Face Recognition System for Students’ Attendance Register

Mustafa M. Eid
Department of Computer Teacher Preparation, Faculty of Specific Education, Damietta University, Damietta, Egypt

Amany F. El-gamal
Department of Computer Teacher Preparation, Faculty of specific Education
Mansoura University
Mansoura, Egypt

Elsaeed E. Abd Elrazek
Department of Computer Teacher Preparation, Faculty of Specific Education, Damietta University, Damietta, Egypt

ABSTRACT
Face recognition is very important topic because of its applications. The purpose of this work is developing a system that can recognize a person and register postgraduate students' attendance at faculty of specific education, Damietta University, Egypt. The proposed system consists of five stages: image acquisition, face detection, pre-processing, features extraction and classification. Image acquisition to capture real-time images. Face detection to detect face region from the image. Pre-processing stage involve the effective way of suppressing the unwanted distortion of image. Feature Extraction is a method of capturing visual content of images such as extraction of color, texture. In this work, Gray Level Co-occurrence Matrix is used for calculating texture features of the image. Four features namely, Angular Second Moment, Correlation, Inverse Difference Moment and Contrast are computed. Four classifiers were used: KNN (Nearest Neighbor), Naïve Bayes, Decision Tree and Discriminant Analysis. The accuracy of KNN is better than other classifiers therefore, KNN is used. The performance of the proposed system is evaluated by using dataset of postgraduate students' faces. Experimental results show that the proposed system achieved accurately of 90%.

Keywords
Face Recognition, Texture Classification, K-Nearest Neighbor, Gray Level Co-occurrence Matrix.

1. INTRODUCTION
Face recognition is challenging and interesting research topic in the field of pattern recognition which has been found widely used in many applications such as verification of credit card, security access control, searching image databases of licenses drivers, missing children, immigrants and police bookings [1]. There are two central issues of an automatic face recognition system; they are (a) Feature selection of representation of face. (b) Classification of new face image based on the chosen feature representation [2]. Face recognition is basically used for two primary authenticity modes: **Verification**: generally described as one to one matching system because the system tries to match the individual image is presented against a specific image already on file. **Identification**: It checks the image presented against all others already in the database. Identification systems are described as a 1-to-n matching system, where n is the total number of images in the database. Face recognition technology is a combination of various other technologies and their features and characteristics makes face recognition a better performer depending on the application. Face recognition works under three phases: face detection, feature extraction and face recognition. An explanation of each phase of face recognition is given in the next sections [3].

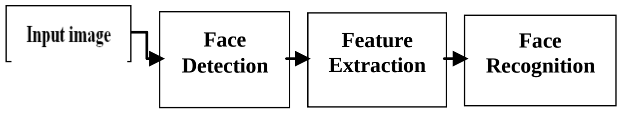


Fig 1: Face recognition system phases

Face detection is the process which extracts all the faces from an image and gives their location. It ignores the things in background like trees, buildings, etc. [4]. Texture is one of the important characteristics used in identifying objects or regions of interest in an image. Texture contains important information about the structural arrangement of surfaces. The textural features based on gray-tone spatial dependencies have a general applicability in image classification. The three fundamental pattern elements used in human interpretation of images are spectral, textural and contextual features. Spectral features describe the average tonal variations in various bands of the visible and/or infrared portion of an electro-magnetic spectrum. Contextual features contain information derived from blocks of pictorial data surrounding the area being analyzed. Textural features contain information about the spatial distribution of tonal variations within a band [5]. It is used to specify the roughness or coarseness of object surface and described as a pattern with some kinds of regularity, such as the gray level co-occurrence matrixes [6], Markov random field (MRF) model [7] and simultaneous auto-regressive (SAR) model [8]. The features extracted from these patches should give a more discriminated representation of the image, the matter that will lead to better retrieval results. GLCM give a measure of the variation in intensity at the pixel of interest and GLCM texture considers the relation between two pixels at a time, called the reference and the neighbor pixel. The paper is organized as follows: section 2 describes the system architecture. The experimental results are presented in section 3. Finally, section 4 concludes the work.

2. SYSTEM ARCHITECTURE
The flowchart of the proposed system is used to register postgraduate students' attendance at faculty of specific education, Damietta University. It is divided into main five stages illustrated in Figure 2.

