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Performance Enhancement of Facial Expression Recognition using Appearance based features

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Abstract— Ability of recognizing facial expression is important part of behavioural science, which helps to ease the communication. This ability can serve in many contexts. Hence, facial expression is an important research area over the last two decades. In this paper, describes the extraction of the minimum number of Gabor wavelet parameters for the recognition of facial expressions and work with facial components like eyes and mouth by using hierarchical approach. The objective of our research was to investigate the performance of a facial expression recognition system and less work with feature extraction to classify expression. This system recognizes basic seven expressions happy, sad, neutral, angry, surprise, fear and disgust. We present a hierarchy for facial region extraction from static image. For determination of face effective areas is used from bounding box. This method has high ability in intelligent selection of areas in facial expression recognition system. Using determination of effective areas classify expression directly. Remaining faces fed to Gabor filter and it further reduces by Principle Component Analysis (PCA) to classify expression using Euclidean distance. Results test on JAFFE database indicates that proposed system for facial expression recognition is good accuracy and generating superior results as compared to other approaches.

Keywords— Facial Expression Recognition (FER), Feature Extraction, Gabor Filter, Principle Component Analysis (PCA), Linear Discriminant Analysis

I. INTRODUCTION

A human face has significant and unique characteristics, which play most dominant role in recognizing the expression of human faces. Facial Expression Recognition (FER) defined as a change that happens in response to human internal emotional states. It is used in different application of Human Computer Interaction (HCI) like face image processing, facial video surveillance system, and facial animation in the area of Computer Vision, Digital Image Processing and Artificial Intelligence. Automatic recognition of human expression is challenging task and has gained much attention during recent years. In FER, the stage of feature extraction plays a major role. In literature [1], Mehrabian et al. have shown that facial expression contributes 55% to the total communication. While vocal and verbal contributes 38% and 7% respectively.

Ekman and Frisen have identified six basic universally accepted expression in their research discussed in [2]. These basic six expressions are happy, angry, disgust, sad, fear and surprise.

The purpose of the research is to develop an automated and interactive computer vision system for the recognition of human facial expressions. Due to recent advances in image processing, it opens up the wide possibility of interaction with the machine and provides the different techniques for the automatic detection of face from image and classification of emotional and conversational facial signals. Space-time analysis for understanding the facial expressions in the previous work, however suffer the following shortcomings:

A. Most of these technologies are not in real-time to respond to the facial expression of the user. Facial movement patterns are trained offline from the training image dataset, since it limits its reliability for applications large variations between and contains a large number of possible Face action unit combinations [2].

B. In FER, for feature extraction, different techniques are available which depends on geometric and appearance based features. However, these techniques having performance variant according to the input images, rate of recognition of each expression and timely manner.

C. At the step of Classification of expression, classifiers do not generalize well for each expression and adapt the specific properties of database [3].

D. Possession of a large amount of data, images is usually makes it difficult to analyze human expressions. Raw data of FER are defined in a magnified image of facial expressions and facial expressions that can be used for higher-dimensional image space analysis. Therefore, this analysis is critical for dimension reduction [4].

E. Human's gesture is a dynamic process.

In this paper, we focus on various feature extraction methods using appearance based features for recognizing human facial expression. A number of approaches have been developed for extracting features from face images are Gabor Filter, Principal Component Analysis (PCA), Linear Discriminate Analysis (LDA), Local Binary Pattern (LBP), with different classifier Support

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Vector Machine and Artificial Neural Network (ANN).

II. METHODOLOGY

Working with Appearance based features of Human faces for recognizing expression accurately, there is different steps performed for pre-processing, feature extraction and classification. But there is some problem like choosing an appropriate pre-processing method for facial images, finding feature vectors using feature extraction techniques and appropriate classifier. From Literature Survey Gabor Filter reveal more facial expression as both transient and in in-transient way [2].It is favoured by most researcher because its outstanding performance in facial Expression analysis.

