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A measure of happiness and sadness based on facial expression recognition

Mohamed A. Abdulhamed [a] , Zainab I. Othman [b]

University of Basra, Basra, Iraq
mohammed@uobasrah.edu.iq [a] , zainabalfahad@uobasrah.edu.iq [b]

Abstract: Face recognition systems are one of the most important applications in the field of computer vision. Where these systems enter into the development of many applications, especially in the field of medicine, security and Human Computer Interaction (HCI), In addition to the development of robotics. The system proposed in this paper includes the design of a software model capable of distinguishing two of the most important expressions of the human face: happiness and sadness, plus to the natural expression of the human face. The proposed system includes the approach to the design of any recognition system, starting from image acquisition and pre-processing, through the extraction of attributes. Finally to classify and give the output of the recognition. In the first stage a hybrid algorithm was adopted to extract the oval face. Two dimensions principal component analysis (2DPCA) for stage of features extraction. In the classification stage was used Euclidean distance. The results obtained showed high accuracy to distinguish the proposed expressions, so that the results of the recognition reached (95 %) percent when testing 120 samples from a Multimedia Understanding Group (MUG) Database [1].

Keywords: computer vision, facial expression, recognition, pca, HCI, MUG.

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1 Introduction

The human face is one of the main sources of communication among humans. Thus the facial area represents the main window to transfer internal emotions to the outside world, whereas according to the opinion of the doctors and experts in the psychological field, the movement of the muscles of the faces of humans is the most popular way of human interaction [1]. Communication among humans is essentially divided into two parts: Verbal (auditory), such as speaking, and non-Verbal (visual), such as body language. Mehrabian [2] has proven that the non-verbal part has the greatest influence in the social communication; the verbal part represents about 7% of the communication in messages and vocals represent around 38% but the main contributor to communication is facial expression which constitutes 55% of the message. For this reason, we find that many of researchers in the computer vision field are interested in Facial Expression Recognition System (FERS). The importance of these systems appears in multiple areas, including security, medicine and entertainment field [3]. This research is also linked to competition between researchers in Robotics development, aiming for robots to be able to read and interact with the emotions of humans [4]. However, researchers and developers in this area are facing problems in the design of complete system for facial expression recognition.

1.1 Previous Study

There are a number of researchers in this field, we mention some of them such as Le Hoang Thai, and Do Thi Thanh Ha **(2012)** [5]. In this research used 2DPCA and 1DPCA algorithm for features extraction and then compare between them. To test and evaluate their performance used Jaffe and YALA face database. The experimental results appeared that the performance and speed of 2DPCA are better than PCA, where the classification accuracy based on 2DPCA for Jaffe and YALA database are 88.19%, 84.74%, respectively.

X. Guo, X. Zhang, Ch. Deng, and J. Wei **(2013)** [6]. The proposed system that was used in this study was based on Independent Component Analysis (ICA) realign on 1DPCA and 2DPCA for features extraction stage, while the Support Vector Machine (SVM) as classifier. The Jaffe facial expression database used for train and test system, the accuracy rate which obtained is 88.09%.

Finally, Swati Mishra and Avinash Dhole **(2016)** [7]. In this system recognition of five different expressions is done by using some extracted features such as eyes and mouth. A well-known Viola Jones face detection method is used for the detection of the frontal face. The eyes and mouth region is taken for feature extraction in which local binary pattern (LBP) is used as a feature. Then obtained LBP features are clustered by using an efficient method named adaptive Neuro Fuzzy Classifier (ANFIS) to efficiently recognize various expressions. The Jaffe database used to train and test system, the recognition rate obtained by test 110 images is 85.45%.

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2 Methodology

The proposed system is one of the facial expressions recognition Systems for measuring unhappiness and joy of human face. It based on the proposed method to features extracted, which is to develop classic 1D-PCA method (based on converting the two-dimensional image into a one-dimensional vector), while method used depends on the dimensions of the entire image (2D) that is called 2D-PCA algorithm, which increases the efficiency of indistinguishable, in addition to reducing the execution time. Thereby reducing the time calculation used in the classic way. The proposed classification categories (happy, sad, and neutral) based on Euclid Distance classifier, whilst the MUG and JAFFE facial expressions database is used to train and test that system. Flow chart in figure (1) illustrate over view structure of proposed proposed.

