Door Lock System through Face Recognition Using MATLAB

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Abstract—Face recognition is a biometric technology with a wide range of potential applications such as access control, banking, information security, human computer interaction, virtual reality, database retrieval etc. This paper addresses the building of face recognition system by using Principal Component Analysis (PCA) method. PCA is a statistical approach used for reducing the number of variables in face recognition. While extracting the most relevant information (feature) contained in the images (face). In PCA, every image in the training set can be represented as a linear combination of weighted eigenvectors called as “Eigenfaces”. These eigenvectors are obtained from covariance matrix of a training image set called as basis function. The weights are found out after selecting a set of most relevant Eigenfaces. Recognition is performed by projecting a new image (test image) onto the subspace spanned by the eigenfaces and then classification is done by distance measure methods such as Euclidean distance. A number of experiments were done to evaluate the performance of the face recognition system.

Keywords—PCA, MAX232, MATLAB

I. INTRODUCTION

Face is one of the most important visual objects in our life which playing a major role in conveying identity and emotion and includes rich information. Face recognition is a huge research area in computer vision, pattern recognition and plays a vital role in the applications of image analysis and understanding. Face recognition commonly includes feature extraction, feature reduction and recognition or classification. Feature extraction is to find the most representative description of the faces, making them can be most easily distinguished from others. Face reduction is to not only decompose and compress the original features but also not destroy the most important information. Recognition or classification is to choose the available measure method such as Euclidean distance, which is used to classify the feature of images present in the database and test image. Because the face image is often with a high dimension, it is difficult to use the original data directly, so it is critical to choose the effectively distinguished features for extraction and reduction. In all kinds of the algorithms of face recognition, Principle Component Analysis is effective feature extraction method based on face as a global feature. It reduces the dimension of image effectively and holds the primary information at the same time. In this paper face recognition system is described and it is followed by the PCA algorithm. Typical structures of face recognition system consist of three major steps, acquisition of face data, extracting face feature and recognition of face shows typical structure of face recognition system in which subject under consideration given to the system for the recognition purpose this is consider to be acquisition of face image. Later on feature is extracted from the image and finally it is given for the recognition purpose.

II. DESCRIPTION

A. HARDWARE

In hardware the components are serial port, MAX232 voltage level converter controller to take input and generate output. To drive the relays we have used ULN 2803 IC which has...
arrays of 8 Darlington pair of transistors. Darlington pair of transistors are capable of provide larger amount of current to drive the relays. 8 LEDs are used as indicator each corresponding to 8 data lines of the data port.

CIRCUITS

- RS-232 Level converters circuit for UART communication.
- ULN based relay driver circuit/motor driver circuit
- Programmer Circuit for Microcontroller

FLOW DIAGRAM

B. SOFTWARE

The software section is completely based on MATLAB. In our interface we have used MATLAB for face recognition. We have used it in such a way that it matches the face from the predefined database and generates an event. This event is used to control the device by giving the controller input to control the output and thus control door control.

III. KEY COMPONENTS

A. HARDWARE

- Computer system
- USB webcam
- DB 9 connector
- MAX232
- AT89S8253 controller
- Relay driver (ULN 2803)/motor driver
- Resistors, LED, PCB, RELAYS etc.

B. SOFTWARE

- Window OS
- Matlab

IV. OPERATION

A. FACE RECOGNITION SYSTEM

Typical structures of face recognition system consist of three major steps, acquisition of face data, extracting face feature and recognition of face. Fig. 1 shows typical structure of face recognition system in which subject under consideration given to the system for the recognition purpose this is consider to be acquisition of face image. Later on feature is extracted from the image and finally it is given for the recognition purpose. These steps are elaborated as follow:

ACQUISITION OF FACE DATA

Acquisition and Processing of Face Data is first step in the face recognition system. In this step face images is collected from different sources. The sources may be camera or readily available face image database on the website. The collected face images should have the pose, illumination and expression etc. variation in order to check the performance of the face recognition system under these conditions. Processing of face database require sometimes otherwise causes serious affect on the performance of face recognition systems due changes in the illumination condition, background, lighting conditions, camera distance, and thus the size and orientation of the head. Therefore input image is normalized and some image transformation methods apply on the input image.

