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A Proposed Method of Face Recognition Based on Edge Detection and SVD

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Abstract: In the last decades, there has been a stronger focus on security around the world. One of the important issues in security is the need for correct authentication of persons. Traditional methods of establishing a person's identity include passwords, keys or identification cards but these surrogate representations of identity can easily be lost shared, manipulated or stolen there by compromising the intended security. In this study, we present a new approach for face recognition using Singular Values Decomposition (SVD) to extract relevant face features and edge detection using Markov basis. The system consists of six steps is edge detection for input images, image resize, image merge, segmentation of images, SVD to feature extraction and classification by use Euclidian distance to select face image. Edge detection is one of the basic steps in image processing, image pattern recognition, image analysis and computer vision techniques. It is solving many complex problems, edge is determined on the basis of the boundary between two different areas of color intensity in the image. In this study, the proposed method of detecting the edge was used to detect facial expressions that has found by Abbas and Mousa, the results of using this suggested method to color image or gray image is more accurate and clarity than traditional methods. All images in database will change it size to improve the result and increment recognition ratio. All images implementation the segmentation for feature extraction for each part in image, this segmentation increases the feature the extraction of image then applies SVD algorithm on each part from segmentation image and tack features (U) and features (S). Finally, we use Euclidean distance to classify the face images. The system has been evaluated on five databases the result of a classification ratio in the overall system when the use of ORL database has been obtained on ratio 97.5%, CMU database has been obtained on ratio 100%, MMI face database has been obtained on ratio 100%, face 94 database has been obtained on ratio 100% and HZFD (Husein and Zainab Face Database) has been obtained on ratio 100%.

Key words: Image processing, edge detection, color and gray image, Laplace filter, Gaussian, Markov

INTRODUCTION

Pattern recognition systems have been designed to classify many different kinds of patterns. This includes personal verification and identification from biometrics such as face recognition, fingerprint recognition, iris recognition, medical diagnosis of patients from the experimental results and several other applications (Mahanta, 2009). The first problem is to deal with the representation of input data which can be measured from the objects to be recognized. This is the sensing problem. Each measured quantity describes a characteristic of the pattern or object. The second problem in pattern recognition concerns the extraction of characteristic features or attributes from the received input data. This is often referred to as the pre-processing and the feature extraction problem. The third problem in pattern recognition involves the determination of the optimum decision procedures which are needed in the identification and classification process (Atilgan, 2009). Face recognition presents a challenging problem in the field of image analysis and computer vision and as such has received a great deal of attention over the last few years because of its many applications in various domains (Jafri and Arabnia, 2009). Face recognition problem is a big problem because of variations in different face images of the same person due to changes in facial expressions, viewpoint, illumination conditions, hair style, age, presence of beard, moustache, etc. Therefore, face recognition is a very high level computer vision task, in which many early vision techniques can be involved. In this study, better results were achieved to face recognition by using edge detection and algorithm SVD through the use of five databases, the highest ratio was 100%.

Literature review: Rasied *et al*. (2005) the algorithm for face recognition is performed by singular valued

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decomposition on the extracted feature of images and then training were done using back propagation neural network where the ORL database of faces were used. By performing SVD on the extracted images, the size of input layer cells. Therefore, many experiments were presented in this reseach in order to determine at which parameters, the system could give a good performance. The system gave an approximately 90% for training image recognition rate and 77% for testing images at hidden cells equals to 30 and 40. The feature extractor in use SVD good discrimination ability was obtained with an accuracy rate of 92% (Rasied *et al*., 2005).

Gao *et al*. (2008) Fisher Linear Discriminant Analysis (FLDA) has been widely used for feature extraction in face recognition. However, it cannot be used when each object has only one training sample because the intra-class variations cannot be statistically measured in this case. A novel method is proposed to solve this problem by evaluating the within-class scatter matrix from the available single training image. By using Singular Value Decomposition (SVD), we decompose the face image into two complementary parts: a smooth general appearance image and a difference image. The datadase ORL has recognition ratio 75.56% (Gao *et al*., 2008).