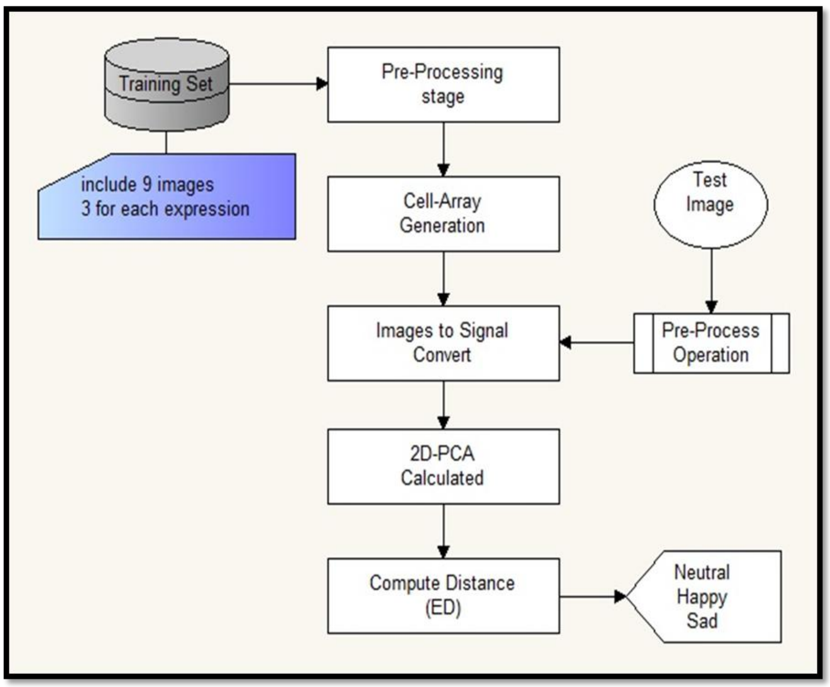

Figure (1): Happiness and Sadness Measuring Structure.

2.1 The Used Database

Firstly, the database used to train and examine the system must be identified. Multimedia Understanding Group (MUG) database is one of the modern database which has been prepared for the purpose of facial expression recognition. Completed by specialists from the multimedia understanding group at the Aristotle

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University of Thessaloniki, 2004. The MUG overcame many of the problems of the previous expression database such as using private studios with uniform lighting, plus to, high-resolution cameras. It contains on more than 1000 a photo taken in the form of a series of snapshots to perform a given expression. MUG includes 86 subjects in both gender, colored images, blue background, with dimensions (896*896). As seen in the figure (3.2), for more details visit the web site (www.mug.ee.auth.gr).

2.2 Pre-Processing Stage

This stage aims to make all the pre-treatment processes that include load, image processing operations, besides getting the region of interest of the proposed system which represent the facial area. In the system proposed these processes include several sequential steps, starting the download of the train set or test images, passing through image preprocessing operations such as Re-sizing, Converting, and reducing the noise of capture images. Firstly, after entering the image to the proposed system begin the image processing operations. As follows, for a fixed size scaling function applied using a type of interpolation is called Bicubic Interpolation, which is used 4by4 of adjacent pixels equivalent of 16 pixels. Programmatically, re-sizing formula written as follows in equation (1):

$$\boldsymbol{B} = \boldsymbol{imresize}\ (A, Output\ Size, method) \ldots (1)$$

Where A: input image, Output Size: [numrows numcols], *method*: interpolation used.

In the second step of the image pre-processing operation the Median filter applies to reduce noise, which may accompany the input image. It is one of the most popular non-linear filters in the processes to improve the image because it works to remove the noise without affecting the edges of the detected object in the image. In the last step of the pre-process, we check whether the input image gray level or not. If they skip to the next step, otherwise, the image is converted to gray level and stored in Tiff extension; this format means (Tagged Image File Format) is a format for computer files to store the bitmap image. Hence, it can benefit from this arrangement in the computer vision applications because it possess high-quality graphic to represent each image format. The image results appear as the figure (2).