EXTRACTING FACE FEATURE

Feature extraction process can be defined as the process of extracting relevant information from a face image. In feature extraction, a mathematical representation of original image called a biometric template or biometric reference is generated, which is stored in the database and will form the basis (vector) of any recognition task. Later these extracted features used in recognition. A greyscale pixel is considered as initial feature.

RECOGNITION OF FACE

Once the features are extracted and selected, the next step is to classify the image. Appearance-based face recognition algorithms use a wide variety of classification methods such as PCA, LDA. In classification the similarity between faces from the same individual and different individuals after all the face images in database are represented with relevant features. Sometimes feature extraction & recognition process done simultaneously[1].

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B. MATLAB TOOLS
There are two MATLAB tools that we are using here:

IMAGE ACQUISITION

Image Acquisition Toolbox enables us to acquire images and video from cameras and frame grabbers directly into MATLAB. It can detect hardware automatically and configure hardware properties. Advanced workflows let us trigger acquisition while processing in-the-loop, perform background acquisition, and synchronize sampling across several multimodal devices. Image Acquisition Toolbox provides graphical tools and a programmatic interface to help us work with image acquisition hardware in MATLAB.

IMAGE PROCESSING: The toolbox enables you to customize the acquisition process to include integrating image processing functionality to identify objects, enhance imagery, or construct mosaics and panoramic views as the data is acquired. The IP toolbox cares to process the image according to the user need for desired output.

C. PCA ALGORITHM

PCA is a useful statistical technique that has found application in fields such as face recognition and image compression, and is a common technique for finding patterns in data of high dimension. Mathematical concepts that will be used in PCA covers standard deviation, covariance, eigenvectors and eigenvalues. Feature extraction for face representation is one of the central issues to face recognition system. Among various solutions to the problem, the most successful seems to be those appearance-based approaches, which generally operate directly on images or appearances of face objects and process the image as two-dimensional patterns. The purpose of PCA is to reduce the large dimensionality of the data space (observed variables) to the smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the data economically. The jobs which PCA can do are prediction, redundancy removal, feature extraction, data compression, etc. Because PCA is a classical technique which can do something in the linear domain, applications having linear models are suitable, such as signal processing, image processing, system and control theory, communications, etc.

The PCA algorithm is shown in the following steps:

STEP 1. Let a face image $X(x, y)$ be a two dimensional $m \times n$ array of intensity values. An image may also be considering the vector of dimension $m \times n$. Let the training set of images $\{X_1, X_2, X_3, \ldots, X_N\}$. The average face of the set is defined by

$$X = \frac{1}{N} \sum_{i=1}^{N} X_i \quad (1)$$

STEP 2. Calculate the Covariance matrix to represent the scatter degree of all feature vectors related to the average vector. The Covariance matrix $C$ is defined by
STEP 3. The Eigenvectors and corresponding eigenvalues are computed by using
\[ CV = \lambda V \]  
(3)

STEP 4. Sort the eigenvector according to their corresponding eigenvalues from high to low.

STEP 5. Each of the mean centered image project into eigenspace using
\[ wi = W^T (x_i - \bar{x}) \]  
(4)

STEP 6. In the testing phase each test image should be mean Centered, now project the test image into the same eigenspace as defined during the training phase.

