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Facial Expression Recognition using Ensemble Learning Technique

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***Abstract*: The most natural, influential and powerful way to communicate or convey a message is face expressions. In the field of computer engineering, facial expression recognition system, is helpful in areas like healthcare system, computer graphics, biometric devices, mobile phones, etc. Technologies such as virtual reality (VR) and augmented reality (AR) make use of facial expression recognition to implement a natural, friendly communication with humans.**

In this paper an approach for Facial Expression Recognition using Ensemble Learning Technique has been proposed. Ensemble methods use various learning algorithms to obtain good predictive performance that could be obtained from any of the basic learning algorithms alone. In the proposed method, initially the features are extracted from static images using color histograms. This process is done for all images gathered in the training dataset. The ensemble technique is then applied on the featured dataset in order to categorize a given image into one of the six emotions, happy, sad, fear, angry, disgust, and surprise. A satisfactory result has been obtained using static image dataset taken from kaggle and uci machine learning repository.

Keywords: About Ensemble Learning, Color Index Histogram, K Nearest Neighbor, Support Vector Machine, Random Forest.

I. INTRODUCTION

Facial expression recognition system is basically a human and computer interactivity that is speedily increasing in today's world. Thus recognition of facial expression plays an important role in the area of computer technology. Experimental results shows that 7 percent of the inter-action occurs through language, 38 percent through paralanguage, and face expressions contributes 55 percent of the whole communicated messages and hence it is very important for humans to communicate [1], [2]. Facial Expression Recognition offers to recognize the facial features into one of the six basic emotions: happiness, sadness, fear, disgust, surprise and anger. Expression recognition offers various applications in many fields such as health-care, virtual reality, human-computer interaction, video-conferencing, driver safety, image retrieval, cognitive science, human emotion analyst, personality development etc [1]–[4].

The facial muscles are organized into units of action (AUs) that function together to form the different expressions of the face.

The muscle movements are of two types; the detected movements, typically experienced by any other person, and unnoticed movements, that are very rapid and produce micro-expressions that require some individual trained systems to identify them, Ekam et al. [2] classified the facial expressions into six universal expressions: anger, surprise, happiness, sadness, fear and disgust.

To do this, an ensemble learning technique has been proposed. This technique uses different learning algorithms to acquire predictions. Thus predict better individual models than the individual learning models.

The paper is organized in V sections. In section II, an overview of work that has already been done in the area of facial expression recognition is presented. In section III, the proposed approach used for the research work is presented. In Section IV, discussion of experimental results obtained has been discussed. Conclusion and future work is discussed in section V.

II. RELATED WORK

Earlier researchers have carried out substantial work in the field of static image classification techniques. This section discusses some of the most relevant techniques.

Fundamental experiments on this subject are of major concern, but most important contribution to today's science was the pioneering work by Charles Darwin.

Charles Darwin et al. [1] introduced and evaluated facial expressions and found out that universally a random set of expressions exists throughout all human beings.

Silvan Tomkins illustrated a primary list of "simple" emo-tion that influenced many researchers, particularly a pioneer in this area, Paul Ekman [2]. His findings today presents an important landmark and forms the basic understanding of modern facial expressions in the study of human facial expressions and emotions.

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Paul Ekman et al. [2] conducted various experiments on human beings non-verbal communication and facial ex-pression in particular. His results and findings lead to the definition of six emotional categories, which are considered to be universal: happiness, sadness, anger, disgust, fear and surprise. Scientists from the fields of computer science, robotics, and computer graphics started to gain knowledge in building such systems that could interpret human emotion in an automated manner.

Happy, S et al. [3] proposed facial signs for face ex-pression recognition.

A method has been proposed that point out and recognises features from the face areas that includes nose, eye localization and lip corner recognition. The recognition is formed on the localization of face muscles which are active. This method worked on the images of all resolutions which includes low resolution size without affecting the accuracy of recognition .

