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Feature Extraction Technique for Emotion Detection using Machine Learning

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***Abstract*—*Facial Expression Recognition, due to its wide research areas, becomes an active research topic, and it relies on advancements in Image Processing and Computer Vision techniques. Such systems have a variety of interesting applications, from human-computer interaction to robotics and computer animations. Technologies used in this exemplary project are basic programming languages like Python and machine learning. This project aims at structuring a facial expression recognition system capable of distinguishing the six universal emotions: disgust, anger, fear, happiness, sadness, and surprise in real-time scenarios.*

The system uses a Haar cascade classifier for feature extraction, and the Fisherface algorithm uses a uniform Local Binary Pattern. This project's main purpose is to create a healthy work environment for the corporate sector and help patients with Asperger syndrome. This can have wide usage by psychologists as well for treating their patients in therapy.

Keywords — *Facial Recognition, Fisherface algorithm, Local Binary Pattern (LBP), Fisher Linear Discriminant (FDL)***,** *FER (Facial expression recognition), PCA (Principal Component Analysis), AAM* **(***Active Appearance Models), PCA (principal component analysis).*

I. INTRODUCTION

Emotions help in 70% of communication. The most strong and natural method of expressing the feelings of a person is facial expression. Many research and applications have been practiced for recognizing human expression in domains like medicine, finance, and online tutoring. Computer vision and machine learning use various facial recognition systems for encoding expression data from facial representation. Happy, sad, anger, disgust, fear, surprise, and neutral are seven basic human expressions. It can be addressed for the population of people with Asperger's syndrome, disabled people and can be used for driver state surveillance.

The project uses Python as the programming language environment of Python IDLE software; CPU requirements are 4Gb RAM, and GPU requirements are Nvidia/AMD. It also requires kali Linux and Open CV software for the python module. A basic classifier classifies emotions into six given categories. LBP(Local Binary Pattern), known as the local descript, does all the minor changes in expression for all emotions. After obtaining local features using LBP for face images, distinct expressions can be classified into distinct classes of various emotions, taking place under the Fisherface algorithm and internal LBP used in it.

II. PROBLEM STATEMENT

Even though today's method is robust and works out well, disabled patients cannot express their emotions as the corporate world has many workers working in extreme conditions where they require a high level of concentration and alertness. This problem can be sorted out by using the facial recognition system's software for detecting the expressions of the human. Traditional facial recognition systems use SVM, which includes kernel. This complicates the system and makes it less efficient. Our project does not use SVM as while training the module; it would take a lot of time and RAM, which can cause our system to cease and disable it to respond effectively and swiftly. We tried to do it without using SVM, which required more effort to make algorithm and coding, yet it speeded up the system performance while using our project desktop application on the system.

III. SYSTEM IMPLEMENTATION

A. Local Binary Pattern

We used LBP incorporation with the Fisherface algorithm. Here is how the LBP works and has helped us to reach the desired output.Ojala introduced LBP operator. The operator labels the image's pixels by thresholding 3x3 neighborhood for each pixel with a center value, and then the binary number result is considered. After that, a histogram of labels accounts for textual description.

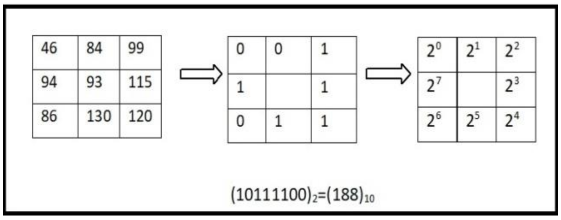

Fig3.1 Matrix conversion in LBP

Common LBP operator has a major setback which is its 3x3 neighborhood in distinct sizes. Bilinear interpolation and circular neighborhood help pixel values allow radius and any no. of pixels in the neighborhood. Extended LBP examples are shown in Fig 1.1 in which (P, R) denotes P as sampling point on a circle with radius R. Extended part of LBP uses uniform patterns. A Local Binary Pattern is uniform if it has 2 bitwise transitions from 0 -1 and vice versa when a binary string is circular. Take an example 00000000,11100001 and 001110000 are uniform in nature. In our project, we are trying to use LBP as an internal aspect of the Fisherface algorithm, which tends to pixelate the images of the video by capturing the image and then dividing it in 3*3 matrix, which is then used for differential selection emotion by comparing it with the database.

