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Development of a Secured Door Lock System Based on Face Recognition using Raspberry Pi and GSM Module

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ABSTRACT

Security is an important part of everyday life. The main aim of the system is to develop a secured door lock system. The system consists of three sections. The first section is the face recognition system that is based on Haar-like features detection method and Local Binary Pattern (LBP) recognition algorithm. The second section is the password security system. And the last section is the alert system through GSM module. The system is composed by the combination of face recognition security system, password security system and the alert system through the GSM module. In this system, the iteration used in face recognition system is reduced by using Local Binary Pattern (LBP) algorithm. In saving time, the processing time of this system, therefore, is better than that of the normal system.

KEYWORDS: *Raspberry Pi, GSM module, Webcam, Face Recognition System*

I. INTRODUCTION

Today security and safety is becoming more and more popular day by day and it is getting improved and used for the ease in our life. Now days, technology has become an integrated part of people's lives therefore the security of one's home must also not be left behind [1]. This paper describes the prototype of a secured door unlocking system. Face Recognition has been one of the hot fields in computer vision and biometrics, since it is a challengeable work to identify a face image with varying expression, occlusion, disguise, and illumination. Along with fingerprint match and eye retina match, they become a prominent method in biometrics technology [2].

The system consists of face detection, face recognition, a password custom, a GSM module and a door lock. Face detection is the process of detecting the region of face in an image. The face is detected using Haar-like feature and face recognition is implemented using Local binary pattern histogram(LBPH). The system comprises a webcam to detect the faces and a solenoid door lock for unlocking the door. Every users detected by the webcam will be checked for compatibility with the database in the system. If the face is recognized, the password box will appear. The user will enter the password. If the password is correct, the door will open automatically. On the other hand, GSM module will send the notification to the owner for the unknown person. The main control circuit on this system is Raspberry Pi. The software used is OpenCV Library and Python.

II. System Architecture

Figure 1 shows the block diagram of "a Secured Door Lock System based on Face Recognition using Raspberry Pi and GSM Module". In this system, we are using Raspberry Pi for connecting with camera to capture images continuously through OpenCV platform and compared with stored images in the database and send data to Door Lock and GSM module.

The working of the each component is specified as follows,

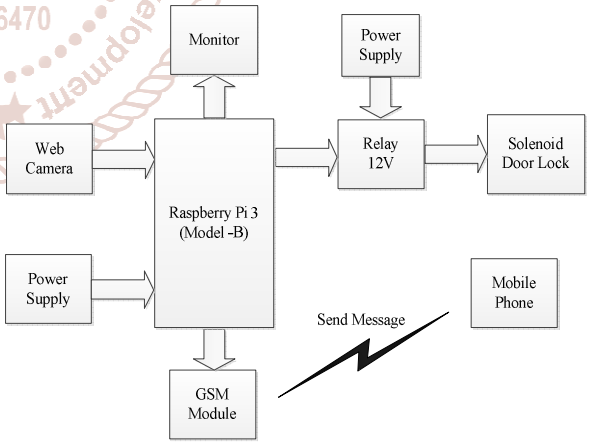

Fig. 1: General Block Diagram of a Secured Door Lock System based on Face Recognition using Raspberry Pi and GSM Module

A. Web Camera

According to user convince, user can use Web camera or Pi camera. In this system, we use a Web Camera having 16 MP interpolated resolution also plug and play USB interface which can be configured with Raspberry Pi which is already connected with door. The webcam is already accessory for Raspberry Pi. It is used for capturing an image and send the captured image to the Raspberry Pi. Figure 2 shows the web camera.

Fig. 2: Web Camera

B. Raspberry Pi

Raspberry Pi is a small board computer having the ability to act like a controller. When image is taken by camera module and send to the raspberry Pi. The raspberry pi compares it with stored face images. At the first time, we capture the ten type of images to create a database in the system and this database is compared with the live captured images. After comparing the two images, output is considered to be positive or negative as this controller is digital and based on the output response it gives commands to GSM module[3]. Fig. 3 shows the Raspberry Pi.

Fig. 3: Raspberry Pi

C. GSM module

GSM module is used to send a message to the authorities after comparing the captured images with the stored images and based on whether output is positive or negative. If the output is positive, the GSM module will not work in this system. If the unknown person is trying to open the door, the GSM module send to the authority person otherwise send "Unknown person is trying to unlock the door, take action"[3]. Figure 4 shows the GSM module.

Fig. 4: GSM module

D. Relay

A relay is an electrically operated device. It has a control system and (also called input circuit or input contactor) and controlled system. It is frequently used in automatic control circuit. To put it simply, it is an automatic switch to controlling a high- current circuit with a low-current signal. Our system will use one- channel relay module. Fig. 5 shows the Relay.