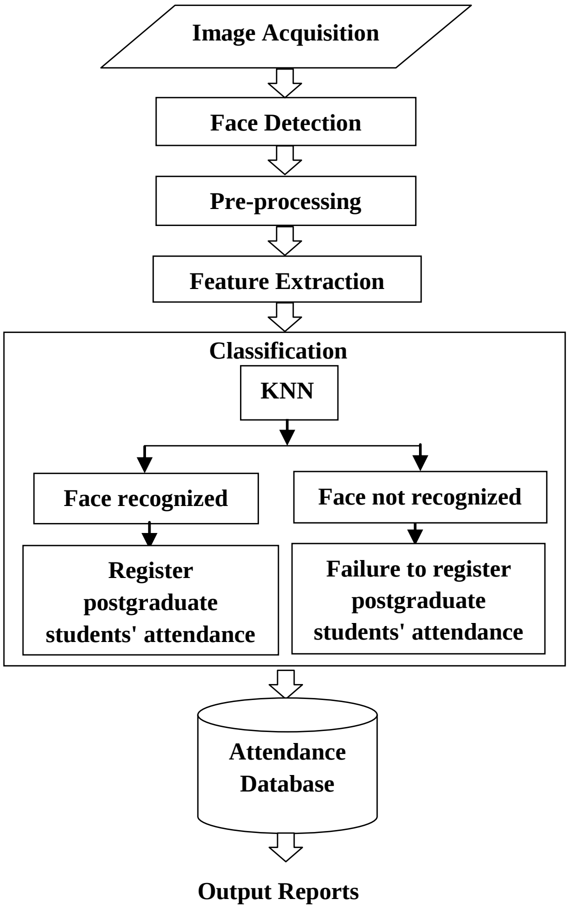


Fig 2: Flowchart of the proposed system phases

The stages involved are as follows:

1) Image Acquisition (Create Dataset)
2) Face Detection
3) Pre-processing
4) Feature Extraction
5) Classification

2.1 Image Acquisition (Create Dataset)

A simple camera was used to take photos for postgraduate students' faces to create the dataset that will be used for this work. This dataset contains 300 images with 15 different postgraduate students; each postgraduate student has 20 images. Figure 3 shows a variety sample set of these faces. This sample shows the various kinds of postgraduate students' faces that will be tested in the following classifiers. These variations include: facial expressions (open/close eyes, amused/not smiled), dissimilar poses (frontal image, side movements or changes in angle), under illumination conditions [9]. The dataset files of facial images are in jpg format. Moreover, each image size is 300x290 pixels.

Fig 3: Variety sample of postgraduate students' faces (faces dataset)

2.2 Face detection

Face detection is a technique to detect the area where the face is located in an image. The various fields of applications for face detection are face recognition, facial expression recognition, face tracking etc. The output of face detection algorithm is an image that the face of postgraduate student is shown by any bounding box or any method of representation, for example, rectangle, dots, circles etc. [4]. In this work a 2-D image is taken of any post graduate student. Then, the region of interest is selected by using b-box. After that, cropping is done where the unwanted part of image is removed. Finally, face is detected from the image as shown in figure 4.

(a) (b)

Fig 4: (a) The original image (b) The image after applying face detection and cropping

2.3 Pre-processing

Pre-processing is initial stage which involves the effective way of suppressing the unwanted distortion of image [1]. Also, it is a step that enhances the quality of feature extraction because it enhances the quality of the image [10]. In this paper pre-processing involves the acquiring the image, resizing and adding some enhancements to the image such as converting image to grayscale, histogram equalization and Noise removal of the dataset images using median filter. Accuracy of human face recognition system is mostly affected by varying lighting conditions. To overcome the illumination invariant problems and different details, wavelet decomposition method was used to representing the well-lit face images. At various scales and frequencies, the facial features are extracted by multi-resolution property of Discrete Wavelet Transform.

2.3.1 Image Resizing

The images have dimensions approximately 300 x 290 pixels. By the method of resizing, all the images are scaled to 256 x 256 pixels to have a better and accurate feature extraction.

2.3.2 *Image Enhancement*

Image enhancement technique is used to improving the quality of the image. Filtering is a technique which acts as a tool for removing the noise present in any image [11]. Median filter is used to eradicating unwanted disturbances which is presented in an image. The results that are obtained will improve and enhance the original image so that, it can increase the chances for success of subsequent processes.