B. HAAR Cascade

Haar cascade is known as object detection algorithm of machine learning used in identifying objects in an image or video based on various features suggested by Paul Viola and Michael Jones for their paper "Rapid Object Detection using a boosted cascade of a simple feature Algorithm consists of four stages:

1. Haar FeatureSelection
2. Creating IntegralImages
3. Adaboost Training
4. Cascade Classification

Haar Cascade algorithm is best suited for the detection of the face on real-time processing. We opted for it because we needed the software to be efficient and swift but more importantly to be accurate as in our project, if there is a slightest the chance that the classifier is not able to perform up to the given criteria, accuracy will have a sharp fall and result will start to show up any errors. Here is how the classifier works.

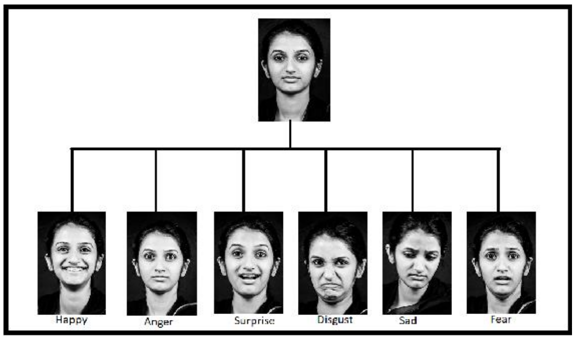

Fig 3.2 Classified data set

a) Cascade Classifier

In a cascade classifier, every stage undergoes training by boosting technique. It also gives the capability to train a largely precise classifier while taking a weighted mean of weak learners' decisions. Every stage in the classifier labeled a region defined for the sliding window's present location into positive and negative. When an object is found, it is denoted by positive, and when not found, it is negative. Classification of the region is completed if the label is negative, the window is sided to the next location by a detector. The classifier qualifies the region next region is the label is noted as positive. The object observed at the present location is reported by the detector when the final stage classifies the region as positive.

For rejecting negative samples, fast stages are designed. A wide majority of windows do not have an object of interest which is presumption. In reverse, true positives are rare, and verifying them is worth our time.

- A positive sample should be correctly classified for positive to happen.
- The negative sample is classified as positive by mistake for a false positive.
- The positive sample is classified as negative by mistake for a false negative.[0]

C. Fisher Face Algorithm

Now, after the face detection is done by the Haar Cascade classifier efficiently, the next step is to extract the features which Fisherface algorithm does by extracting principles which are components, and they differentiate features from one another due to this functionality features will be discrete and cannot dominate each other. This recognition uses a set of rules based on dimensionality reduction. Principle component analysis and Fisher Linear Discriminant (FLD) method characterize images.LDA can be applied for dimensionality reduction and differentiation of multiple linear features. It also helps in contrast models in images.

D. Principal Component Analysis

It consists of mathematical strategies which use orthogonal transformations, which convert observations of correlated variables into variables that are not correlated, and their values are principal components. Original variables are more than and equal to principle variables. The structure of the transformation is so that the principle component has a greater variance and the highest component has a limitation that it should be orthogonal with the previous component. Data should be dispersed normally for the components to be individualistic or independent. Comparative scaling of original variables makes PCA sensitive.

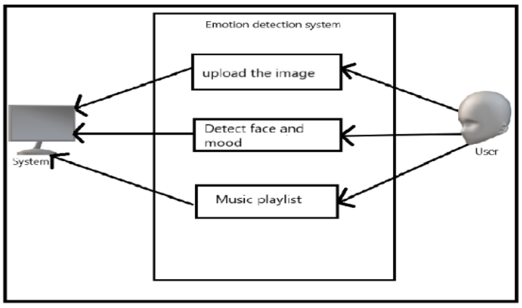

Fig 3.3 Use case diagram

E. Facial Motion Analysis

This procedure is also done under the Fisherface algorithm internally to classify the spontaneous facial expressions effectively; we transform in which facial motion magnification converts subtle facial expressions into overemphasized expressions. To process the face images, we first need to extract the good facial feature points. Some other facial expression recognition methods usually extract the feature points manual, but we automatically extract the feature points using the Active Appearance Models (AAMs). AAM is generative, parametric with a variation of appearance and optical shape displaying capabilities. The linear model helps portray Principal Component Analysis variations, and maximum variance is figured out while restoring the subspace of training data. A 2D shape of a 2D AAM is a triangular mesh with different vertices unique in nature. According to mathematics, shape vector **s** is having 2D coordinate vertices, which forms the mesh as **s**=((x1, y1), (x2, y2), . . . , (xl, yl)T and shape variation is represented as a linear combination of mean shape and shape base vectors.

A standard approach to compute the linear shape model is to use the Principle Component analysis to gather a manually marked training set of images for a set of shape vector quantities. **S**is names as ith-based shape vector corresponding ith eigenvector corresponding ith largest eigenvalue.

