) = \sum_{i=1}^{N} |x_i - y_i|$$

Euclidean Distance

$$d_A(x,y) = \sum_{i=1}^{N} \sqrt{x_i^2 - y_i^2}$$

The feature vectors must be normalized before classification algorithm run. The overall KNN algorithm is running in the following steps:

1. KNN algorithm uses training set that consist features and labelled classes store in database.
2. Calculate distance between test features and all training feature.
3. Sort the distance and determine k nearest neighbour.
4. Use simple majority of the category of nearest neighbour assign to the test.

The KNN classification algorithm is performed by using a training set which contains both the input feature and the labelled classes and then by comparing test feature with training feature a set of distance of the unknown K nearest neighbours determines. Finally test class assignment is done by either averaging the class numbers of the K nearest reference points or by obtaining a majority vote for them [20].

In this section, the different components and their description is discussed of the proposed work. In the next section, the proposed model is described using the algorithm steps.

4. Results Analysis

The chapter provides the detailed understanding about the obtained results and the comparative study of traditional LBP based image classification technique and the proposed multiple features based classification techniques. The comparative performance is evaluated in different parameters and their values are demonstrated in this chapter.

4.1 Image Database

The experiment results have been implemented with an image database including about 1000 images formed by ten image categories as shown in table.

Table 3 Different categories of image database

Category Number	Category Name
1	African
2	Sea
3	Monument
4	Buses
5	Dinosaurs
6	Elephants
7	Roses
8	Horses
9	Mountain
10	Food

Each category shows a different semantic topic. Each group has 100 pictures .These pictures are stored in JPEG format with size 384*256.Each image has three component R, G, and B. For each image texture, colour and edge descriptor are separately calculate and stored in database. Figure shows a sample of each category.

Fig. 6 Sample of each category of training data

4.2 Experimental Results

Based on the above sample database, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 images per category were used to train the proposed method and 30 images per category were used to test the performance of the system. The performance of both traditional technique as given in [1] and the proposed model over different performance parameters is compared in this chapter.

4.2.1 Accuracy

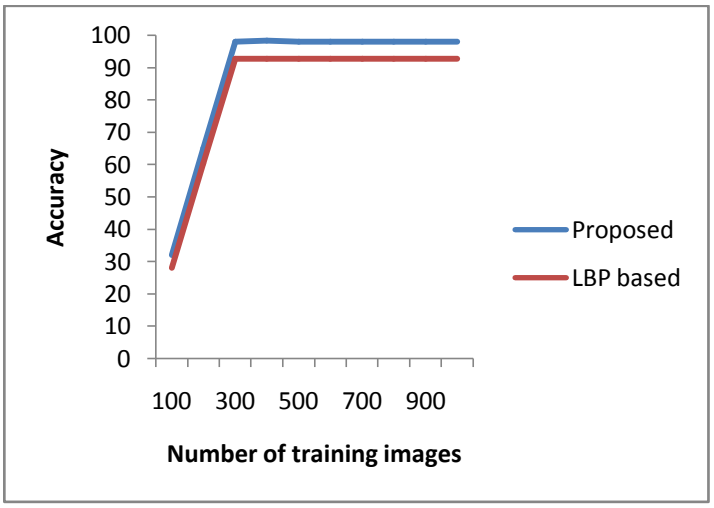

Fig.7accuracy

The accuracy of any classification system depends on the amount of patterns correctly recognized during the prediction of class labels over the total samples produced for classification. The accuracy of the classifier can be defined using the following formula:

$$\text{accuracy} = \frac{\text{total correctly classified patterns}}{\text{total testing samples}} \text{X } 100$$

The comparative accuracy of both the implemented classification techniques is given in fig. 7. In this diagram the X axis contains the number of training images and the Y axis shows the correctly recognized amount of data in terms of percentage. Additionally for representing the performance of classifier the proposed classifier is demonstrated using the blue line and the red line shows the performance of the LBP based classifier. According to the obtained results the proposed technique provides more accurate classification outcomes as compared to the traditional classification technique.