A. Gabor filter bank with 5 frequencies and 8 orientations which is normally used for feature extraction require more computational time and handle large number of feature vectors.

B. Secondly, Gabor Filter, when combine with another feature extraction algorithm are complicated to construct. For the solution of following problem is to improve a performance by reducing size of feature vector and work with minimum number of features using PCA followed by Gabor.

C. Working with Facial components such as the eyes and mouth are sufficient for to distinguish facial expression [2].

D. To minimize Gabor feature vectors and working with facial components so, increase performance in terms of recognition rate.

E. Making hierarchical approach for classification of expression.

FER proceed in mainly three steps [6]:

1) Preprocessing
2) Feature Extraction
3) Classification

For the proposed methodology, Database: Standard Available Facial Expression Database such as a JAFFE Database. The database contains 213 images of 7 facial expressions (6 basic facial expressions + 1 neutral) posed by 10 Japanese female models. Each image has been rated on 6 emotion adjectives by 60 Japanese subjects [16].

Steps of Proposed Method:

a) Crop the image to localize the face because in facial image there is some background detail which is not necessary.

b) Apply histogram equalization on cropped image. To enhances the contrast of images by transforming the values.

c) Convert image into Binary Image by applying following pseudo code:

```
for each pixel p( i , j ) of image
        if  pixel p( i , j ) < threshold
                p( i , j ) ← 0 ;
        else
                p ( i , j ) ← 255;
        end if
end for
```

d) Apply Mask on the Image. The mask is also binary image.

e) Bounding Box on Facial components (Eyes and Mouth). Make bounding box around connected components by pixel 8 and making areas of each facial component.

f) Measure the height and width of facial components. Using bounding box there is box around each eye and mouth by which height and width is measured.

g) Based on Facial components parameters (Lip Width, Lip Height, Eye Height, Eye Width and its ratio) classify two cluster of expressions are:

i. First is Category: 1 Happy.
ii. Second is Category: 2 Angry, Fear, Disgust, Neutral, Sad and Surprise.

h) On Category: 2, apply GABOR+PCA to extract the features. Gabor Filter having high number of feature redundancy and applies PCA on that to reduce its size.

i) Apply Classification on extracted features using Euclidean Distance.

j) Calculate recognition rate.

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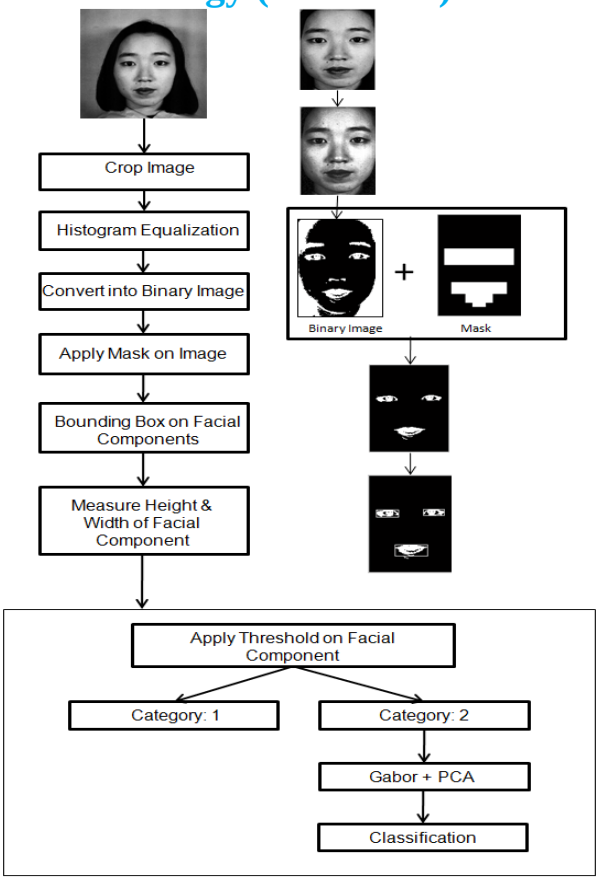


Figure 1: Proposed Approach

Measurement of Facial Components

Here, for the proposed methodology measurements of facial components are taken for point of hierarchical approach. As shown in table 4.1 the parameters are calculated for 30 images in each 7 expression of 10 subjects. It shows average of each expression's eyes and lip's height and width and further computing ratio of width/ height.