After obtaining mean shape **s0,** it is combined with training images while using piece-wise affine warp, which is corresponding triangles in which shape of a training image is landmarked A(x) is a part of shape **s0** consisting of x pixels.

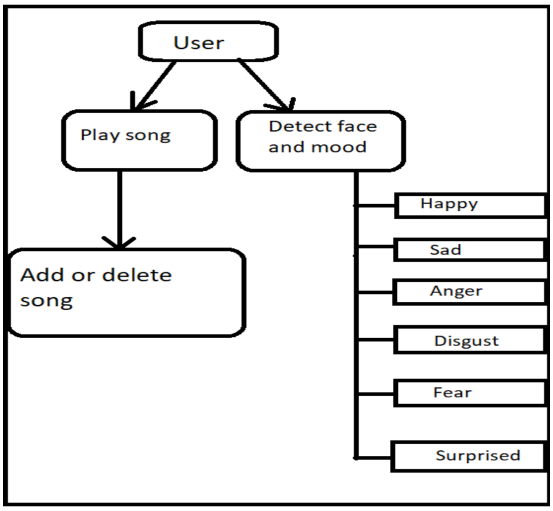

Fig 3.4 Activity diagram

F. Flow Chart

This is the flow chart that explains the project's whole idea that we are trying to achieve. It is the real-time result with our database by using several classifiers and algorithms. The whole step-wise functionality is described in the flow chart.

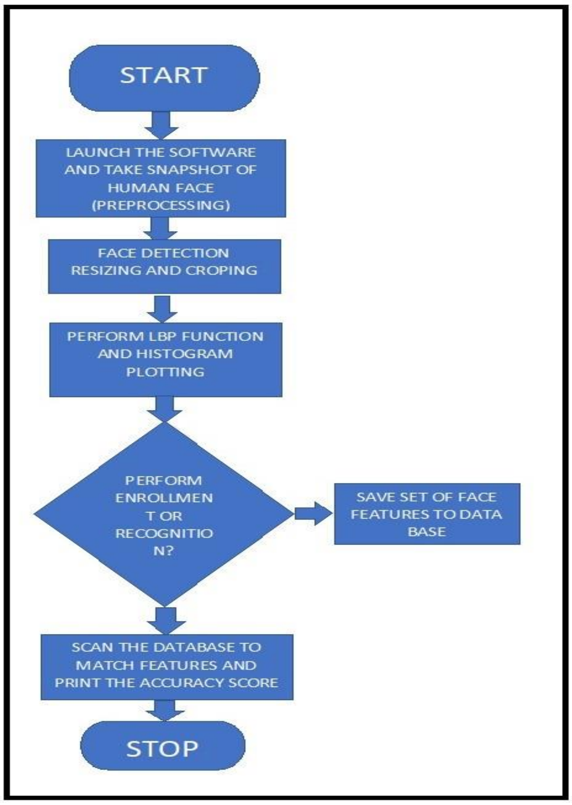

Fig 3.5 Flow chart

G. System Blocks

The below diagram of project system block representation explains how the project will be executed step-wise by following the pattern. The Block diagram of feature extraction of emotion analysis does the following-Image Processing Process-The image processing process consists of pre-processing and processing stages. The pre-processing stage includes the acquisition of the image and conversion of the image from RGB to 8-bit Grayscale. The Fisherface method is applied in the processing stage to match the training image's traits and test image traits by using the Euclidean formula.

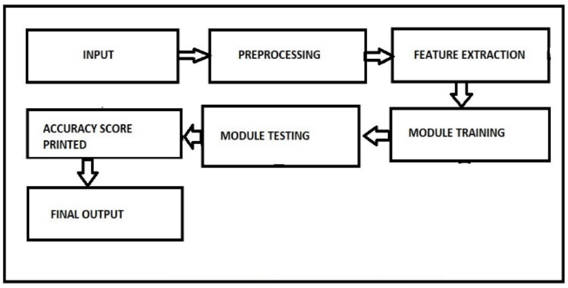

Fig 3.6 Feature extraction system blocks

IV. SCOPE

The scope of our project is

- To learn to code in Python for various modules present in the project.
- To learn about various Pre-processing techniques and select one that is suitable for our project.
- To learn about various Feature extraction techniques and different types of classifiers.
- Selection of suitable techniques for implementation of respective modules.

V.ADVANTAGES

- It will help the user to divert his/her mood.
- Time-effective process.
- Cost-Effective
- Easy to use
- More accurate out-of-sample accuracy.
  More "efficient" data usage as every observation is used for both testing and training.

VI. LIMITATIONS

- There should be a proper distance of face from the camera.
- If we want to develop an android application, it will not be feasible.
- Lighting also plays an important role as too much and less lighting can cause face detection difficulty, resulting in errors.

