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Real Time Detection of Facial Expressions using Machine Learning Algorithms

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Abstract— ***Identifying Human Emotion is important in facilitating communication and interactions between individuals. They are also used as an important mean in studying behavioral Science and in studying Psychological changes. There are many applications which uses Facial Expression to evaluate human nature, their feelings, judgment, and opinion. Recognizing Human Facial Expression is not a simple task because of some circumstances due to illumination, facial occlusions, face color/shape etc. Since face is the prime source for recognizing human emotion, this paper will provide the best method that can be adopted for non-invasive real time emotion detection. This paper involves a comparative analysis of facial expression recognition techniques using the classic machine learning algorithms- KNN, SVM, Ensemble classifiers. The machine learning algorithms have been implemented on JAFFE IMAGE DATABASE on MATLAB 2016a. Successful and satisfactory results have been obtained giving the future researchers in this field an insight into which technique to be used when, to get the desired results.***

Index Terms*: *Facial Expression recognition systems (FER systems), K-nearest neighbor (KNN), Support vector machine (SVM), Speeded up robust features (SURF)

I. INTRODUCTION

Keeping in mind the advances in the field of digital image processing, the Facial Expression Recognition (FER) is one the most important applications that is being utilised in today's world. Looking at how interactive human world and computers have become; the FER system is used in artificial intelligence to create a better human computer interaction.

For example, the FER is used in robots so that they can understand the emotion of the human they are interacting with and react accordingly. Not only that, even in studying psychological and behavioral sciences the FER systems are being used. Whatever be the face shape, colour, skin texture, age of the person the FER systems detect the emotion represented by the face. Ekman and Friesen [1] represent 6 basic facial expressions (emotions) from the JAFFE Database shown in figure 1, which are Happy, Surprise, Disgust, Sad, Angry, and Fear. As per Meharabian [2], 55% communicative cues can be judged by facial expressions; hence recognition of facial expressions became a major modality. In this paper, we have developed FER system based on different classifiers and compared the results and accuracy.

Figure 1: Six Basic Human Expressions [3].

In this paper, we will focus on K- Nearest neighbor (KNN) classifiers, Support vector machine (SVM) classifiers and Ensemble based subspace KNN classifiers. The FER has been implemented on MATLAB using the Classification learner Toolbox on MATLAB 2016a. And then the trained classifier was imported onto the model that detects emotion in real time using the webcam app that was additionally downloaded on MATLAB. Machine learning algorithms are being used successfully used by the proposed method in real time emotion detection (in live video).

II. METHODOLOGY

Using the concept of machines learning, we created a train dataset that contains around 7 different file classes-Happy, Sad, Angry, Disgust, Surprise, Fear and Neutral. This was created by dividing the JAFFE image database into 7 class files.

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Figure 2-A functional block diagram of the FER system

Now we used the SURF feature extraction technique, the features from each emotion class were extracted and a total of 500 features were used among all the features extracted which were converted from array to table and the table was loaded into the classifier- This was done using the help of classification learner toolbox of MATLAB. Keeping the holdout validation as 10% that is, 10% of the data was kept for validation purpose for the classifier post the training. Different classifiers were trained on the features extracted and validation accuracy was generated. Based on the trained classifier one chooses to export to the model, the real time emotion is recognised in comparison to the amount of accuracy achieved. The model accesses the webcam and captures the images in the live video where the face detection is done using Haar classifier [4] and then the snapshot of the face is used to extract features and the classifiers predict the emotion.

III. OUTPUT RESULTS AND DISCUSSION ON CLASSIFIER PERFORMANCE

The *KNN model* while making prediction on new data(unlabeled) considers the nearest K different classes and the majority of the classes in the neighbor will decide the class of the data [5]. This KNN classifier gives an accuracy of 87% on the JAFFE image database. Figure 3 represents the confusion matrix of the model.