Figure 5: Relay

E. Solenoid Door Lock

Solenoid Door locks are locks that are generally mounted directly on or in doors / gates. Fig. 6 shows the solenoid Door Lock.

Fig. 6: Solenoid Door Lock

F. Software

The system is largely based on Python programming from detecting the face to recognizing the face. Python is used to capture and process images. The capture image is then processed using Open CV library that integrates with Python. The face recognition part is carried out by the Local Binary Pattern algorithm.OpenCV (Open Computer Vision) is a library mainly aimed at real-time computer vision. It is written in C++. There are bindings in Python, Java and MATLAB/OCTAVA. Here, the openCV is used for processing the given image and for comparing the image.

III. System Flowchart

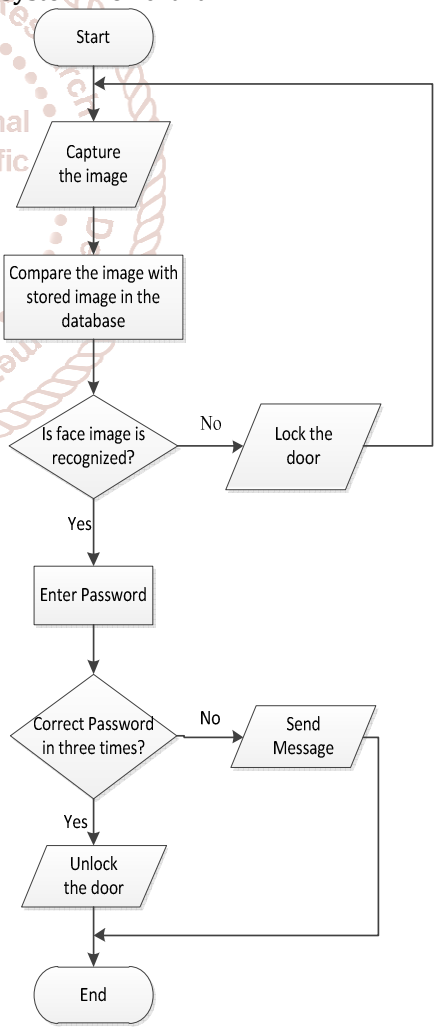

Fig. 7: Flowchart of the overall proposed system

Fig. 7 shows the flowchart of "a Secured Door Lock System based on Face Recognition using Raspberry Pi and GSM

module". Firstly, the session starts, it will work as follows - the Web camera will first take the image and send it to the raspberry pi. Then, It will compare the captured image with the stored image with the database. The Local Binary Pattern Histogram Algorithm comes in the action by comparing the captured image with the stored image and based on this it produce the results. If the result is positive, the password box will appear. The user can enter the password. If the password is correct , the door will be unlock automatically. Otherwise, the password is wrong in three times, then with the help of GSM module, an SMS will be automatically generated to the authorized user that "Unknown person is trying to unlock the door, take action" and the door will remain lock itself. The captured image is not matched with the stored image in the database, the door will remain closed. And the system gets reset. In this way, the security can be achieved over the Raspberry Pi and GSM module.

IV. Methodology

A. Face Detection

Face detection is one of the fundamental applications used in face recognition technology. OpenCV provides a Haar cascade classifier, which can be used for face detection. In this system, Haar cascade classifiers is chosen in the face detection process. The reason for using Haar classifier is because of its speed , high detection accuracy and low false positive rate. Haar classifier is an algorithm created by Paul Viola and Michael Jones; which are trained from lots of positive pictures (with faces) and negative pictures (without faces).[4] The image of the value of simple features is classified by Viola Jones. Each feature is a single value obtained by subtracting sum of pixels under the white rectangle from sum of pixels under the black rectangle.

The single value for Haar features are computed using the following equation:

$$\Delta = dark - white = \frac{1}{n}\sum_{dark} I(x) - \frac{1}{n}\sum_{white} I(x) \quad (1)$$

Where, n is the number of pixels, I(x) is the real value of detected on an image.Figure2 shows the three types of features.

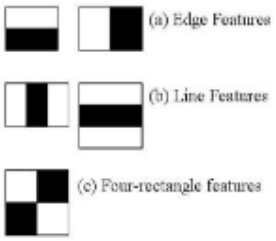

Fig. 8: (a) Edge features (b) Line Features (c) Four-rectangular features

B. Face Recognition

The detected faces check the data base and then compare LPBH values and then match the present data base and face are recognized.