Pritha *et al*. (2010), this proposes a method, comprising of Laplacian of Gaussian (LoG) filter for intricate facial detail enhancement, Singular Value Decomposition (SVD) for holistic feature extraction and Feed Forward Neural Network (FFNN) for classification. Applications of LoG filter highlights, otherwise, hidden details such as wrinkles, moles, etc. The principal components from SVD form a basis for the original dataset. The FFNN uses gradient descent batch mode, back propogation algorithm with adaptive supervised learning. The method is christened L-SVD-NN and is tested on the Yale and ORL face dataset achieving an accuracy of 84.85% (Pritha *et al*., 2010).

Singular Value Decomposition (SVD) algorithm step: Let, A denote the face sub image matrix and the SVD of A is expressed by [U, S, V] = SVD(A) which produces a diagonal matrix S of the same dimension as A with non-negative diagonal elements in decreasing order and unitary matrices U and V of the dimension r×r and c×c:

$$A_{rc} = U_{rr} S_{rc} V_{cc}^{T}$$

Properties of the SVD: There are many properties and attributes of SVD. Here, we just present parts of the properties that, we use in this study of Abbass and Mousa (2017):

- The singular values $\sigma_1, \sigma_2, ..., \sigma_n$ are unique, however, the matrices U and V are not unique
- Since, $A^TA = VS^TSV^T$, so, V diagonalizes A^TA, it follows that the vj's are the eigenvector of A^TA
- Since, $AA^T = USS^TU^T$, so, it follows that U diagonalizes AA^T and that the ui's are the eigenvectors of AA^T
- If A has the rank r then $\{v_i, v_j, ..., v_r\}$ form an orthonormal basis for R(A) of A^T, $R(A^T)$ and $\{u_i, u_j, ..., u_r\}$ form an orthonormal basis for R(A)
- The rank of matrix A is equal to the number of its nonzero singular values

MATERIALS AND METHODS

The proposed system: The proposed system consists of three main stages: preprocessing, features extraction and classification images. In the classification stage there are two phases, first training images, second testing the images.

The main steps of proposed system: Read the images from database.

Pre-processing stage

Edge detection: For n = 3, we will use some elements of a Markov basis B and Laplace filters to generate a new filter. The method depend on a'aproposed method for face image edge detection using Markov basis that has found by Abbas and Mousa (2017) where (Z_2^*):

$$Z_2^* = \begin{bmatrix} -21 & -4 & -19 \\ -3 & 94 & -2 \\ -21 & -1 & -22 \end{bmatrix}$$

The results of using this suggested method to color image or gray image is more accuracy and clarity (Fig. 1).

Smoothing image by using Gaussian or median filter

Image resize: Input image with specific size and returns image that is scale the size of input image. The input

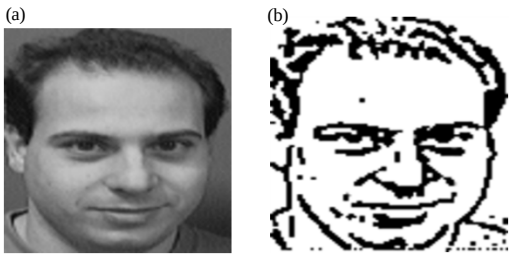

Fig. 1: a) Original gray image and b) The result of suggested method

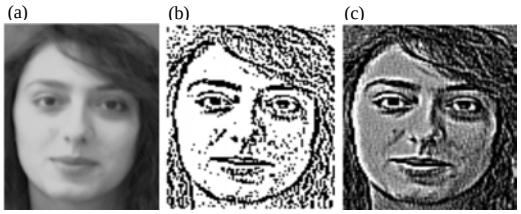

Fig. 2: Image merge: a) Original; b) Edge-detec and c) Image merge

image can be a grayscale or RGB, output image that have same type gray or color image. By default use in MATLAB imresize to change size image as need. It has been resized to (336×480) which applied for all the images.