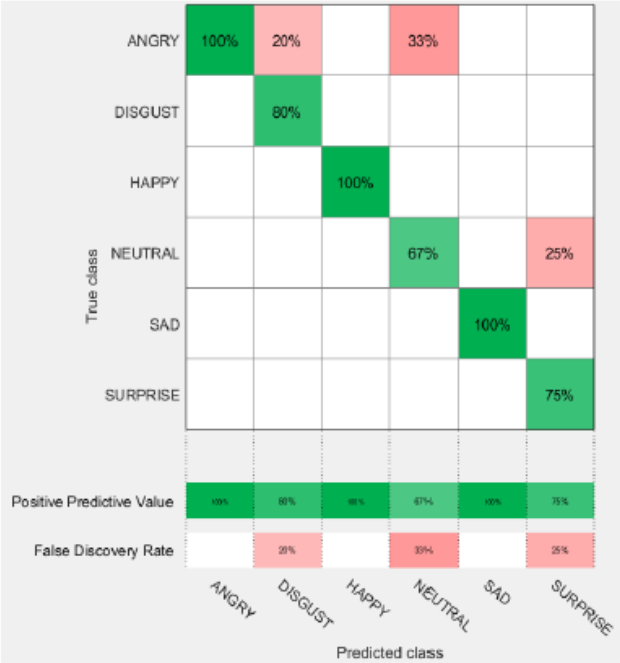

Figure 3- Confusion matrix- KNN classifier

The *SVM model* searches for the closest points, which it calls the "support vectors", draws a line connecting them and then declares the optimal hyperplane to be the plane that bisects and is perpendicular to the connecting line dividing the classes. When a new test data is brought in, it declares which class it belongs to as the division has already been made [6]. Not all SVM Problems are linearly separable, at times the data distribution is such that on applying simple linear SVM the accuracy will be very low. So, it's very important to select the correct kernel function that gives better accuracy to segregate the data in the train dataset. The following table shows the Accuracy result of the SVM classifier when different kernels are used.

Classifier type	Accuracy %
SVM Classifier (linear)	73.9
SVM Classifier (Quadratic)	87
SVM Classifier (Cubic)	91.3

Thus, from the table above it was concluded that the cubic SVM is the best fit and hence the cubic SVM model was exported into the model for real time emotion detection. Figure 4 represents the confusion matrix of the model.

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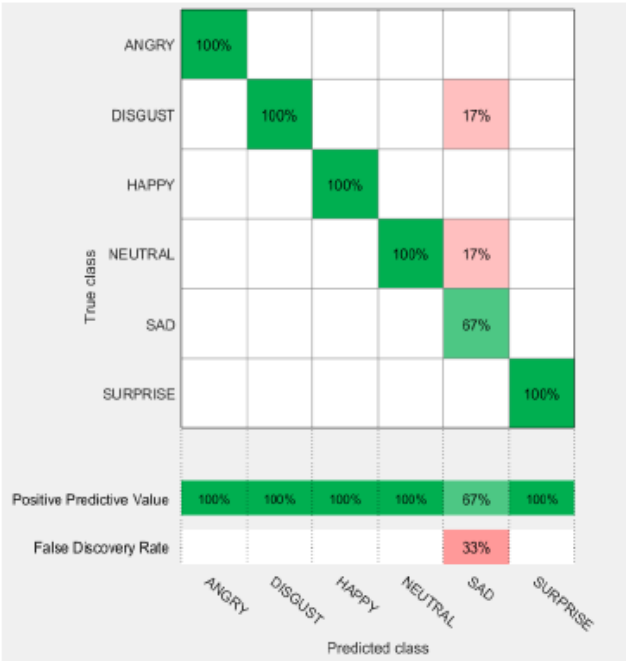

Figure 4- Confusion Matrix- SVM Cubic Classifier

The *Ensemble based Subspace KNN model* makes use of prediction of individual models that train random parts of the training set and generate results and by comparing the prediction results of these individual models the ensemble subspace model classifies the real time new image that is given for prediction. In our case the individual model was the KNN model. This method improved the accuracy by a great extent, but the computational time was more. The accuracy achieved was 95.7% on the JAFFE image database. Figure 5 represents the confusion matrix of the model.