4.2.2 Error rate

The error rate of the algorithm is sometimes also termed as the misclassification rate. The misclassification of the proposed and traditional image classification technique is given using

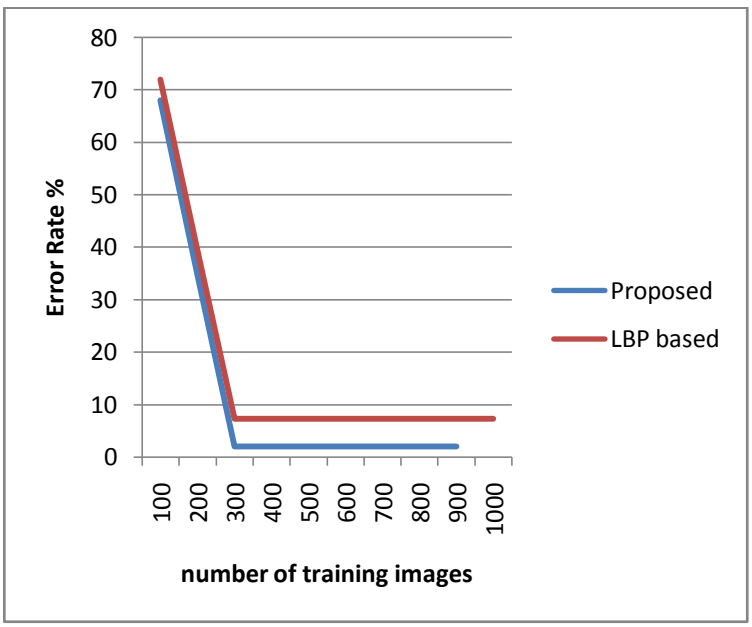

Fig.8 error rate

The misclassification rate or the error rate of the system is the amount of data which is not properly recognized during the prediction of class labels over the total number of inputs samples. That can also be evaluated using the following formula:

$$\text{error rate} = 100 - \text{accuracy}$$

Or

$$\text{error rate} = \frac{\text{total misclassified samples}}{\text{total testing samples}} X100$$

The fig. 8 contains the comparative error rate of both the classification techniques namely proposed classifier and the uniform LBP classifier. The blue line is used in this diagram demonstrate the performance of the multi-feature extraction classification technique and uniform LBP performance is given using the red line. The X axis of the diagram contains the number of training images and the Y axis shows the misclassification rate of the classifier. According to the results the proposed technique outperforms as compared to the traditional technique. Thus the proposed model is adoptable as compared to traditional algorithm.

4.2.3 Memory used

The memory consumption of the system is also termed as the space complexity of the classifiers. The space complexity of the traditional LBP based classifier and the proposed multiple feature based classifier is compared using fig. 9.

$$\text{memory used} = \text{total memory} - \text{total free size of memory}$$

fig. 9 contains the performance of both the classifiers thus the performance of the proposed technique is given by the blue line and the red line shows the performance of uniform LBP classifier. For representing the performance of the algorithms the X axis contains the number of training images and the Y axis contains the memory consumption in terms of KB (kilobytes). According to the computed results the amount of main memory consumption increases as the amount of files for testing sample is increases. On the other hand the performance of both the classifier is simulating similar behaviour. But in the traditional technique the amount of memory consumption is less as compared to the traditional technique because the proposed technique computes three different features and the traditional technique classifies the data using the single feature computed. Therefore, the proposed technique is resource consuming approach as compared to traditional technique.

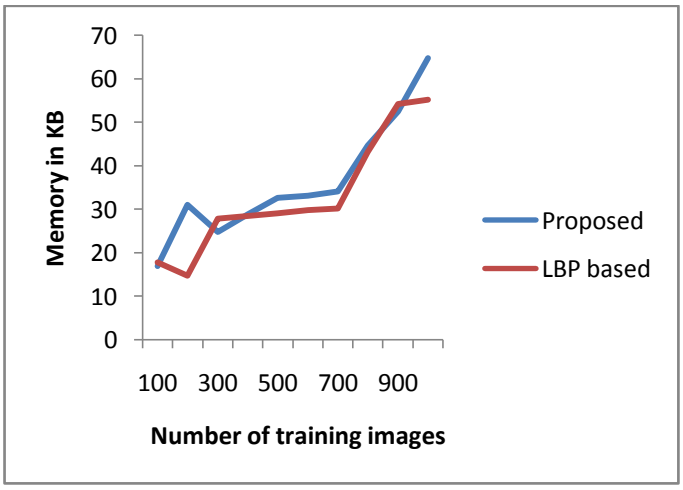

Fig.9 memory consumption

4.2.4 Time consumption

The amount of time required to classify the input samples are termed here as the time complexity of the algorithms. The comparative time complexity of the algorithm is given using fig.10 the computation of the time complexity is performed by the finding difference between initialization of the algorithm and completing the algorithm processes. The formula for time consumption can be given as follow:

