

Advanced Face Recognition Based Door Unlock System Using Arduino & MATLAB

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Abstract—Internet of Things (IoT) offers incipient and exhilarating opportunities to increment the connectivity of contrivances within the abode for the purport of home automation. Mobile contrivances are ideal in providing a utilizer Interface in a habitation Automation system, due to their portability and their wide range of capabilities. The main purpose of this paper is to design and implement an efficient home security system. Using IoT controlling and automating the entrance of house through an easy manageable interface and cloud can be used as database of the information collected. The proposed work consists of the home security with real time access and control via mobile phone and Arduino as control unit. A security system which has a webcam is deployed at the entrance of the house. This is connected to the Arduino. GSM module is used to send alert messages. Face recognition is done through EHD algorithm using MATLAB.

Keywords— Arduino, Face recognition, Door Access control, GSM module, camera, MATLAB.

1. Introduction

In these new ages, security of home is the desideratum for the progress of society as a complete which in turn will avail construct our cities keenly intellectual, thus this facial recognition method will help to achieve admittance of the house which is a huge progress towards security of the house. A facial apperception system is the one which captures facial images of a person and confirms his identity utilizing a USB or Web or CC camera. The human face postulates an essential part in our convivial sodality, passing on individual's character. Human face is considered as a key to security. The framework gets facial pictures and corroborates the character of a man utilizing a webcam. It is an application fit for distinguishing a man from a computerized picture. This can be done by visually examining culled facial components from the picture and a face database. This is different from other biometrics frameworks where iris or palm prints are taken into account. The proposed system has unmistakable propitious circumstances due to its non-contact handle. Face pictures can be caught from a disunion without physically contacting the individual being apperceived, and the ID does not require participating with the individual.

It is used as a component of security framework which can be contrasted with different biometrics. It has turned out to be a major commercial recognizable proof and advertising instrument.

2. Analysis of Related Work

There are many works related to face recognition and detection using different methods by various authors. The main algorithms that can be seen here are PCA algorithm and Eigen vectors. Following section briefs about various papers related to this work. According to Ayi et al. [1], recognition of Face is a difficult problem because of similarity in faces and variations in image of the same face. It changes with various factors like age, conditions of illumination, noise. Recognizing a face that is independent of these variations is the main task of face recognition systems. This paper focuses on variations that are due to changes in illuminations.

There were three main approaches to deal with image variations due to illumination changes:

A. 3D shape of the object extracted using gray-level information. Here all the detected solutions are either the object's shape and reflectance properties or the illumination conditions.

B. In the presented work it its examined and it depends on portrayal of pictures and stored model that are generally insensitive to changes in illumination.

C. Handling image variations using a model. Here few pictures of the similar item is taken under various light condition and the pictures can be utilized either as free models or cumulated into model-predicted apperception framework. The local operators that are considered insensitive to illumination changes were examined. A face database was built. Further identity of face, brightening effects, view point and demeanor were included. Genuine separations between sets of pictures of a given face out of a various faces were computed. Comparison was done based on variations between pairs of images. The variations were observed due to illumination, viewpoint or expressions. According Patil & Katariya [2] proposes principal components analysis was the basis of several face recognition systems. Preprocessing takes place where a gallery of m training images is registered to one another and each image is unrolled into a vector of n pixel values. The subtraction of mean image for the gallery is made. 'Centered' images are obtained as a result which is placed in a gallery named matrix M . Basis vectors consist of a subset of Eigenvectors. The set of unit length Eigenvectors represent an orthonormal basis when they are sorted by decreasing Eigen value. Centered gallery images are projected after Eigen space is computed in this subspace. A centered probe image is projected during runtime recognition and the match is the one which has nearest gallery image to the probe image.

A few frameworks construct that the pictures are enlisted before face apperception. Facial highlights can be recognized and enrolled utilizing diverse strategies. Distinctive frameworks utilize diverse separation measures and distinctive number of Eigenvectors for this reason.

Yugashini et al. [3], says, there are many ways for security protection. Fingerprint, eye iris, retina, voice, face etc. are some of the methods in the biometric identifications. They all have advantages as well as disadvantages. These pros and cons should be kept in mind for developing these types of systems such as the system should be trustworthy, the cost should be kept in mind, their workability, the requirement of physical contact with the device and so on. It is very important to have a proper security system to prevent unlawful entry. To design these types of systems with various methods many studies has been done. In this type of systems everything is done by the system itself and therefore no man power required. The pictures are already stored in the systems database and therefore

when the system identifies the face then it will open the door and let the person enter the house. Here the process works like, it requires web camera which is connected to the PC (MATLAB) and the power supply is provided. The LCD display is directly connected to the microcontroller and the electromagnetic door is also connected with the microcontroller through driver. There are few steps which are followed to run this system. They are firstly to identify the human face they should differentiate the important features of the facial image.