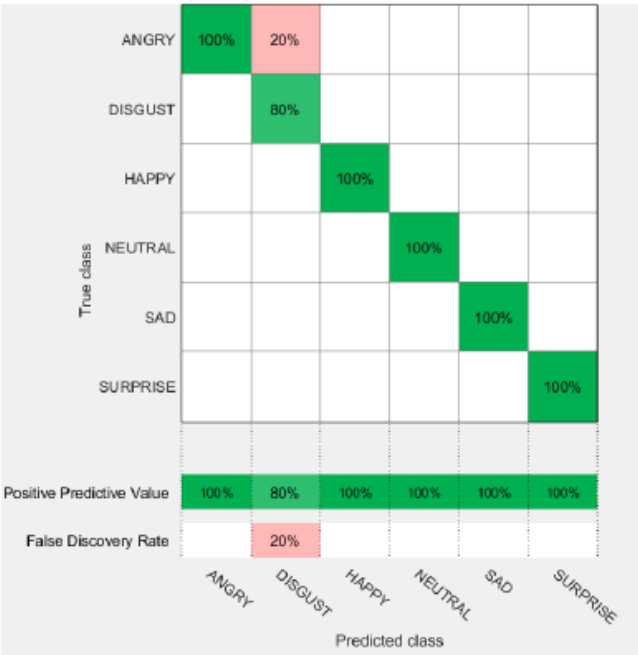

Figure 5- Confusion matrix- Subspace KNN model

TABLE I
COMPARISON OF RESULTS

Classifier	Accuracy (%)
KNN classifier	87
SVM Classifier (linear)	73.9
SVM Classifier (Quadratic)	87
SVM Classifier (Cubic)	91.3
Ensemble Subspace KNN	95.7