Figure (2): Image Pre-Processing Steps (A), Input image (B) Noise Add, (C) Median Filter Apply.

2.3 Face Oval Detection

This step is considered the main task for the initial treatment phase in which the basic features of the proposed system are determined. These features are facial area, specifically facial disc in which the three basic emotion can be represented and can be shown to the outside world. Hence, we proposed prototype algorithm to extract this region (face oval). The proposed method depends on the application of two types of algorithms as follows: Firstly, apply the Viola and Jones (V&J) algorithm [8] directly to the image

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processed in advance. It can be represented as figure in (3.6), which illustrates the steps of that method to extract the whole facial area depending on the model algorithm, after making minor amendments on that algorithm. Generally, V&J method relies on three main stages: Haar like features selection, cascading classifier, and AdaBoost classifier. After that comes the task Integral Projection Function (IPF) that applying on the resulting image of the entire face detection space by V&J algorithm. In which one of their types is used for finds sum of the similar pixel values in both horizontal and vertical directions to determine the edges of the face oval area. IPF relying on similarity of those pixel values with each other and different from background pixel values. All about this proposed method can be found in detail on the proposed paper [9]. The figure (3) explains the step of the face oval detection.

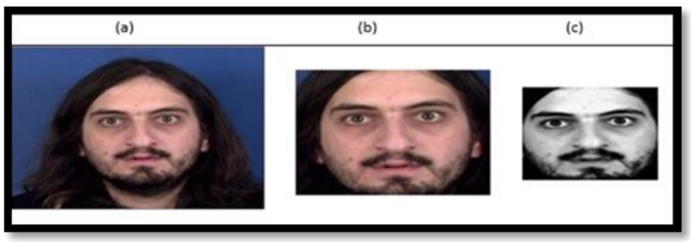

Figure (3.9): Face Oval Detection Steps: (a) Input image, (b) Whole face, And (c) Face oval.

2.4 The training set

The training set is a group consisting of 9 images so 3 images for each emotion of the proposed expressions, also these images must be selected carefully and accurately, according to the experience. This small number of training samples increases the efficiency of the proposed system which reduces the storage space and thus reducing the stages of the system operations. Thereby increasing the speed of the implementation of the system.The size used for train and test set equals 300*300, this selected the size as a result of the experiment to increase the accuracy of the recognition result, so that whenever high image resolution select lead to more accuracy rate. The figure (4) shows the train set of the proposed system from MUG database.

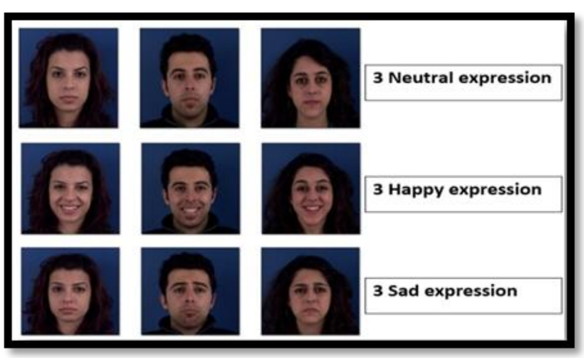

Figure (4): Train Set images of Happiness & Sadness Measure.

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2.5 Convert image to single precision

Rationally, to make any mathematical process we must transfer training samples (face images) to the format supporting those processes. Therefore we need to make some mathematical operations for calculating 2D-PCA method steps. So we can convert those intensity images whether test or training samples to single precision to perform these operation. The advantage of this format reduces the size of the data to represent the image. The next programming formula using for completion of the conversion process as equation (2):

Output Image = im2single (Image RGB) …. (2)

3 Two Dimensions PCA Calculated for features extraction stage

After the above, the stage of finding a main component (PC) come to represent the expression categories depending on the 2D-PCA method to extract features. This algorithm includes the following steps:
Step 1: Average image
We can be applied equation (5) to found the mean image, the result image shown in figure (5).

$$Average = \frac{1}{A}\sum_{i=1}^{A}\{Xi\} \quad ...(5)$$

Where M: number of input images, Xi: 2D input image, while Average: mean Image.