$$\text{time consumption} = \text{completing time} - \text{initial time}$$

The computed classification time of the classifiers are compared, thus for comparing the performance red line shows the performance of the LBP based classifier and the blue line shows the performance of proposed classifier. The X axis of diagram shows the number of training images and the Y axis shows the time consumed in terms of milliseconds. According to the obtained time consumption the proposed technique consumes higher time as compared to the traditional classifier. Therefore, the proposed technique is not suitable for the applications which need to have the less time consuming techniques to classify the data.

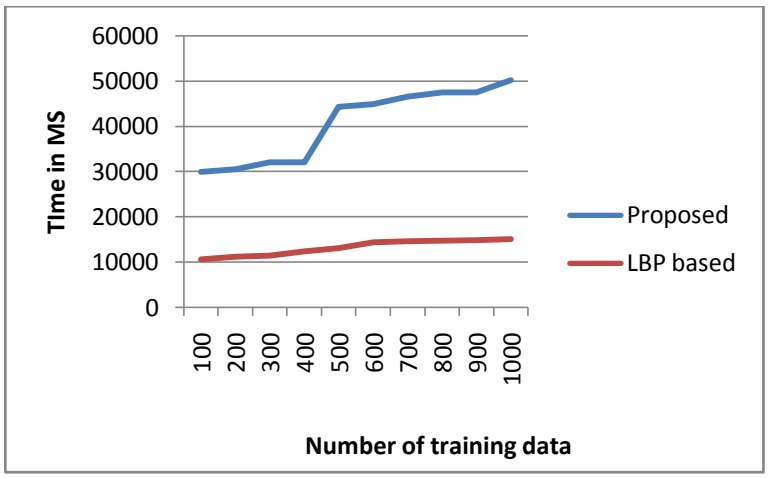

Fig.10 classification time

The comparative performances of both the methods are summarized using the table 5.2

Table 4 Performance summary

S. no.	Parameters	Proposed	LBP
1	Accuracy	High	Low
2	Error rate	Low	High
3	Memory consumption	High	Low
4	Time consumption	High	Low

According to the table 5.2 the proposed system accuracy is better than LBP but storage requirement and time consumption is higher as compare to LBP.

5. Conclusion

The data classification is a task of data mining. In this approach the computational algorithms are trained on specified patterns and their corresponding outcomes. After training the similar kinds of patterns are recognized using the algorithm. The training of the algorithms basically development of the data model by which the similar kinds of data patterns are identified. The learning process can be supervised and unsupervised based on the nature of data. In the supervised learning the algorithm need to have the data attributes and their corresponding pre-defined classes. During the classification the system only accepts the attributes and algorithm predict the classes of the input patterns.

In this presented work the image classification is investigated and an accurate classifier is developed. Basically there are a number of classification schemes for images are exist among most of them either very slow or inaccurate in nature. Therefore, the performance improvement on the traditional image classification techniques is required. The proposed classification technique is motivated from the LBP based image classification technique. Therefore, to improve more the traditional classifier a multiple feature based classification technique is introduced in this work.

The proposed classification technique involve the image low level features such as edge, color and texture for classifying the images more accurately in the specified domain. For extracting these features the grid color movement, edge histogram descriptor and the local binary pattern is used. After extraction of image descriptors the class labels for each images are defined using the traditional KNN (k-nearest neighbour) classifiers. The proposed technique outperform as compared to the traditional classification technique. The proposed multi-feature extraction classification algorithm implemented using JAVA technology and their performance is compared with the uniform LBP classification algorithm.

According to the obtained performance of implemented system the proposed model provides accurate classification outcomes, but that produces slightly higher resource consumption. Therefore, that is suggested to use the classification technique where high accuracy required and the resource consumption is not assumed.

6. Future work

The proposed classifier is accurate and efficient but as compared to single feature based classification scheme that produces higher resource consumption. Therefore, in near future the key work is needs to be focused on reducing the resources.

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