Different Types of images of a single person is saved in the database. Therefore to recognize a face, Eigen vector helps in providing the image in the screen to be projected to face space. Then it is compared with the image provided and this way it can differentiate and recognize the face.

Ibrahim et al. [4] says that face recognition is very important and a requirement these days. It is used in various places like security check, verification of credit card, and access control. It can also be used to identify a criminal. Face recognition is the capacity to show a specific face and decide it from the other face pictures, it is conceivable to improve one individual identification. In automated face acknowledgment system, face detection is the initial phase. Without face identification, face acknowledgment is impossible. The two main algorithms utilized for face acknowledgment are feature-based algorithm and image-based algorithm. Here, face acknowledgment framework is intended for door control application. Eigenface strategy is utilized in the face acknowledgment framework.

Principle Component Analysis is the technique used. PCA is a feature selection and dimensionality reduction technique. Eigenface technique has been taken from PCA. The face recognition system is developed in two stages- first stage is training stage and the second stage is evaluation stage. During the training stage, a particular amount of training images of an individual is captured. The traits are drawn out from the intensity image of the person faces using PCA. The traits are then stored in the database. In the evaluation stage, the unrecognized faces are recognized autonomously. The implementation is easier by using artificial neural network. The outcomes are centered on three elements: illumination impact, separation of individual's face and the orientation edge of the individual's face towards the camera.

According to Sathe et al. [5], face recognition is done using two techniques- Viola Jones method and

Principle Component Analysis. The main technique is Viola Jones method, which can recognize portions of the face, for example, eyes, nose, mouth and jaw and are put away in the database. This technique is utilized to accelerate the procedure. The second technique is PCA, which perceives the face from all the faces put away in the database. Firstly, image detection is carried out using Viola-Jones method. It is used to capture the face. Advantages of this method are- it is used to speed up the process, it is simple and very efficient. AdaBoost is used for feature selection. Secondly, image acquisition is done, in which the captured images and videos are directed to MATLAB by using image acquisition toolbox. Thirdly, principle component analysis is done. Image recognition is done by PCA. It reduces the large dimensionality of data space to smaller dimensionality of feature space. Prediction, data compression, redundancy removal are the jobs done by PCA. Lastly, image processing is done. The recognition rate of the system increases with increase in number of images in the database. After a certain sum of increase in Eigen value, the recognition rate starts saturating, because increasing number of images in database increases the recognition rate. Enhanced security is one of the greatest advantages of face recognition system.

3. Proposed Methodology

The Proposed method uses the following steps in the designing process:

1. Installing of USB or Digital camera to capture live face images.
2. Create a database of authorized person by capturing their images with different poses.
3. Capturing current image of unknown individual, and saving the captured image and comparing with the available database image.
4. GSM module should be interfaced to send ready messages to approved individuals when the unapproved individual tries to open the locked door, as an SMS and call or Email.
5. It can likewise be utilized for video reconnaissance. For example, it can catch the live video of unidentified people who is

attempting to get access and it is stored in the database. These videos can then be utilized to decide the offenders who tried to gain illegitimate access to enter.

6. Interface relay as on output side.

The framework will work in two unique parts. The initial phase is catching the pictures in various postures and making a database of them by putting away those pictures. What's more, also is to contrast the current caught picture and the put away pictures in the database. Eigen faces procedure and Euclidian separations algorithm are used for facial component extraction when perceiving the face.

The PCA Algorithm works as follows:

1. Start.
2. Consider original faces training set.
3. $E = \text{eigenfaces}(\text{trainingSet})$
4. $W = \text{weights}(E, \text{trainingSet})$
5. Input unknown image X
6. $W_x = \text{weights}(E, X)$
7. $D = \text{avg}(\text{distance}(W, W_x))$
8. if $D = 0$ goto step 9
9. if X is a face then store X and W_x , goto step 11
10. if X is not a face goto step 11
11. END.

Camera module: An USB camera which interfaces to the computer module wired or remotely, is utilized to catch pictures and send the caught pictures to the MATLAB by means of zigbee. Camera module has LEDs and flashes for dealing with poor light condition.

At the point, when a picture is taken by USB Camera, it is compared with a database picture. Out of the blue, the pictures with different poses are captured and make a database of numerous pictures. This picture is then compared with the pictures that are caught live. Subsequent to checking the two pictures, in light of the output based on positivity or negativity of the output, it provides directions toward the GSM module.