Figure (5): The Main Image of proposed system.

Step 2: Subtract training set images from Mean image
In this step, find the difference (subtracted) of each image in the training set A={X1, X2, … Xi} from the main image. This step is working to increase the normalization of 2D-PCA algorithm where it works on the centering of each train image. It accomplish by applying the equation (6).

$$B = Xi - Average \ ... (6)$$

Where B: output training set, Xi: input image, and Average: mean image.

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Step 3: Covariance Matrix Calculated
We can find a covariance matrix (Cov) values for training matrix (X) by applying the equation (7).

$$\text{Cov} = \frac{1}{A}\sum_{i=1}^{A}(x_i - u_x)(x_i - u_x)^T \ldots (7)$$

Where Cov: covariance matrix, M: number of training set, xi: sample of train set, ux: mean images.

Step 4: Eigen Values & Eigen Vectors Calculated
To find the Eigen vector and Eigen values corresponding by applying equation (8), in order to get Eigen space (Eigen Expression) to represent the proposed three expressions, as shown in figure (6). Hence, PC extracted is equal to number of train set images. That represent orthonormal vectors corresponding to the d largest eigenvalues of Cov matrix.

$$D = B * B^T \ldots (8)$$

Where B: subtracted matrix which means each one column represents Eigen vector of covariance matrix (Cov), BT: transpose B matrix. The Matrix values (D) that have been extracted contain diagonal vector that represents the Eigen Space (Eigen Expression).

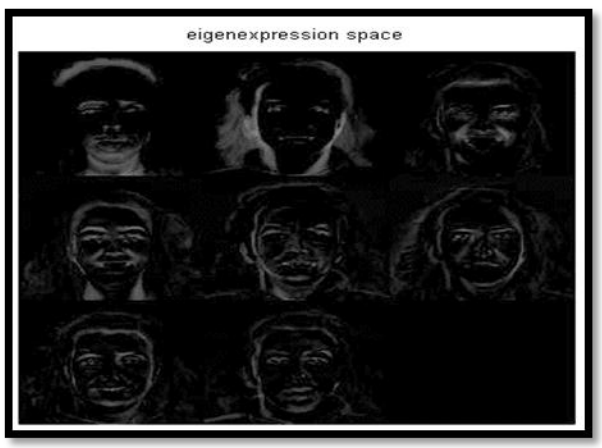

Figure (6): Eigen expression of proposed system.

Step 5: Weights Matrix Find
At the end, equation (9) applies to create the weights matrix by project each image of the train set on the Eigen expression to form the final matrix of dimension 9 by 9 used in the classification stage.

$$Weights = \sum_{i=1}^{M} X(:,i) * Eigen\ Expression \ldots (9)$$

Where Weights: output weights matrix, X: train set matrix, Eigen Expression: represents Eigen space matrix.

4 Classification Stage

At this stage, Weights values that have been extracted from the previous stage are relied upon to find the least value of the difference between them and test image, the resulting value represents the value of the biggest similarity that determined output results. This process is accomplished by using Euclidean metric to find a distance difference. ED classifier depends on the equation (10). Then we select the minimum distance between new Eigen vector for the test image and the Eigen expression vectors to give recognized result, whether joy, frown, or neutral expression.

$$d_{x,y} = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2} \qquad \text{... (10}$$

Where, x and y are tow vectors, while dx is the Euclidean distance between these two vectors.

5 Analyses and Results

For the analysis of proposed system, which has been proposed to recognize two of the most common expression to the emotions of human beings which are sadness and joy, as well as the neutral expression. The proposed system is relying on the use of the MUG facial expression database for test proposed system, where, 9 images selected for train set to be divided into 3 reference images to represent each expression. The table (1) shows more detail about the number of images used. The time taken for the implementation of the proposed system based on test MUG database used is 2.6066 sec, and estimate the total average time spent for the recognition a given test image.

Table (1): Number of samples used for proposed system.