Table 1: Measurement Table of Facial Components

Expression	Eye			Lip		
	Width	Height	Ratio	Width	Height	Ratio
Happy	60.29	24.88	2.5858	33.70	14.64	2.4391
Disgust	46.58	21.94	2.2371	34.05	14.17	2.5820
Fear	46.58	23.76	2.0301	33.41	15	2.3465
Sad	47.17	18.29	2.7774	33.82	15.23	2.2921
Neutral	45.82	19.76	2.4078	33.23	15.88	2.1466
Angry	45.88	23.17	2.0539	33.75	16.25	2.1268
Surprise	42.70	27.70	1.5679	31.88	16.58	1.9518

Also, from table 4.1, we analyze the Happy Expression having highest width of lip. Surprise expression has lowest width and highest height of lip. According to each expression parameters the Happy, Sad, Fear and Disgust are based on Lip measurement classify where Neutral, Angry and Surprise are based on Eye measurement classify. Thus, making hierarchy of Expression and one by one each expression classify and remain applying further feature extraction algorithm.

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Feature Extraction

After the localization of the face and facial components of the input image, the next step is to extract representative features. Extracting a features affected with expression, is a crucial step from all steps of FER [5]. These feature parameters are further divided into two parts: Geometric based and Appearance/Texture based [6]. As shown in Figure1 different techniques for Appearance based features.

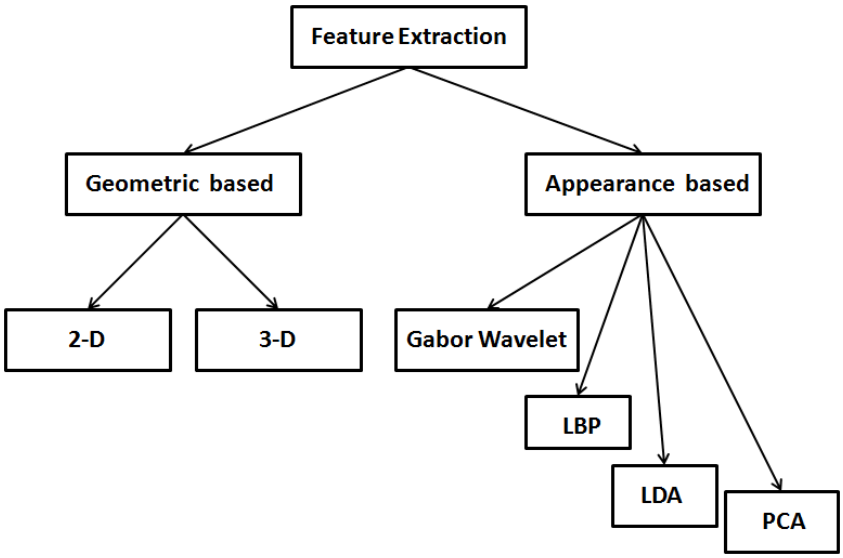


Figure 2: Techniques for feature extraction

Priya Sisodia et. al [6] have used gabor filter bank for detecting an appearance based features. Image was first converted to gray scale and then face was detected and resized. Few of the most representative features are selected through feature selection method and SVM was used for classification.

Rosdiyana Samad et. al [3] developed the algorithm to identify minimum number of Gabor wavelet parameters for natural FER. They convert image into grayscale and resize before applying a Gabor filter after that Gabor features are down sampled and dimensions of feature vector were reduced using PCA. Classification using SVM claims 81.7% recognition rate for FEEDTUM database.