IV. OUTPUT RESULTS OF REAL TIME EMOTION DETECTION

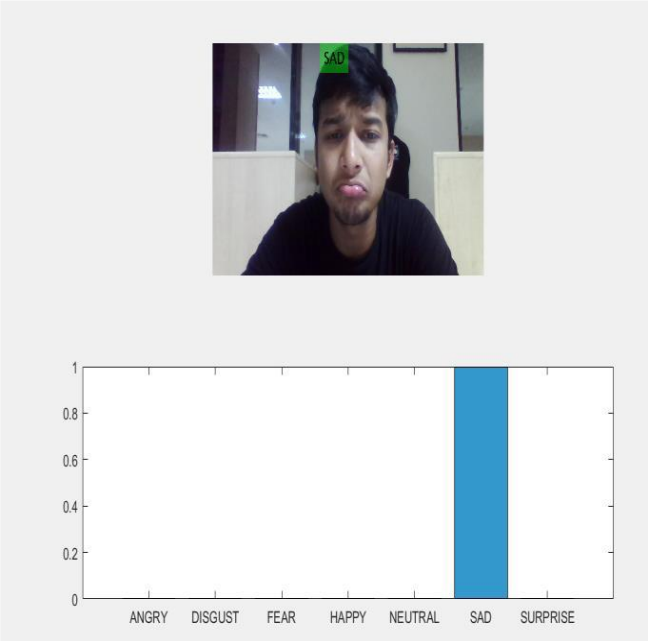

Figure 6- Real time emotion detection for Sad

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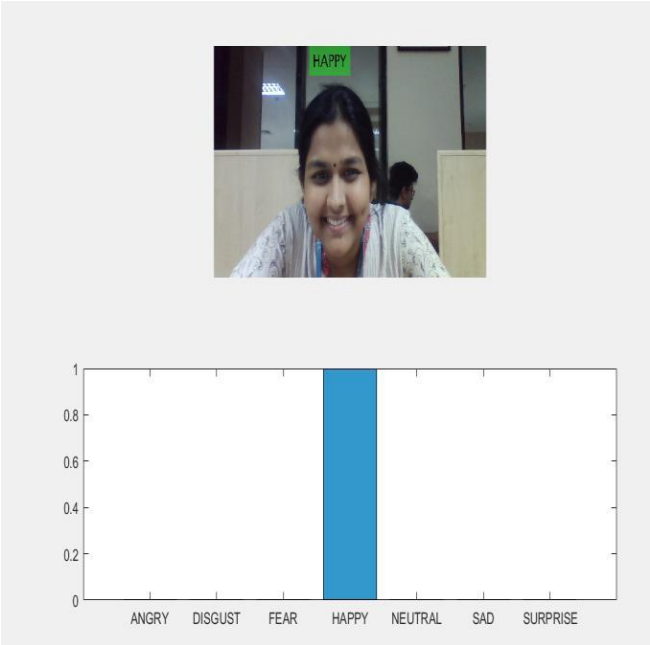