Figure 5 illustrates Median filtering which is used to reducing noise in an image by considering each pixel within its neighboring pixels to decide whether or not it is representative of its surroundings. Then, it replaces the pixel value with the median of the values of the neighboring pixels. The median has been calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value [10].

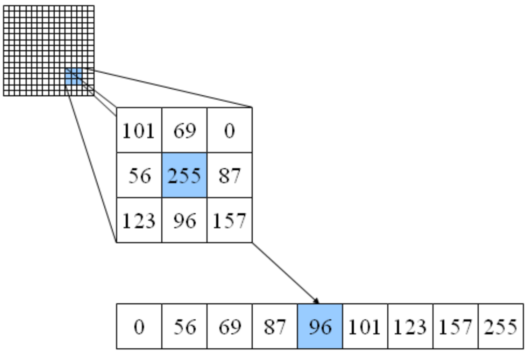
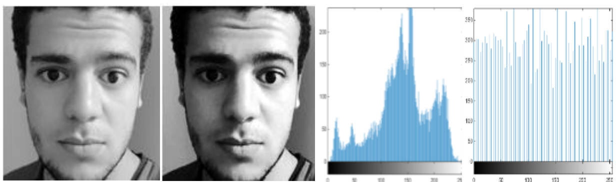


Fig 5: Median filtering processes

Histogram Equalization is basically used for contrasting enhancement, transformation function is given in the following equation [12].

S = T(r) where T(r) is a monotonically increasing function in the interval $0 \leq r \leq 1$

Figure 6 illustrates enhance contrast by using histogram equalization, in other words, the preceding transformation generates an image whose intensity levels are equally and cover the entire range [0, l]. The result of this intensity-level equalization process is an image with increased dynamic range, which will tend to have higher contrast.



Grayscale image | The image after histogram equalization | Histogram of the Grayscale image | Histogram of the processed image

Fig 6: Enhance contrast by using histogram equalization

2.3.3 Image Decomposition

Wavelet decomposition method is used to overcome the illumination invariant problems, different poses and details of the image. Moreover, the wavelet decomposition is used for compression or resizing of an image without affecting the quality of an image via various wavelets in different levels [13]. It may involve distinct wavelets such as Gabor, and Haar. Wavelet decomposition and decomposition level is favored at 4th level by Haar. Thus, the original image sizes of 139*139 have reduced to the four levels of 70*70 by wavelet decomposition as shown in figure 7.

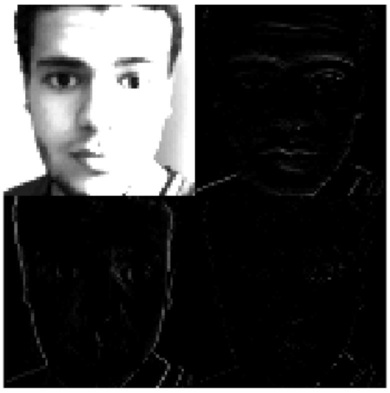


Fig 7: Decomposition of sample image by Haar at 4th level

Table 1 shows the accuracy rate on two different wavelet methods, Gabor wavelet transform and Haar wavelet transform, with the same classifier. The accuracy rate of Haar wavelet is better than Gabor wavelet by 9.86% Therefore, Haar wavelet transform is used in this work as the basis of pre-processing method in the following experiment.

Table 1: Comparison of two wavelet method by using KNN classifier

Classifier	Wavelet Method	Accuracy
KNN	Haar wavelet	90%
	Gabor wavelet	80.14%

2.4 Feature Extraction

Our interest is to study the statistics of texture features useful for postgraduate students' faces classification. GLCM is proposed in this work. Texture feature calculations use the contents of the GLCM to give a measure of the variation in intensity at a pixel of interest. An introduction to GLCM and texture features are given in the flowing subsection.

2.4.1 *Gray Level Co-occurrence Matrix*

Haralick first introduced the use of co-occurrence probabilities using GLCM for extracting various textural features. GLCM is also called as Gray Level Dependency Matrix. It is defined as "a tabulation of how often different combinations of pixel brightness values (grey levels) occur in an image", GLCM is created from a gray-scale image and considers the relation between two pixels at a time, called the reference and the neighbor pixel [14].