Ways to overcome these limitations are:

Adequate lighting should be maintained 'during the procedure. High definition video has a quite low resolution compared to a digital-based camera image, but it preoccupies large amounts of disk space and a high amount of processing time.

1. As technology is improving day by day, higher-definition cameras are available. Computer networks can transfer more data which results in faster processors. A facial recognition algorithm is way advanced and better when it picks out a face from an image and can recognize it.
2. A faster way to get over most of the setbacks is to change how an image is captured. Using a checkpoint for a case needs a subject to line up and channel through one point. Then a camera can focus on a single person, closely generating a useful front high-resolution image set.

VII. SYSTEM COST

This whole Facial Detection model on a real-time basis has cost us Rs.4500, which includes cost included in survey applying system installation and working hours with controller and hardware.

VIII. RESULT

The below Fig.8.1 includes three emotions captured on the laptop. This is a user-side view of emotion detection, which can be tagged for further application code.

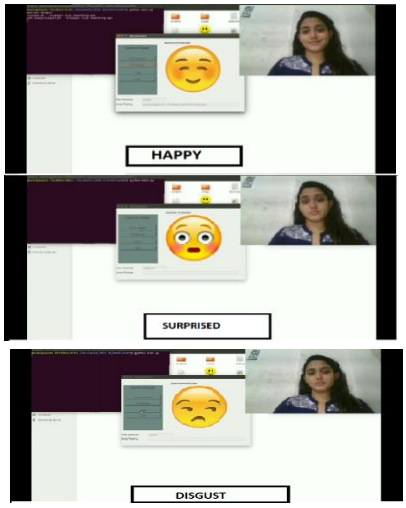

Fig 8.1 User screen view for Emotion detection

To analyze the implemented algorithm's effectiveness, the confusion matrix for the same was implemented below for the case study of fear detection.

		Predicted Values	
		FEAR	OTHER THAN FEAR
Actual Values	FEAR	TP=25	FN=5
	OTHER THAN FEAR	FP=9	TN=174

Fig 8.2 Confusion matrix for fear emotion

Following values are obtained from the confusion matrix; TP=25, FN=5, FP=9, TN=174, WhereTP= True Positive, TN= True negative, FN= False Negative, FP= False Positive. According to the formulae as mentioned below,

1. Accuracy (TP+TN)/(TP+FN+FP+TN) : (25)+(174)/(25+5+9+174) = 0.9343 (93.43%).
2. Sensitivity (TP)/(TP+FN) : (25)/(25)+(5)= 0.8333 (83.33%).
3. Specificity (TN)/(TN+FP): (174)/(174)+(9)= 0.9508 (95.08%).

Emotions Detected	Accuracy Detection (%)	Sensitivity Detection (%)	Specificity Detection (%)
Happy	96.24%	82.76%	98.37%
Angry	96.24%	80.77%	98.40%
Sad	94.81%	81.25%	97.27%
Disgust	92.96%	82.35%	94.97%
Fear	93.43%	83.33%	95.08%
Surprise	97.18%	95.65%	97.37%
Neutral	92.02%	71.05%	96.57%

Table 8.1 Result table for all emotions

The result table 8.1 above gives the result for accuracy, sensitivity, and specificity of the emotions. The graphical implication of the result table is given as below fig 8.3.

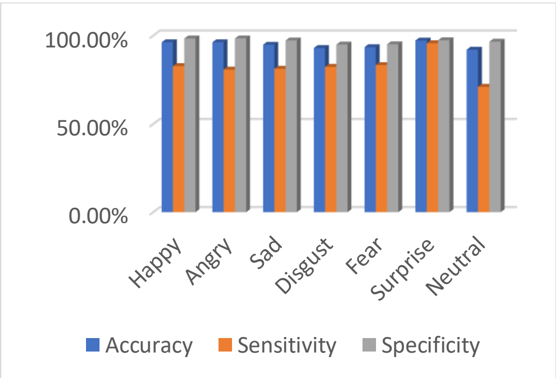

Fig 8.3 Graphical representation of the result

IX. CONCLUSIONS

In this paper, a noble approach to recognize facial emotions is developed by the Haar cascade classifier, and the obtained shape is applied to the Fisherface. Facial expression recognition method. In the proposed work expression classifier is learning by boosting HAAR feature-based lookup table. Local binary patterns save many computational resources while retaining facial information efficiently. It demonstrates that the LBP features are discriminative and robust over a range of facial image resolutions in real-world applications where only low-resolution video input is available. In the future, feature detection can be further improved and can be utilized for artificial intelligence in a very niche and risky areas.

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