GSM Module: Message has been sent to the approved individual using the GSM module. On the off chance that there is a positive output implying that the caught picture matches with the one in the database picture and saying face coordinated and access allowed message will be sent to the ensured individuals. If the individual is not authorized, face unrecognized and access denied message is sent. Further the message,

some obscure identity is endeavoring to access the house is sent to the affirmed clients of the system.

Arduino Module: Arduino Uno is nothing but a microcontroller board which is based on the Atmega328. It consists of 20 digital input/output pins (6- PWM outputs and 6- analog inputs), a ceramic resonator of 16MHz, an ICSP header, a USB connection, 6 analog inputs, a power jack and a reset button.

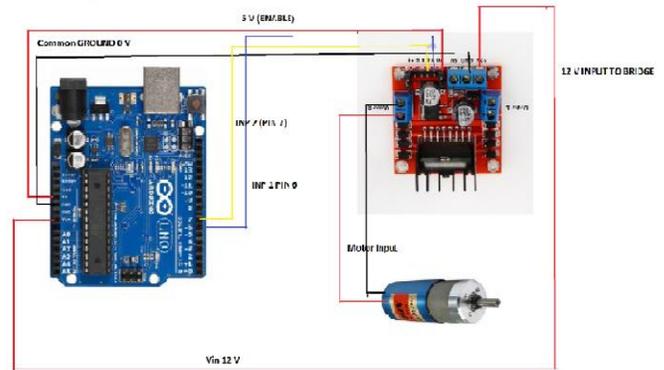


Fig. 2 Connection of Arduino, H-bridge and motor

The above figure 2, shows the connection of Arduino, H-bridge and motor. Motor is used to control the movement of the door. Bridge takes 12V input for enabling the Arduino UNO. The Arduino is then connected to GSM module which controls the sending and receiving of messages. The communication between Arduino and GSM is serial. The connection of the system is as shown in figure 3.

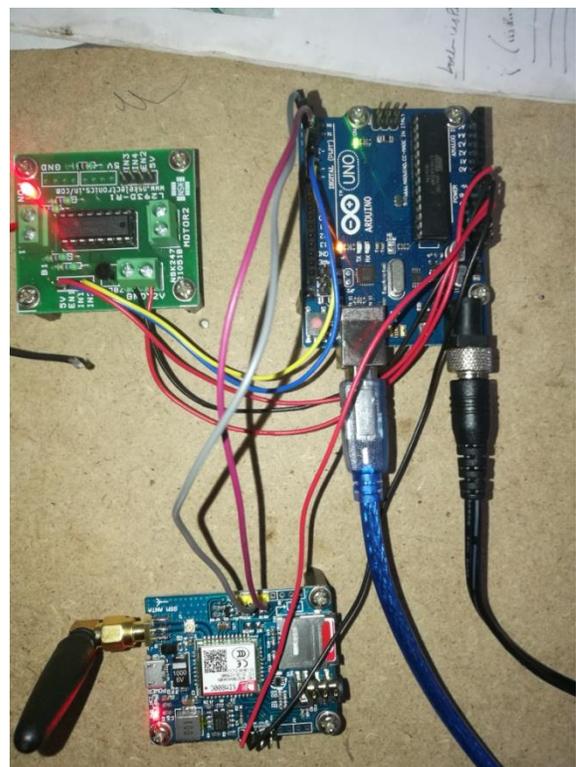


Fig. 3 Connection of the system

The figure 3, shows the connection of Arduino with GSM and H-bridge. A SIM card is being inserted into the GSM module which enables sending of messages to the registered mobile number. This alerts the owner as to when the door is unlocked and locked.

Fig.1 flow chart of face detection and recognition

Figure1 represents the flowchart of how face detection and recognition takes place. The person stands in front of the camera which is fixed near the door of the house considered. After capturing the image of that person, it is compared with the images stored in the database which contains images of people who have access to the house. If the images match, the door is unlocked. In case of failure after comparison, the GSM module sends the alert message to the authority.