Gabor filter, named after Dennis Gabor, is a linear filter used for detection of edge. Orientation and frequency representations of Gabor filters are similar to those of the human ocular system, and they have been found to be specially reserve for discrimination and texture representation. In the spatial domain, Gaussian kernel function for a 2D Gabor filter which is modulated by a sinusoidal plane wave. Gabor Wavelet is essential filter, which is used to extract local features from image with applying different scale and orientation. Gabor function is defined as [8]:

$$\varphi(x, y, \omega, \theta) = \frac{1}{2\pi\sigma^2} e^{-\left(\frac{x'^2+y'^2}{2\sigma^2}\right)} e^{i\omega x'}$$

Where (x, y) represents the pixel position, ω for center accuracy of filter plane, θ shows the orientation of Gabor filter, σ is standard deviation in x and y direction and x' and y' from following equation

$$x' = x\cos\theta + x\sin\theta \; y' = -y\sin\theta + y\cos\theta$$

This Gabor function has a Gabor filter in all orientations and then it convolute with the images as shown in figure 3.

Samad Rosdiyana et. al [5] have presented use of edge-based feature extraction with Gabor Features. Image was filter by Gabor and convolute with multiple edge detector. They were use multiple edge detector because each edge detection problem of manual selection of threshold value. The features are reduced in dimension by PCA and classify by SVM, which resulted 91.7% recognition rate for FEEDTUM database among all subject dependent recognition.

Abdulrahman et. al propose a method which is implemented using Gabor wavelet transform with PCA and LBP [8]. This hybrid approach gives 90% average recognition rate for JAFFE database.

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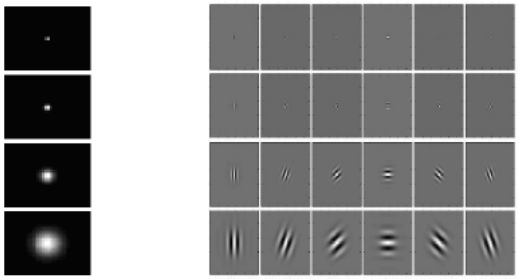


Figure 3: Gabor kernel having (a) Four scales and (b) six orientations [8]

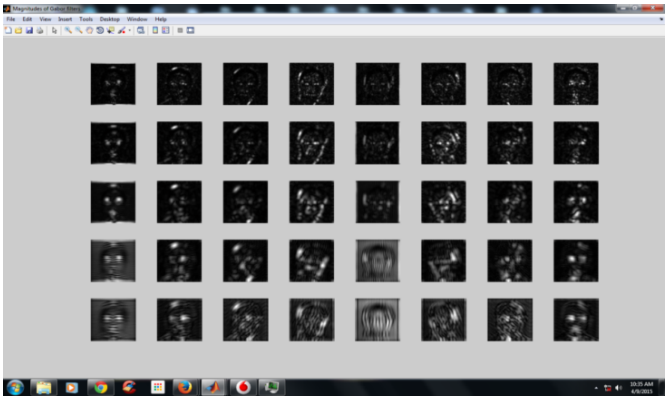


Figure 4: Convolute Image with Gabor filter

Due to large number of feature vectors from Gabor Filter,Gabor filter convolute with Image having large number of feature vector.

SizeofGaborFeatures = (m* n * u * v)/(d1*d2)
m=number of raw of image
n=number of column of image
u=number of scale
v=number of orientation
d1=downscaling vector
d2=upscaling vector
m=256,n=256, u=5, v=8, d1=4,d2=4
SizeofGaborFeatures = 163840 * 1
So, PCA apply on Gabor Features to reduce size.