GLCM is the basis for the Haralick texture features. This matrix is square with dimension (Ng), where (Ng) is the number of gray levels in the image. Element (i, j) of the matrix is generated by counting the number of times a pixel with value (i) is adjacent to a pixel with value (j) and then dividing the entire matrix by the total number of such comparisons made. Each entry is considered to be the probability that a pixel with value (i) will be found adjacent to a pixel of value (j) [15].

2.4.2 Textural features extraction from GLCM

Haralick defines fourteen textural features measured from the probability matrix to extract the characteristics of texture statistics of remote sensing images [15]. Four important features: Angular Second Moment (energy), Correlation, Inverse Difference Moment and Contrast are selected for implementation. The reason of choosing these features because the complexity of the algorithm reduced by using these texture features. In GLCM will be required only 2-D frontal image of the post graduate student whose face to be recognized. This 2-D frontal image is converted into 1-D matrix by concatenated of 2-D matrix. A set of textural features can be extracted from the GLCM as illustrated in the following part.

2.4.2.1 Angular Second Moment

Angular Second Moment measures the image homogeneity as defined in the following equation.

$$ASM = \sum_{i=0}^{Ng-1} . \sum_{j=0}^{Ng-1} pi^2 j$$

Where i, j are the spatial coordinates of the function p (i, j), (Ng) is gray tone.

Angular Second Moment is also known energy. It is the sum of squares of entries in the GLCM. It is highly when image has very good homogeneity or when pixels are very similar [16].

2.4.2.2 Inverse Difference Moment

Inverse Difference Moment (IDM) is a measure of image texture as defined in the following equation.

$$IDM = \frac{\sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} Pij}{1+(i+j)^2}$$

IDM weight value is the inverse of the contrast weight.

It is usually called homogeneity that measures the local homogeneity of an image. IDM feature obtains the measures of the closeness of the distribution of the GLCM elements to the GLCM diagonal. It has a range of values so as, to determine whether the image is textured or non-textured [17].

2.4.2.3 Contrast

This statistic measures the spatial frequency of an image and is difference moment of GLCM as defined in the following equation.

$$Contrast = \sum_{i,j} |i-j|^2 \, p(i,j)^2$$

Where i, j are the spatial coordinates of the function p (i, j).

It is the difference between the highest and the lowest values of a contiguous set of pixels. It measures the amount of local variations presented in the image. A low contrast image presents GLCM concentration term around the principal diagonal and features low spatial frequencies [14].

2.4.2.4 Correlation

Correlation measures the linear dependency of grey levels of neighboring pixels' texture as defined in the following equation.

$$Correlation = \frac{\sum_{i=0}^{Ng-1} \sum_{j=0}^{Ng-1} (i,j)p(i,j) - \mu x \mu y}{\sigma x \, \sigma y}$$

Where µ is GLCM mean, σ2 is the variance of the intensities of all reference pixels.

Digital image correlation is an optical method that employs tracking & image registration techniques to accurate 2D and 3D measurements of changes in images. This is often used to measure deformation, displacement, strain and optical flow, but it is widely applied in many areas of science and engineering [17].

This gives rise to some interesting properties of correlation:

- Single objects usually have a higher correlation value within them than between adjacent objects.
- Pixels are usually more highly correlated with pixels nearby than with more distant pixels.
- Correlation is quite a different calculation from the other texture measures described above. As a result, it is independent of them (gives different information) and can often be used profitably in combination with another texture measure [18].

Table 2 illustrates extraction four Statistical Texture Parameters using GLCM. Angular second moment and contrast are the most significant parameters in terms of visual assessment and computational load to discriminate between different textural patterns.

Table 2. Texture features extraction for some application images

ASM	IDM	Contrast	Correlation
0.5545	0.7451	718.9530	-3.7610
0.5624	0.7496	713.9645	-2.6365
0.5644	0.7510	714.7372	3.7621
0.5659	0.7517	713.6644	3.7649
0.5688	0.7538	706.5316	-2.2686
0.5672	0.7514	716.9957	5.0021
0.5757	0.7565	710.5020	1.0042