Mistry Zhang et al. [4] illustrated a recognition system for human face expression using feature optimization used on the evolutionary particle swarm optimization (PSO). Their system first uses modified local binary patterns to generate a fundamental initial facial recognition and representation, which conducted horizontal and vertical neighborhood pixel comparison. To improve functionality, a PSO version filled with the initiative of a micro-genetic algorithm (mGA), called GA embedded PSO, is introduced.

Sadeghi et al. [5] presented a mechanism for recognition of face expressions that uses elimination of geometric variability and Local binary patterns as descriptors of image quality. For reduction of geometric variance in face images, a fixed geometric module comprizes to one of the facial expressions was taken.

Pushpaja V et al. [6] proposed that the face motion and a generic face be recognized and defined. This paper uses the method of optical flow, the technique of active form system, the algorithm of concept element analysis (PCA) and the technique of neural networks. The procedure works fine on controlled environment but face difficulty in uncontrolled environment.

Lee et al. [7] defined a binary pattern of local color vector for recognition of face region. They calculated the color standard prototype histogram (i.e. color standard values LBP) using Y, I and Q channels as the color angular pattern histogram (i.e. color angle values LBP) using Y and I channels and finally merge these histograms into the descriptor. The main problem with these techniques is that the discriminative capacity is not much enhanced because the interchannel data of the images was not used very well by these methods.

F. Melgani et al. [8] introduced a model for SVM classi-fiers and presents that SVMs are more useful than any other conventional non parametric classifiers. It also shows that SVMs have low susceptibility to the Hughes effect and low computational time consumption. Many authors have used SVM for classification

G.Baudat et al. [9] proposed a function space F using the kernel trick from a set of selected data. Then the data is projected onto the function space F. The performance of the feature vectors obtained is high and the computing time efficiency is also decreed.

Zhu et al. [10] extracted and proposed multi-scale LBPs by changing the number of local neighbors and local neighbor-hood radius across each image channel and concatenating all LBPs to build a single descriptor. Multiple LBPs introduced from each RGB color image channel were also concatenated.

III. PROPOSED APPROACH

An approach for system architecture of the method is divided into 5 levels. In level 1, the image data is collected and read as input. In level 2, Feature Extraction using HSV is applied so that data in required format will be obtained. In level 3, different classifiers are trained on existing dataset. In level 4, analysis of predictions is made on test data according to accuracy given by various classifiers. In level 5, after selecting the prediction given by highest accuracy classifier, output is given. Fig. 1: presents the block diagram of proposed approach.

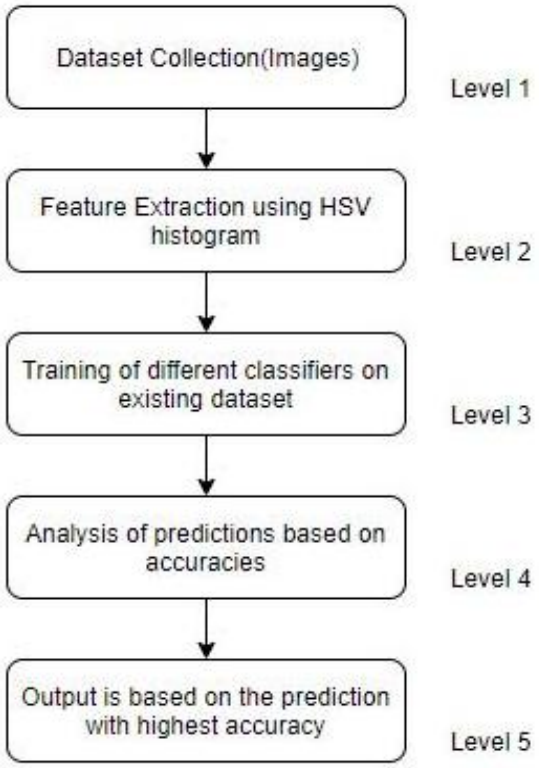

Fig. 1: Block Diagram

The complete algorithm of the method has been discussed in subsequent sections.

A. Feature Extraction

Features are defined by the behavior of an image. Feature plays a necessary part in the area of image processing. Relevant features needs to be extracted from the images to represent features in feature vector form. In this process, firstly data is fetched in form of images which will be converted into numerical data representing several extracted features from images including RGB values and corresponding labels.