Merge image: Image merge is the process of combining relevant information from two or more images into a single image. The resulting image will be more informative than any of the input images. The two images must be of the same size, merge which merges the two approximations or details structures obtained from X_1 and X_2 (where, X_1 is edge detection image and X_2 is original image) by taking the maximum, the minimum, the mean, the first element, the second element. The following example examine the process of merges two different images leading to a new image (Fig. 2).

Features extraction stage

Segmentation step: Image segmentation is the division of image into more regions or categories, after pre-processing stage the image result will divide into more regions based on size image (row, column). As in the following steps:

Step 1: If f(x, y) is the image matrix of dimension m×n divides the number of rows by L, r = m/L where, L is a suitable number of partitions the rows of f(x, y) into equal parts.

Step 2: Divides the number of columns by K, c = n/K where, K is a suitable number of partitions the columns of f(x, y) into equal parts.

Step 3: The number of sub image matrices is (L*K), each sub matrix of dimension r×c (Algorithm 1).

Apply SVD algorithm on the result images from step 1; steps of singular value decomposition:

Step 1: Take sub image matrix result from the segmentation A_{rc} that have size (r×c) pixels. To find U, S and V.

Step 2: To calculate U such that $U^TU = I$. The columns of U are orthonormal eigenvectors of AA^T:

- Find eigenvector and eigenvalue by using equation $|AA^T-\lambda I| = 0$
- We have to convert this matrix into orthogonal matrix, we do this by use the Gram Schmidt orthonormalization method to the column vectors

Suppose $\{v_1, v_2, ..., v_n\}$ is a basis for an inner product space V. Let:

$$w_1 = v_1,\ u_1 = \frac{w_1}{\|w_1\|}$$

$$w_2 = v_2 - \frac{\langle v_2, w_1\rangle}{\langle w_1, w_1\rangle} w_1,\ u_2 = \frac{w_2}{\|w_2\|}$$

$$w_3 = v_3 - \frac{\langle v_3, w_1\rangle}{\langle w_1, w_1\rangle} w_1 - \frac{\langle v_3, w_2\rangle}{\langle w_2, w_2\rangle} w_2$$

$$u_3 = \frac{w_3}{\|w_3\|}$$

$$w_n = v_n - \frac{\langle v_n, w_1\rangle}{\langle w_1, w_1\rangle} v_1, ..., - \frac{\langle v_n, w_{n-1}\rangle}{\langle w_{n-1}, w_{n-1}\rangle} w_{n-1}, u_n = \frac{w_n}{\|w_n\|}$$

Then $\{w_1, w_2, ..., w_n\}$ is an orthogonal basis for V and $\{u_1, u_2, ..., u_n\}$ is an orthogonal basis for V.

Step 3: As in the step 2 calculate value V such that $V^TV = I$. The columns of V are orthonormal eigenvectors of A^TA.

Step 4: Calculate value S where, S is the diagonal matrix containing the square roots of eigenvalues of A in decreasing order.

Features extraction of training and testing images: Let, $A_1, A_2, ..., A_n$ of dimension m×n be the training images matrices and B be the testing images matrices.

To extract the features of every A_i, i = 1, 2, ..., h, suppose, the segmentation of A_i are the sub image matrices $seg_1, seg_2, ..., seg_q$ of dimension r×c. Now, find SVD(seg_j), for all $1 \le j \le q$. To find U_j, $S_j = S_{rc} = diag\ \{S_1^j, S_2^j, ..., S_c^j\}$. The features extraction of A_i is the column matrix:

$$X_i = \begin{bmatrix} U_1(1,1)S_1^1(1,1)S_1^2(1,1)U_2(1,1)S_2^1(1,1) \\ S_2^2(1,1), ..., U_q(1,1)S_q^1(1,1)S_q^2(1,1) \end{bmatrix}^T$$

of dimension (3) q×1 matrix and the features of the matrices $A_1, A_2, ..., A_n$ is the matrix $X_1, X_2, ..., X_n$ of the dimension (3)q×h. In similar way, we can find the features matrix Y of the testing matrix B.