PCA is a statistical method for feature extraction, reducing the dimensionality of features. Each face is represented by Eigen vectors which called Eigen faces [12]. Principle steps of algorithm as follows [6]:

1. Normalize all the faces; each image is stored in a vector of size N.

$$x^i = [x_1{}^i \dots\dots\dots x_N{}^i]$$

2. Calculate average vector and Subtract average face from each face vector
Mean Face as shown in Figure 2.9.

$$\bar{x}^i = x^i - m \quad ,$$

where $m = \frac{1}{p}\sum_{i=1}^{P} x^i$

Create Data matrix $X = [\bar{x}^1 | \bar{x}^2 | \dots\dots\dots\dots | \bar{x}^N]$

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3. Compute the eigenvalues and eigenvectors: The eigenvalues and eigenvectors are computed from the covariance matrix.

Cov=$X^T X$

Cov V =ΛV

Where *V* eigenvectors with respect to eigenvalues

4. Order eigenvectors: Select k best Eigenvector : This matrix of eigenvectors is called eigenspace.

$$V = [v_1 | v_2 | v_3 \ldots . | v_K]$$

5. Project training image: Each of the images is projected into the eigenspace and it called Eigen Faces as in Figure 2.10.

$$\tilde{x}^i = V^T \bar{x}^i$$

In generally image size is not issue for PCA, but it gives n good result in pose and expression variant images but not in illumination affected images [12].PCA having recognition rate, quick speed and simple calculation [6].

Then, Euclidean Distance is used for classification.
we apply PCA for feature reduction and for classification we use Euclidean Distance.

Euclidean Distance:

Euclidean Distance is a simplest method for classification based on the ordinary distance between two points [11]. The distance between two points A = (x1, y1) and B = (x2, y2) is:

$$d(A, B) = \sqrt{(x1 - x2)^2 + (y1 - y2)^2}$$

III.RESULT

TABLE 1: COMPARISON TABLE OF RECOGNITION RATE

Jaffe dataset		Recognition Rate			
Training Image	Testing Image	PCA	PCA + Proposed	Gabor + PCA	Gabor + PCA + Proposed
35	210	49.04	54.76	62.85	75.81
70	210	78.09	78.09	90.00	95.81
105	210	84.28	80.47	92.38	97.20
140	210	90.00	88.09	96.19	93.95
175	210	95.23	93.80	97.61	97.20
210	210	100.00	98.09	100.00	95.81
Average :		82.78	82.22	89.84	92.63