Figure 7- Real time emotion detection for Happy

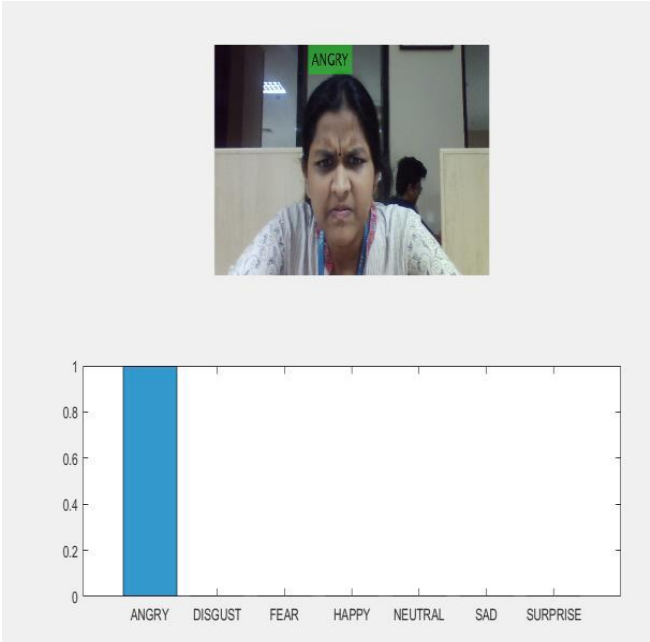

Figure 8- Real time emotion detection for Angry

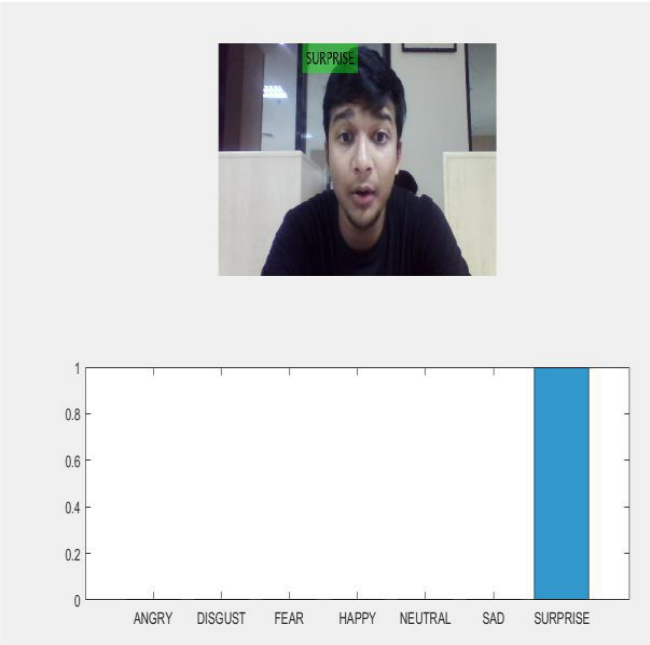

Figure 9- Real time emotion detection for Surprise

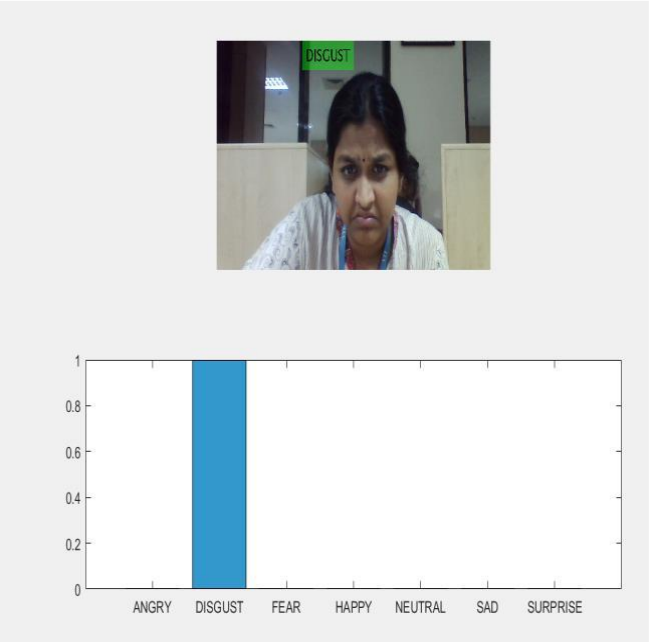

Figure 10- Real time emotion detection for Disgust

V. CONCLUSION AND FUTURE WORK

It has been found that machine learning based pattern recognition algorithms are successful in detecting emotions. The proposed FER System was trained on different classifiers mentioned above and it was found out that the ensemble-based Subspace KNN model gives maximum accuracy compared to KNN model and SVM Model. In real time detection it was observed that the model was getting confused between disgust, neutral and sad. This was because the JAFFE Database on which the classifier was trained had very similar images in these three emotion classes which is why even the accuracy of the classifiers faced a dip as clearly represented by the confusion matrix.

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So, in future more images once added into the model for training will give a clear distinction while detection. (Apart from Japanese women, different other faces need to be added).

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AUTHORS PROFILE

B.Bhavya is currently working as a Business Analyst in Deloitte USI Consulting India Pvt. Ltd. She completed her B. Tech in Electrical and Electronics engineering from Vellore Institute of Technology and has actively involved herself in research work related to Machine learning and Neural Networks. As a part of future work, she is working on a similar FER system based on Convolution Neural Network Algorithm. She is looking for publishing that as well after completion of the research end to end. Machine learning is the most advanced technology that is booming and is being considered in all future work and hence Bhavya believes that there is still a lot of scope for development in the field of AI and Machine learning.

Sriram. S is pursuing B. Tech in Electrical and Electronic Engineering in Vellore Institute of Technology, Vellore campus and has completed three years of engineering. He has constantly involved himself in research work related to subjects like Machine learning and Neural Networks. He has worked in projects like home security system which can detect obstacle and gas leakage using sensors and algorithms related to neural networks and signature detection using feed forward neural networks which can detect the forged and original signatures where the algorithm follows muti-layer classification. He has used MATLAB and python coding for his projects. He has completed an online course from coursera called "Machine Learning" by Andrew. N. G Stanford University which has helped him to understand and implement algorithms related to Machine learning and Neural Networks. As a part of future research-oriented work, he has made the same FER framework using convolution neural networks-based algorithm.

S Nitheesh Kumar is pursuing B. Tech in Electrical and Electronic Engineering in Vellore Institute of Technology, Vellore campus and has completed three years of engineering. He has constantly involved in the projects related to Neural Networks and Machine learning. He has completed a online course in Neural Networks and Deep Learning from Coursera by Andrew Ng, Stanford University which has helped him to understand and implement algorithms related to Neural Networks. He has worked in projects like Image processing which detects the image of a flower using algorithms related to neural networks. He has used MATLAB and python coding for his projects. As a part of future research-oriented work, he has made the same FER framework using convolution neural networks-based algorithm.

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