Classification stage: If $p = (p_1, p_2, ..., p_n)$ and $q = (q_1, q_2, ..., q_n)$ are two points in euclidean n-space, then the distance (d) from p to q or from q to p is given:

$$d(q,p) = d(p,q) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 +, ..., + (q_n - p_n)^2} = \sum_{i=1}^{n} \left((q_i - p_i)^2\right)$$

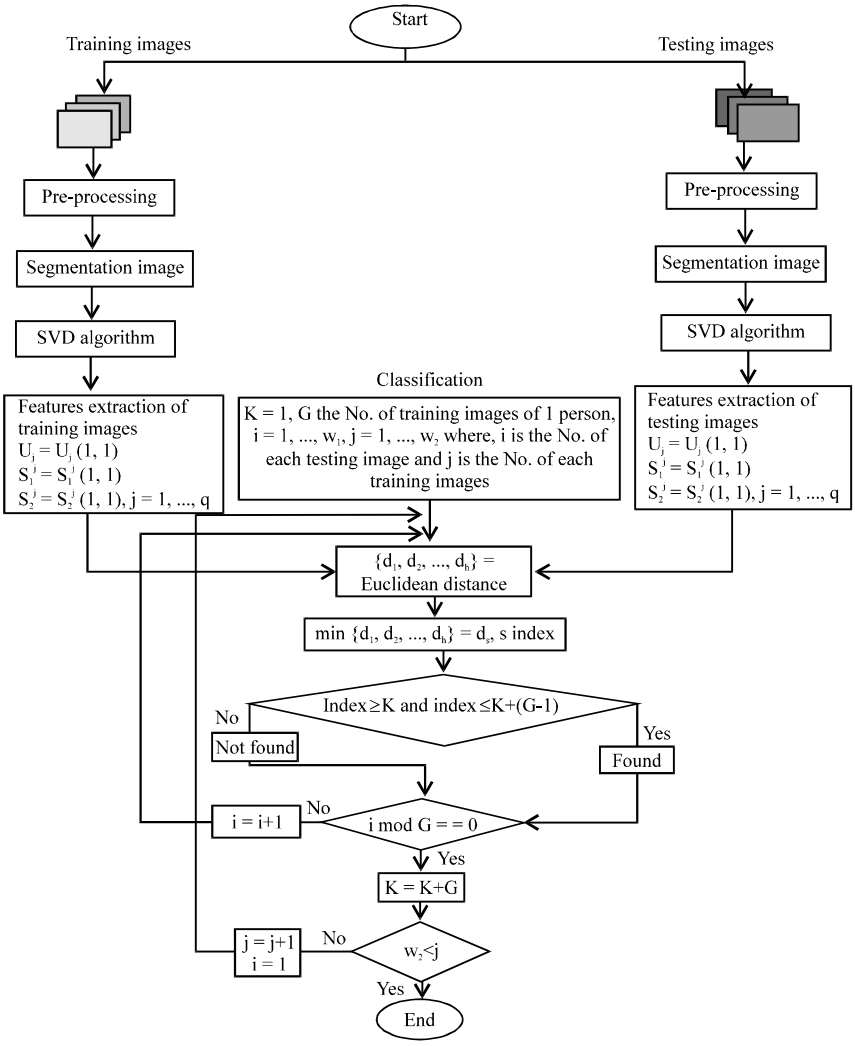

Fig. 3: Flowchart of face recognition system

In this step, we find the Euclidean distance between the features Y and the testing matrix B and every column X_i of the features matrix of training matrices $A_1, A_2, ..., A_n$, denoted by $d_i = d(Y, X_i)$, i = 1, 2, ..., w_1 (Fig. 3).

RESULTS AND DISCUSSION

The result of the edge detection and the discussions of feature extraction for classification. Using ORL database, CMU AMP face database, MMI face database, Faces94 database and HZ face database, implemented approaches are explained for both training and testing phases.