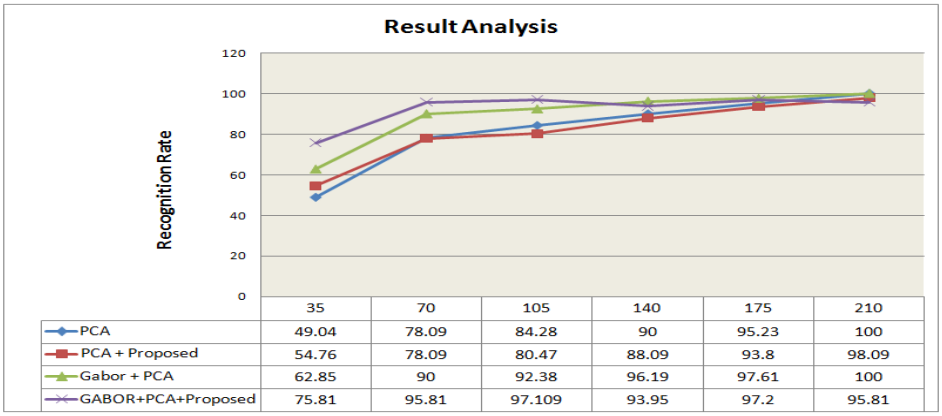


Figure 5: Result Analysis

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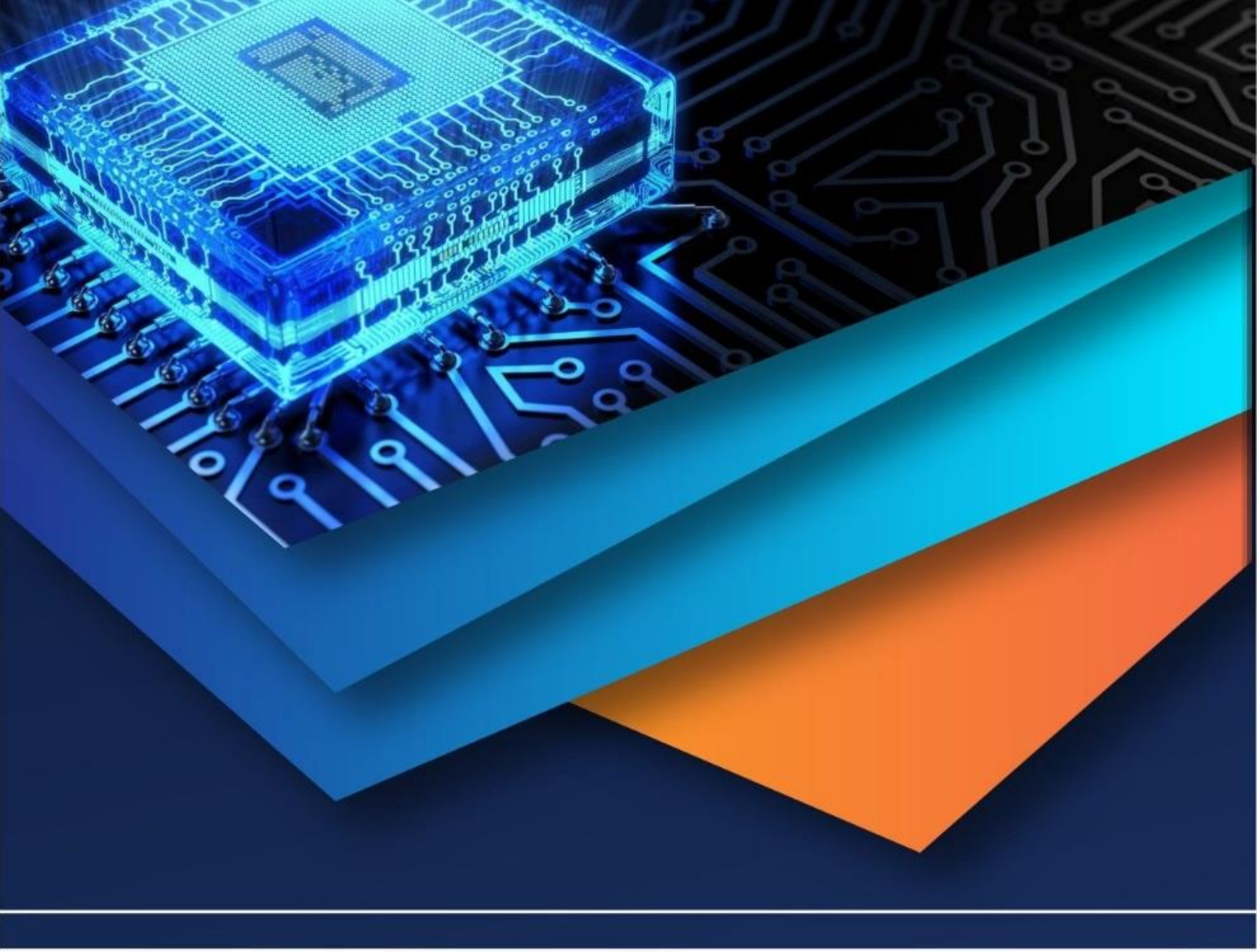
IV. CONCLUSIONS

This paper presents investigation and implementing of FER framework which improve the Performance of FER and reducing complexity. This hybrid approach having a good recognition rate compares to other methods of FER and performance is high due to segment the facial image into expression interested region such as an eye, eyebrows, and mouth, which have less size compared to whole image. Gabor + PCA + Proposed having 92.61 % with Euclidean Distance classification, which is higher than Neural network and SVM. In Future, we will make more work with facial component and based on classify more classes which increase performance of feature algorithm.

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