1) HSV (Hue, Saturation, Value) Histogram for Feature Extraction: The color space of the HSV closely matches the human visual experience of light.

Hue is represented in the range n[0,2] relative to the red axis at 0, green n at 2/3, blue n at 4/3. Saturation is the color depth or purity and is expressed as a radial distance to the outer surface from the central axis. An HSV color histogram can be created with an approach to RGB color space for image retrieval applications. Fig 2: describes RGB Color Space.

B. Classification

In field of computer vision, classification is an important task. Classification of objects is defined as grouping of images in one of all variety of already defined groups. Classification system consists of a database containing pre-defined patterns that can be compared to the object detected to be classified into the correct category. Various classification techniques are Artificial Neural Network(ANN), Decision Tree(DT), Support Vector Machine(SVM) linear regression(LR) and K nearest neighbor(KNN) Classification.

The proposed approach uses ensemble learning method to perform classification. Ensemble learning is the process of strategically generating and combining multiple models, such as classifiers or experts, to solve a specific computational intelligence problem. Ensemble learning is primarily used to improve the overall result of a system (classification, estimation, approximation of function, etc.) or reduce the likelihood of a poor selection.

C. Performance Measurement Parameters

Performance Measurement Parameters describe the performance of classification systems (or"classifier") on overall collection of test data defined for true values. Many performance measures are determined from the matrix called as confusion matrix.

Confusion Matrix: This matrix illustrates the possible procedure through which classification model is confused when it finds the possible predictions. Count values are used to illustrate number of correct and incorrect predictions.

Following are the terms used to draw confusion matrix:

- True positive (TP): positive correct prediction
- False positive (FP): positive incorrect prediction
- True negative (TN): negative correct prediction
- False negative (FN): negative incorrect prediction

This matrix is used to find or measure the accuracy of classification model. It gives the measure that the data samples are classified correctly or not.

Classification Rate/Accuracy: Classification Rate or Accuracy is shown by the relation:

Accuracy= (TP+TN)/(TP+FN+TN+FP)

The overall working of the proposed approach is presented, which includes feature extraction process on training and test image dataset and applying ensemble learning method on different classifiers for classification, after classification, highest accuracy classifier is selected for predicting outcomes. Fig 3: shows the implementation diagram of the proposed approach

IV. EXPERIMENTAL RESULTS

The proposed approach is implemented using Pycharm IDE. It is evaluated on image dataset which is taken from kaggle and uci machine learning repository. The dataset of images is divided into six classes i.e. happy, sad, fear, angry, disgust and surprise. Using ensemble learning method, performance of the various classifiers is calculated, shown in table.

The system is designed in such a way that it will predict the output of given image by selecting the maximum accuracy model. Predicted outcomes of an image define in which category of emotion an image belongs to. With the help of output accuracy's of all the classifiers, first select the better accuracy classifier for classification and thus, predict outcome of that image.

Predicted outcome of input images showing different category of emotions are shown in Fig.4 to Fig.9 respectively.