The first experiment: This experiment, the implemented ORL database was tested (5 images training and testing of a single image). The main part of the implemented system is the use of edge detection and SVD for extracting features (Fig. 4):

- False rate (%) = (5/200)*100 = 2.5%
- True rate = NF-FR = 200-5 = 195
- Recognition ratio (%) = $N_S/N_F \times 100$ = 195/200×100 = 97.5%

The second experiment: This experiment, the implemented CMU AMP face database was tested (Five images training and testing of a single image). The main part of the implemented system is the use of edge detection and SVD for extracting features (Fig. 5):

- False rate (%) = 0
- True rate = NF-FR = 200-0 = 200
- Recognition ratio (%) = $N_S/N_F \times 100$ = 200/200×100 = 100%

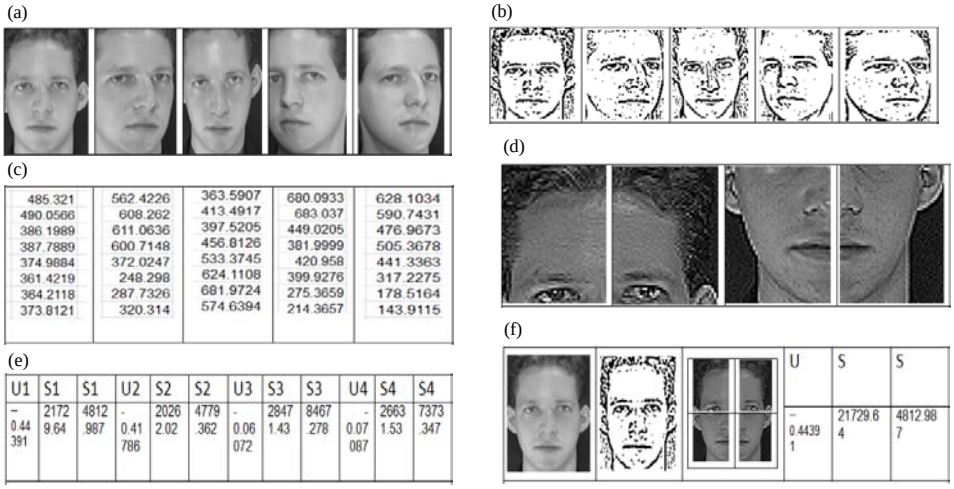

Fig. 4: Example part of the proposed system using ORL database: a) Training image; b) Edge detection image; c) Value edge detection image; d) Segmentation image; e) Feature extraction and f) Testing image

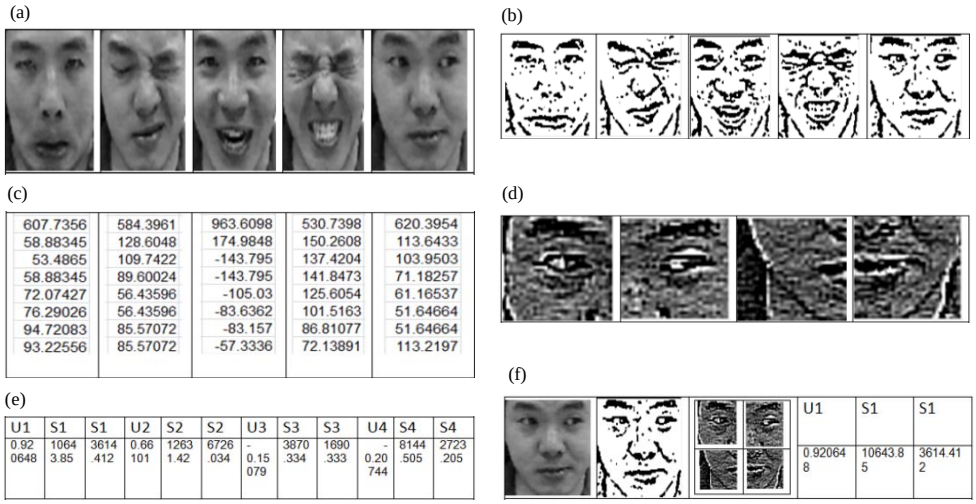

Fig. 5: Example part of the proposed system using CMU AMP face database: a) Training image; b) Edge detection image; c) Value edge detection image; d) Segmentation image; e) Feature extraction and f) Testing image

The three experiment: During this experiment, the implemented MMI face database was tested (Five images training and testing of a single image). The main part of the implemented system is the use of edge detection and SVD for extracting features (Fig. 6):