Database	**Number of Training set**	**Number of Test Set(TS)**	**Number of subject**	**Nu of train set for each expression**	**Nu of test set for each expression**
MUG	9	120	24	3	40

Now we will review the results obtained for each expression based on the confusion matrix that shows the results for the test models, as shown in the table (2) based on MUG database.

Table (2): Confusion Matrix of FERS2 (MUG).

	Neutral	**Happy**	**Sad**	**Average Rate%**
Neutral	38	1	1	95%
Happy	0	40	0	100%
Sad	4	0	36	90%
Total Accuracy Rate	**95%**			

As shown in Figure (7), appear bar chart for both database, where shows the sad expression possesses least accuracy rate, because of the overlap in the representation of emotion with other expressions.

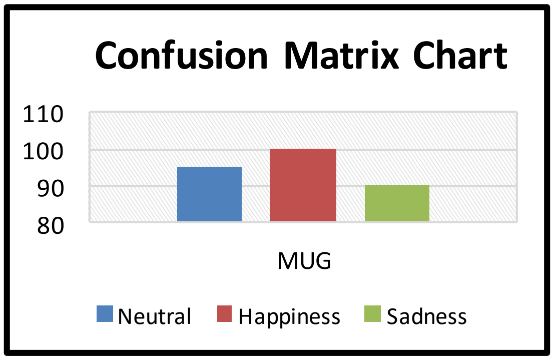

Figure (7): Bar chart of expression Covariance Matrix of proposed system.

In this paragraph, we will clarify the tools used for design and implementation this system show in the table (3). The Graphical User Interface (GUI) that was designed for the examination of the system proposal showed in the figure (8).

Table (3): The proposed system tools.

Type	The Description
Windows Version	Windows 10 Pro 32-bit
Programming language	Matlab R2013a
Processor	AMD A6-4400M HD Graphics 2.70 GH_z
RAM	4096 MB (4.00 GB)
HDD	160 GB

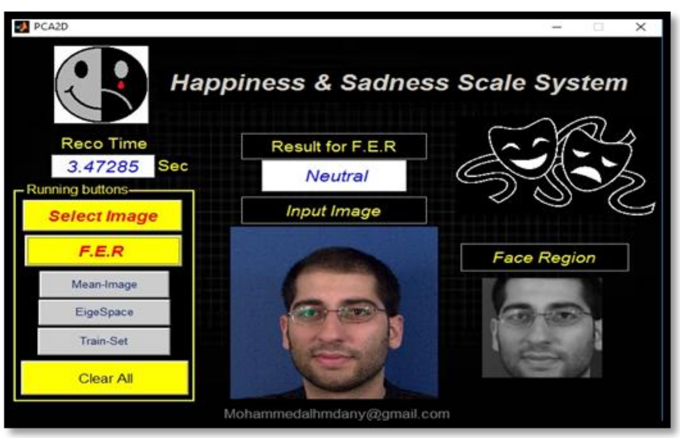

Figure (8): The Graphical User Interface of proposed system.

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6 Conclusion

In this paper ,the proposed models based on the appearance methods that rely on statistical data in certain areas of using Eigen Space, which is one of the efficient and fixed method to represent certain classes, which increases the efficiency of the proposed system. However, Eigen expression based on used principal component analyses as tools to extracted the feature by the representation of a group of principal component (PCexpression) to each class of expressions. Thus, this method will work to reduce dimensional, which reduces the storage space-consuming system. At the end, The accuracy rate that is obtained was excellent by using MUG facial expressions database, hence, the ratio 100% when testing all the samples training set for model proposed, while the overall rate 95%.

7 Future Work

Future work includes several topics, as follows:

- The development of the system to be able to detect the expressions in real time.
- Developing a robot capable of interacting with human emotions based on the proposed models.
- Database design to represent the basic facial expressions belongs to our daily lives and the people who are in our country.
- Training and examination system using other databases, such as MMI, Extended Cohn-Kanade Dataset (CK+), and FERG facial expression database.
- Increasing the number of the detections expressions as an expression of disgust, anxiety and tension.

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