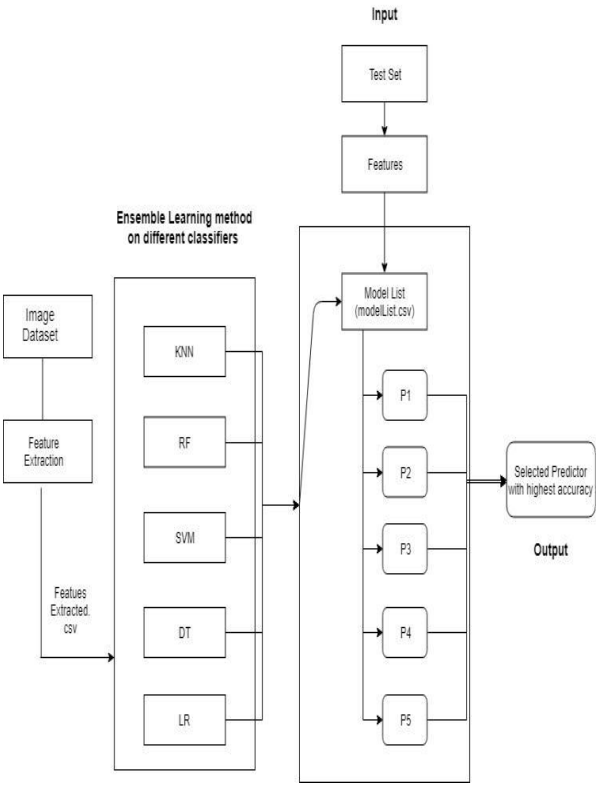

Fig. 3: Implementation Diagram for Proposed Approach

TABLE I: Results of the Proposed Approach

S.No	Classifiers	Random State	Accuracy
1	Knn	1	0.952381
2	Knn	2	0.938272
3	Knn	3	0.936508
4	Knn	4	0.788362
5	Knn	5	0.950617
6	Knn	6	0.932981
7	RF	7	0.952983
8	RF	8	0.91534
9	RF	9	0.93471
10	SVM	10	0.65983
11	SVM	11	0.65574