- False rate (%) = 0
- True rate = NF-FR = 200-0 = 200
- Recognition ratio (%) = NS/NF×100 = 200/200×100 = 100%

The four experiment: During this experiment, the implemented Faces94 database was tested (Five images training and testing of a single image). The main part of the implemented system is the use of edge detection and SVD for extracting features (Fig. 7):

- False rate (%) = 0
- True rate = NF-FR = 200-0 = 200
- Recognition ratio (%) = N_S/N_F×100 = 200/200×100 = 100%

The five experiment: During this experiment, the implemented (HZFD) database was tested (Four images training and testing of a single image). The main part of the implemented system is the use of edge detection and SVD for extracting features (Fig. 8):

- False rate (%) = 0
- True rate = N_F-F_R = 200-0 = 200
- Recognition ratio (%) = $N_S/N_F \times 100$ = 200/200×100 = 100%

Such that:

N_F = The total number of training face images

N_S = The number of correctly detected faces and it is the number of correctly recognized faces (by the face recognition system)

FR = It is the number of not correctly recognized faces (by the Face Recognition system)

FR = The False Rate

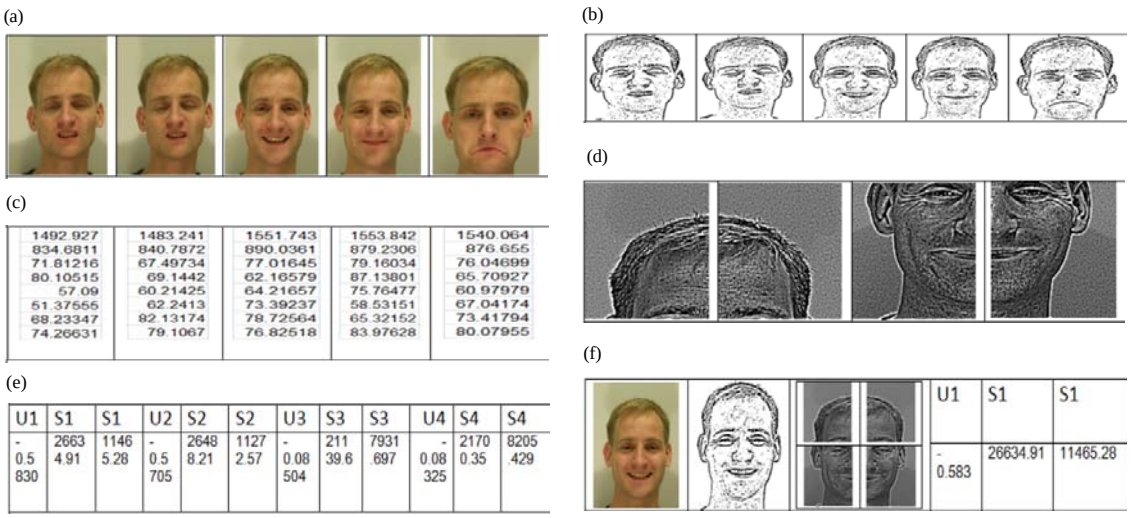

Fig. 6: Example part of the proposed system using MMI Face database: a) Training image; b) Edge detection image; c) Value edge detection image; d) Segmentation image; e) Feature extraction and f) Testing image