Edge Histogram Descriptor algorithm (EHD algorithm) which is used in shape detection and texture extraction has been used in this work. The texture of the face is captured in different angles and illumination conditions. There are five types of edges in EHD algorithm- Horizontal edge, Vertical edge, 45degree edge, 135degree edge and non-directional edge. Here the image is divided into sub-images by a 4x4 matrix. Each sub-image represents one pixel. The edge histograms of 6 bins are extracted based on these sub-images. These sub-images can be considered in our system for facial feature extraction. The proposed work uses IR sensors to detect the presence of the person and switch off/ on lights accordingly. This helps in saving power and promotes smart home system along with security system. Two IR sensors are used, at each end of the door. The light switches on automatically when the person enters the house, detected by the sensor fitted outside. The light is then switched off automatically when the person leaves the house, which is detected by the sensor fitted inside the house at the door. The web cam of the laptop is being used for detecting the face. The picture of the face of the owner is taken, it is then trained to extract all features and stored into the database. When a new person tries to enter, the face is compared with that of the face stored in the database and the door opens by the movement of the motor if the face matches, sending a message to the authorized user. Otherwise, the door remains closed. The entire system is as shown in figure 4.

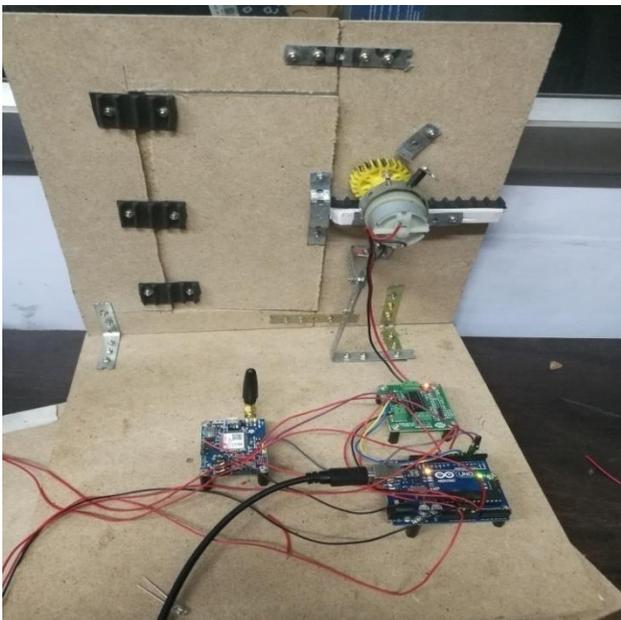


Fig. 4 Door with sensors

4. Results and Discussion

The proposed development method is cheaper, fast, efficient and reliable. Arduino uses less power and make available enough efficiency to go with the requirements needed.

Following are the steps to be considered:

1. If a person attempts to unlock the door, webcam captures the image and sends it to computer. If the image captured is matched with the database, that person can unlock the door and enter inside.
2. If a person is unauthorized to access the door and tries to, the system transmit an alert message to the authorized owner. This message can be like “Alert Unauthorised Identity Trying to Gain Access” which is done using GSM module.

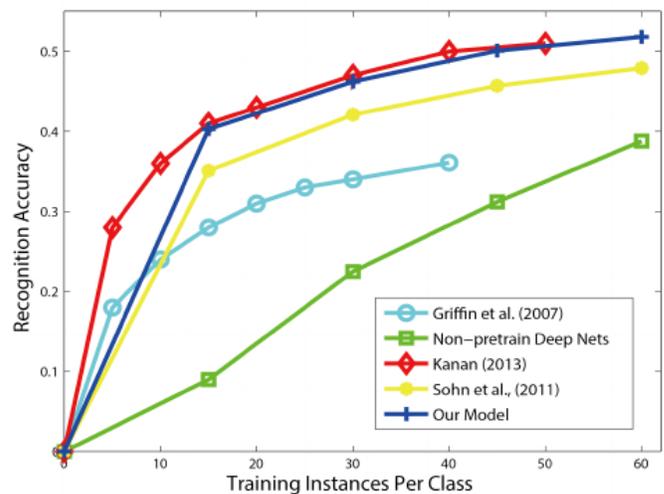


Fig. 5 recognition accuracy v/s Training Instance per Class

The face recognition accuracy v/s Training Instance per Class using MATLAB is represented in Figure 5.

5. Conclusion

The arrangement of a Facial-Recognition-System utilizing Arduino can make the system littler, lighter and work prosperously utilizing lower control use, so it is more convenient than the PC-Predicated Face Recognition system. It is open source software on MATLAB. It sends a security alert message to the sanctioned person. This system does not fail to provide power backup in case of power-failure. This helps in smooth and perpetual functioning. The power-bank is

utilized to charge the Arduino so there is less chance to decelerate the system.

The system can be made user friendly by using a real-time speaking assistant. TLS is a highly secure protocol which can be deployed to ascertain there is no security breach. The accuracy of the system decreases when the number of different faces increases. This can be avoided by training more faces to the system. The above system requires good illumination condition for best performance.

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