2.5 Classification

K-nearest neighbor approach is the proposed classification to recognize the faces of postgraduate students. The input image of postgraduate student's face is classified by a majority vote of its neighbors, with the object being assigned to the class which is most common amongst its k-nearest neighbors. The motivation for this classifier is that patterns which are close to each other in the feature space is likely to belong to the same pattern class [19]. The dataset that is used in this work contains of 300 images with 15 different postgraduate students, each postgraduate student has 20 images. To perform the classification using the extracted features, the entire dataset is divided into two parts. 70% were used for training the model, while the rest 30% were used for testing the model's performance. Some classification algorithms were used for that purpose like, KNN (Nearest Neighbor), Naïve Bayes, Decision Tree and Discriminant Analysis.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The experiments are performed on a computer which has an Intel Pentium Dual-Core processor (1.80GHz) with 4.00 GB memory under Windows 10. The solution is implemented in

Matlab. A simple camera was used to take photos for postgraduate students' faces at the faculty of specific education, in July 2019.

3.1 System Evaluation

Several statistical performance measurement metrics are used to evaluate the proposed system performance. These metrics are calculated from the confusion matrix [20] that illustrated in Table 3. The confusion matrix provides the performance visualization of the classification algorithm. Each column of the matrix denotes the examples in a predicted class, while each row indicates the examples in an actual class. This matrix assists in finding out any type of misclassification due to the classifier. The confusion matrix entries are as follows: (i) true positive (TP) is the number of 'positive' cases that categorized as 'positive,' (ii) false positive (FP) is the number of 'negative' cases that categorized as 'positive,' (iii) false negative (FN) is the number of 'positive' cases categorized as 'negative,' and (iv) true negative (TN) is the number of 'negative' cases categorized as 'negative'.

Table 3. Typical example of confusion matrix

Predicted class	**Positive**	**Negativ**
Actual class		
Positive	TP	FP
Negative	FN	TN

These performance metrics are such as: (i) the accuracy, which is defined as a ratio of sum of the instances classified correctly to the total number of instances, (ii) precision, which is known as the ratio of correctly classified data in positive class to the total number of data classified as to be in positive class, (iii) recall (TP rate), which is defined as the ratio of (TP) to the total number of instances classified under positive class, and (iv) f-measure, which is defined as a combined representation of precision and recall. The mathematical expressions for these metrics are given by [21]:

$$\text{Accuracy (Acc)} = \frac{TP + TN}{TP + FP + TN + FN}$$

$$\text{Precision (P)} = \frac{TP}{TP + FP}$$

$$\text{Accuracy (Acc)} = \frac{TP}{TP + FN}$$

$$\text{Accuracy (Acc)} = \frac{2 * p * r}{p + r}$$

Four different classifications are used for testing the model's performance: KNN (Nearest Neighbor), Naïve Bayes, Decision Tree and Discriminant Analysis. The results show that there is considerable performance variability between the various classifiers methods. K-Nearest Neighbor method perform better than other techniques. Table 4 illustrates the experimental results of different classifications performance measures.

Table 4. Comparison of different classifications performance

Classifiers / Performance Measures	**K-Nearest Neighbor**	**Naïve Bayes**	**Discriminant Analysis**	**Decision Tree**
Accuracy	90%	86.66%	81.66%	61.66%
Precision	92.06%	88,13%	78.65%	58.06%
Recall	91.66%	86.66%	79.54%	81.66%
F-Measure	91.85%	87.38%	80.78%	67.86%

The different results which obtained using evaluation metrics were used to measure the quality of trained classifier when tested with the query image. The result image will be the lowest distance and highest similarity [12]. The experimental results show the accuracy rate of a facial recognition to register postgraduate students' attendance is 90% using KNN classifier.

4. CONCLUSION

In this work, a method for classification of postgraduate students' faces based on GLCM is presented to register their attendance at faculty of specific education. The proposed method considers the spatial relationship of pixels in the GLCM which gives better classification rate. The statistical features: contrast, correlation, energy and homogeneity are used as features in the proposed method. Evaluation of classification algorithms was compared in order to enable efficient postgraduate students' faces classification using the image retrieval. Initial results on a dataset of postgraduate students' faces have proved the feasibility and usefulness of the introduced approach. All experiments show that, using KNN classifier method gave better results than the other techniques. This is due to the fact that the various textural parameters calculated from the GLCM help understand the details about the overall image content. In the future work, the proposed system will be extended to cover more postgraduate students. Also, improving the training set of the proposed system by using different techniques.

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