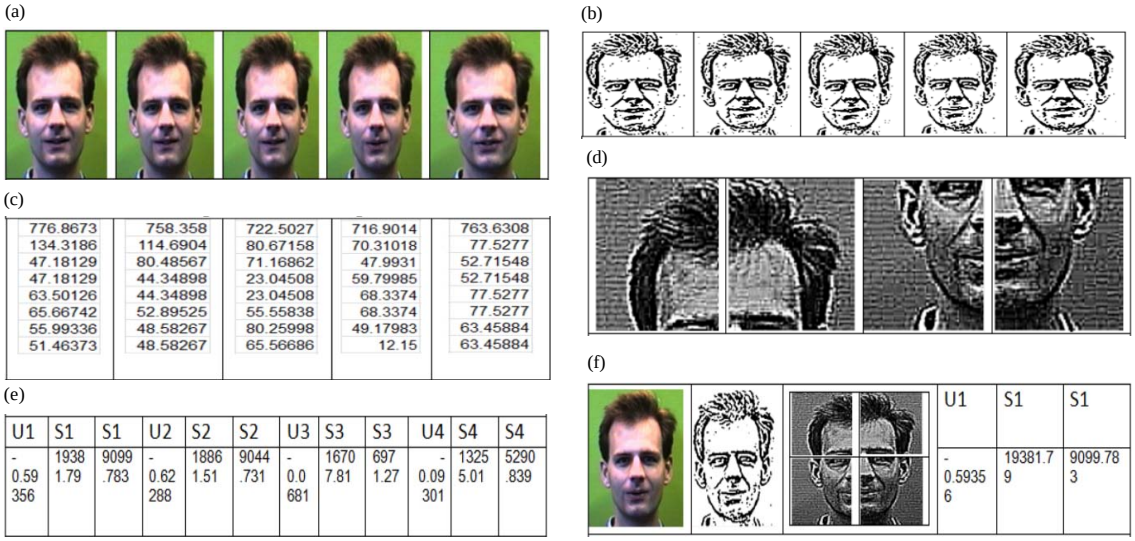

Fig. 7: Example part of the proposed system using Faces94 database: a) Training image; b) Edge detection image; c) Value edge detection image; d) Segmentation image; e) Feature extraction and f) Testing image

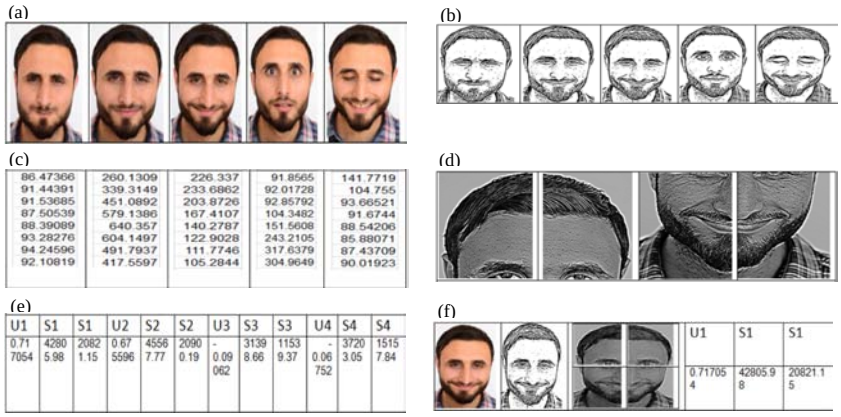

Fig. 8: Example part of the proposed system using HZFD database: a) Training image; b) Edge detection image; c) Value edge detection image; d) Segmentation image; e) Feature extraction and f) Testing image

CONCLUSION

In this study, a reliable and efficient face recognition system is implemented. This system includes set of the database of gray images or color images at different ages and nationalities. All the reseach in this study can be summarized in a four steps: apply edge detection of the database images, Gaussian and Median filter is very important step to enhance and remove the noise for edge detection images and resize the images in order to obtain important face features, proved the SVD algorithm it very effective for features extraction from images, take value (U, S) from result SVD, the most of distinct features in face recognition have been appears in the first three values from U, S in use SVD algorithm and implementing Euclidian distance for gives good results in the classification of face images. Classification system proposed for faces recognition succeeded to achieve a recognition rate 97.5% use ORL database, 100% CMU database, 100% MMI face database, 100% Face94 database and 100% HZFD (Husein and Zainab face database). The evaluation of implemented and comparative results are based on calculating the recognition rate, false rate and true rate over a wide range of facial and then compared the results with previous works. Experimental results demonstrate that the implemented system is more robust and can overcome a number of significant challenges to the face recognition.

Long training time of face recognition system which is a result of the low power of a single feature, hence, a large number of features are required. In the implemented system the required training time is reduced. The illumination variations which pose a significant challenge to face recognition are also considered during the reseach.

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