12	SVM	12	0.65273
13	DC	13	0.78024
14	DC	14	0.48505
15	DC	15	0.72896
16	LR	16	0.24695
17	LR	17	0.29454
18	LR	18	0.31047

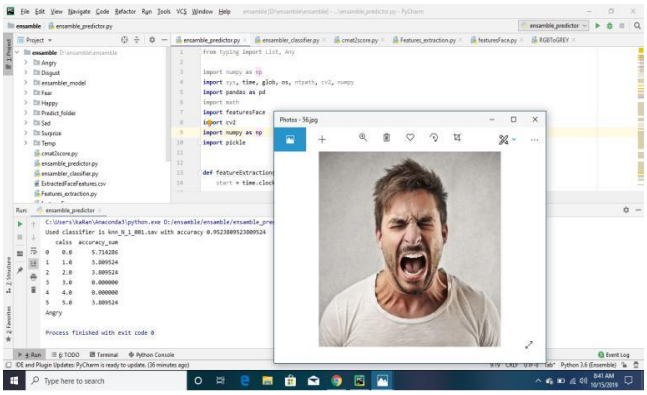

Fig. 4: Predicted Result of a Test Image Showing Emotion Angry

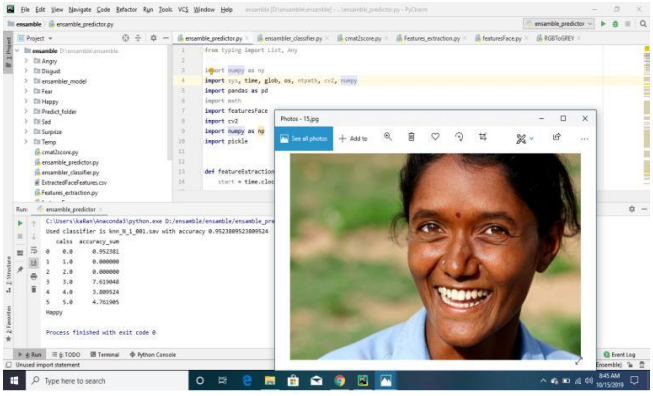

Fig. 5: Predicted Result of a Test Image Showing Emotion Happy

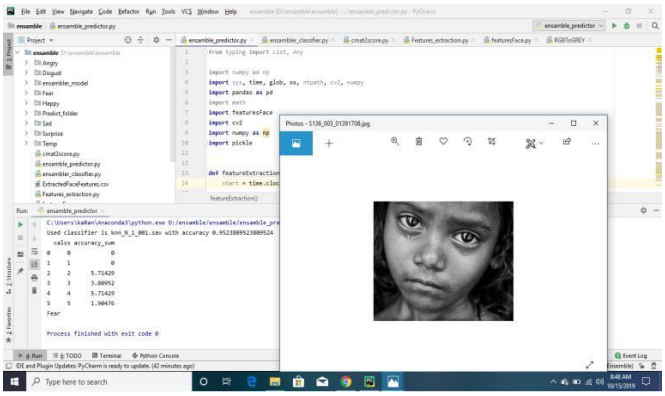

Fig. 6: Predicted Result of a Test Image Showing Emotion Fear

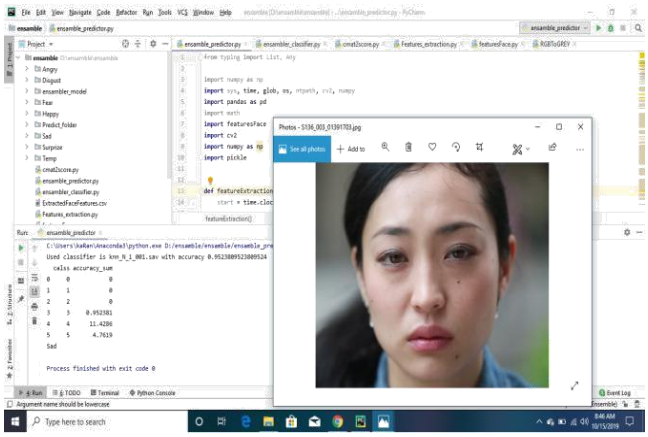

Fig. 7: Predicted Result of a Test Image Showing Emotion Sad

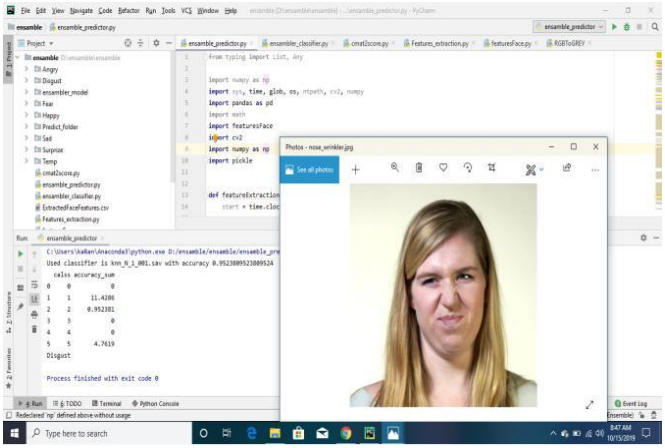

Fig. 8: Predicted Result of Test Image Showing Emotion Disgust

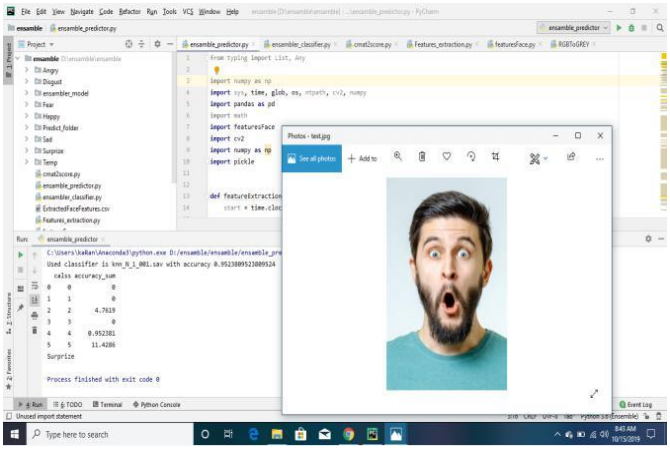

Fig. 9: Predicted Result of a Test Image Showing Emotion Surprise

V. CONCLUSION

A Facial Expression Recognition System has been pro-posed in this paper. An approach to implement Facial Expression Recognition System using Ensemble Learning technique, and it has been achieved successfully.

Prediction of static images given as an input is determined into one of the six universal emotions (Happy, Sad, Angry, Surprise, Disgust, and Fear). The proposed approach uses following classifiers SVM, Knn, Random Forest, Decision Tree, Linear Regression classifiers are used. And 95% classification accuracy has been achieved.

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