STEP 7. This projected image is now compared with projected training image in eigenspace. Images are compared with similarity measures. The training image that is closest to the test image will be matched as used to identify. [7]

D. THE EIGENFACE APPROACH

In mathematical terms, we wish to find the principal components of the distribution of faces, or the eigenvectors of the covariance matrix of the set of face images, treating an image as a point (or vector) in a very high dimensional space. The eigenvectors are ordered, each one accounting for a different amount of the variation among the face images. These eigenvectors can be thought of as a set of features that together characterize the variation between face images. Each image location contributes more or less to each eigenvector, so that we can display the eigenvector as a sort of ghostly face which we call an eigenface. Each individual face can be represented exactly in terms of a linear combination of the eigenfaces. Each face can also be approximated using only the “best” eigenfaces – those that have the largest eigenvalues, and which therefore account for the most variance within the set of face images. The best M eigenfaces span an M-dimensional subspace – “face space” – of all possible images.

In order to calculate the eigenfaces and eigenvalues in MATLAB we have to use the command eig. The syntax of the command is

\[ d = \text{eig}(A) \]
\[ V,D = \text{eig}(A) \]
\[ V,D = \text{eig}(A,'nobalance') \]
\[ d = \text{eig}(A,B) \]
\[ V,D = \text{eig}(A,B) \]
\[ d = \text{eig}(A) \] returns a vector of the eigenvalues of matrix A.

\[ V,D = \text{eig}(A) \] produces matrices of eigenvalues (D) and eigenvectors (V) of matrix A, so that \( A*V = V*D \). Matrix D is the canonical form of A, a diagonal matrix with A's eigenvalues on the main diagonal. Matrix V is the modal matrix, its columns are the eigenvectors of A. The eigenvectors are scaled so that the norm of each is 1.0. Then we use \( W,D = \text{eig}(A'); W = W' \) in order to compute the left eigenvectors, which satisfy \( W*A = D*W \). \( V,D = \text{eig}(A,'nobalance') \) finds eigenvalues and eigenvectors without a preliminary balancing step. Ordinarily, balancing improves the conditioning of the input matrix, enabling more accurate computation of the eigenvectors and eigenvalues. \( d = \text{eig}(A,B) \) returns a vector containing the generalised eigenvalues, if A and B are square matrices. \( V,D = \text{eig}(A,B) \) produces a diagonal matrix D of generalised eigenvalues and a full matrix V whose columns are the corresponding eigenvectors so that \( A*V = B*V*D \). [6]

V. ADVANTAGES

- Automatic system
- More secure

VI. LIMITATIONS

- The camera could be able to capture good images.

VII. APPLICATIONS

Armed with this description of the core technical components of facial recognition and how they function together to form a system, these are few typical applications scenarios envisioned in the academic literature and promoted by systems developers and vendors. The examples we have selected are intended to reflect the wide-ranging needs FRS might serve, as well as diverse scenarios in which it might function. In the scenario that we have called “the grand prize,” an FRS would pick out targeted individuals in a crowd. Such are the hopes for FRS serving purposes of law enforcement, national security, and counter terrorism. Potentially connected to video surveillance systems (CCTV) already monitoring outdoor public spaces like town centers, the systems would alert authorities to the presence of known or suspected terrorists or criminals whose images are already enrolled in a system’s gallery or could also be used for tracking down lost children or other missing persons. This is among the most ambitious application scenarios given the current state of technology. Scenarios in which FRS may be used for authentication or verification purposes include entry and egress to secured high-risk spaces, for example military bases, border crossings, and nuclear power plants, as well as access to restricted resources, such as personal devices, computers, networks, banking transactions, trading terminals, and medical records. In these environments, not only is movement controlled, cooperation is structured by the way incentives are organized.

VIII. CONCLUSION

In PCA based face recognition, increase in the number of Eigen value will increase the recognition rate. However, the recognition rate saturates after a certain amount of increase.
in the Eigen value. Increasing the number of images and variety of sample images in the covariance matrix increases the recognition rate however noisy image decrease the recognition accuracy. In general, the image size is not important for a PCA based face recognition system. Expression and pose have minimal effect to the recognition rate while illumination has great impact on the recognition accuracy. As such, continuous works have been carried out in order to achieve satisfactory results of face recognition system. All these discussion provide useful performance evaluation criteria for optimal design and testing of human face recognition system.

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BIOGRAPHIES

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