In this system, we are using Local Binary Pattern Histogram (LBPH) for face recognition. Open CV is an open source computer vision library that has three built-in face recognition algorithms,(i) Eigenfaces, (ii) Fisherfaces and (iii) Local Binary Pattern Histogram (LBPH). Compared with the two algorithms , the LBPH can not only recognize the front face, but also recognize the side face, which is more flexible[5]. Therefore, the face recognition algorithms used here is Local Binary Pattern Histogram(LBPH). It is a simple yet very efficient texture operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number. And then it converts the binary number into a decimal number , and that decimal number is the new value of the center pixel.

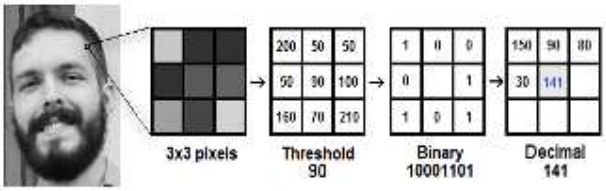

Fig.9. Conversion of grayscale image to decimal

In our case, we are using VNC viewer to run raspbian os for detecting images from the database. At first, we have to save images by using data sets and after that, we will train that faces to LBPH algorithm then it stores into the database. At first, it converts color images to gray scale images and then it coverts into pixels for detecting this will divide the image into various pieces then it stores the values of each pixel. If pixels are less than it will be represented as 0 and pixels which are high will be 1 then it will be arranged in 3 × 3 matrix format for recognizing the images on screen compared to database stored images[6]. Some different variations of faces that captures are showed in the following figure.

Fig.10: Some different variations of faces

V. Results And Discussions

In this system, we designed a Secured Door Lock System with the help of Face Recognition. In this, we are using Raspberry pi which has many features that make the user modify use in different smart applications.

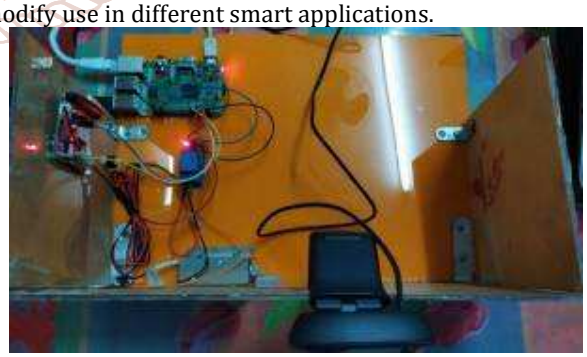

Fig. 11: A prototype of a Secured Door Lock System

Fig. 12: Monitor runs with Raspbian OS

The experiment was performed to implement the face recognition using OpenCV library installed in Raspberry Pi. We used Python in Pyton IDLE 3.6.5 and the database that used was sqlite studio.

The face detection procedure was first implemented which was done by the help of face detection algorithm that we used. Firstly, we used the web camera to capture the images. We registered five users as authorized user and their images are stored in the database. For these users, we took 10 facial images with different poses and expressions.

Fig. 13: Face Capturing and Saving into the database

And also in the Fig. 14, we can see the facial images in the database.

Fig. 14: Some facial images in the database

In the experiment we trained the face images in the database. That the facial images are successfully trained shown in the Fig. 15

Fig. 15: Face Training Process

Based on the LBPH algorithm , the input face images are compared with database facial images for identification. The face recognition results are shown in below in Fig. 16.

Fig. 16: Face Recognition Process

If the face is recognized, the password box will appear. The user will enter the password. If the password is correct, the door will open automatically. On the other hand, The password is wrong in three times, GSM module will send the notification to the owner for the unknown person.

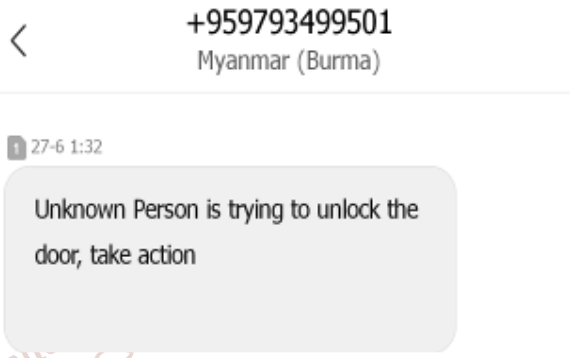

Fig. 17: The notification to the owner for the unknown person

VI. Conclusion

In this paper, a Secured Door Lock System Based on Face Recognition using Raspberry Pi and GSM module is presented. We designed the system which provides security locks for door, comfort, connivance security and energy efficiency for user. This system can be used for authentication in home, banks and other public places. In this system, we have been implemented with a combination of webcam, Raspberry Pi, relay, solenoid door lock and GSM module. And we used the Haar Cascade classifier method to detect the face and Local Binary Pattern Histogram (LBPH) for recognize the face. I conclude that various operations are successfully tested and results are documented.

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