International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 11 | Nov 2021 www.irjet.net p-ISSN: 2395-0072

DESIGN AND IMPLEMENTATION OF A FACE RECOGNITION BASED DOOR ACCESS SECURITY SYSTEM USING RASPBERRY PI

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Abstract - *In a smart security system, automatic face recognition is the most challenging task from the past decade in computer vision. The applications of computer vision and face recognition have increased day by day with new dimensions and new positive impacts in our society. However some of the systems can't identify and recognize any person through the blur conditions, illumination and lightings are the major problems. The authors have proposed a system in this paper that can operate different lightings and identify faces from various angles. It stored various datasets of known persons to identify the compatibility of the system in different conditions.*

Key Words: *Face recognition, Computer vision, Security system, LBPH, Raspberry pi.*

1. INTRODUCTION

A ubiquitous property of human perception is our ability to tell apart between different faces even once they look similar and recognize many different Individuals with almost no effort. Automated face recognition is a vicinity within Computer Vision inspired by this ability. Biometric identification systems specialize in extracting faces from static images and video sequences and deciding whether or not they belong to a database of known individuals [1].

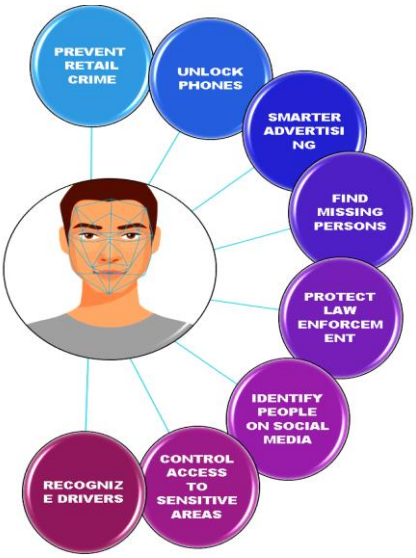

Fig - 1: Various applications of face recognition.

The face recognition system is that the hottest process of identification of a known person by his various image data. During this system, the pc will compare the person standing before the camera with its storage image files. If the face matched with the database files, then it'll recognize the person by its ID or name. If it doesn't then match, then the person is going to be unrecognized. For creating the face detection and recognition program most people prefer to use Python because of its libraries and applications in deep learning and machine learning fields.

Automated face recognition is a motivating computer vision problem with many commercial and enforcement applications. Mugshot matching, user verification, and user access control, crowd surveillance, enhanced human-computer interaction all become possible if a good ace recognition system may be implemented. While research into this area dates back to the 1960s, it's only very recently that acceptable results are obtained [2]. However, face recognition continues to be a district of active research since a totally successful approach or model has not been proposed to resolve the face recognition problem [3].

In this paper, the face recognition system has been used to control the access of general people in restricted areas. The paper has divided into three parts, the author has described the methods of the system at the beginning, in the system setup it discusses circuit diagrams and at the result and discussion part, it analyzes its results.

2. METHODOLOGY

In general, people used to lock their doors to be safe from thieves or other people. There are various home and other security access control systems such as keys, Barcode ID, or another system any unauthorized person can enter there. But within the face recognition system, the face data are stored on Linux operating system based Raspberry pi and it'll compare real-time with the persons are coming before the webcam. Raspberry Pi3 has been used because it's a credit-card sized computer that may work faster than other huge size computers as a result the project will take a tiny low area but work effectively. Another cause for using Raspberry Pi3, its GPIO pins and that we have used some pins to regulate the Door strikes.

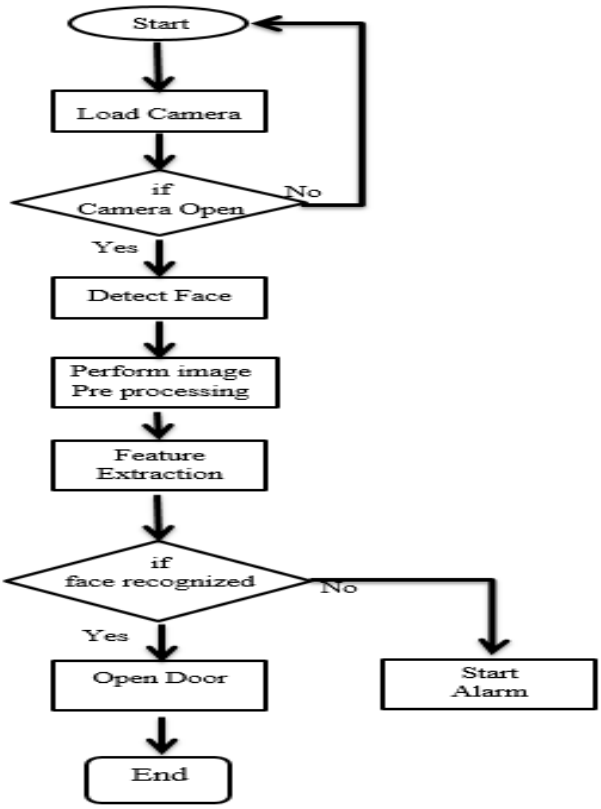

Fig - 2: Flow chart of the face recognition system.

2.1.Face Detection

We have used Open CV which presents Haar Cascade Classifier [3] and it is used for face detection. The system uses the AdaBoost Algorithm to detect multiple facial features. First, it read the Image to be detected and convert the image into a Grayscale image then load the Haar Cascade Classifier to decide whether it contains the human face.

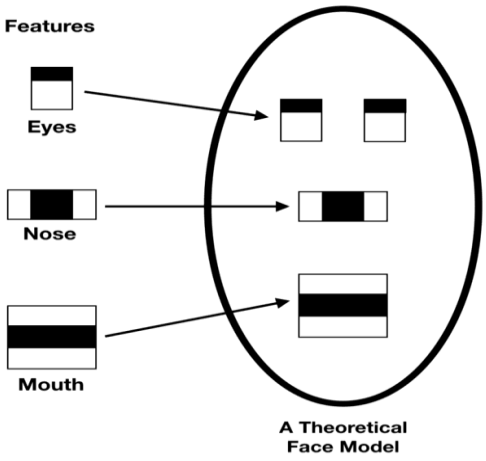

Fig - 3: Rectangular frames to detect face.

If it is, then it proceeds to examine the face features draw a rectangular frame on the detected face otherwise test the next picture.

2.2.Feature Extraction

The original LBP operator is defined in the window of 3*3. Using the median pixel value as the threshold of the window, it compares with the grey value of the adjacent 8 pixels. If the neighbourhood pixel value is larger or equal compared to the median pixel value, the value of pixel position is marked as 1, otherwise marked as (0) [8]. It can be illustrated in Figure below in figure 4.

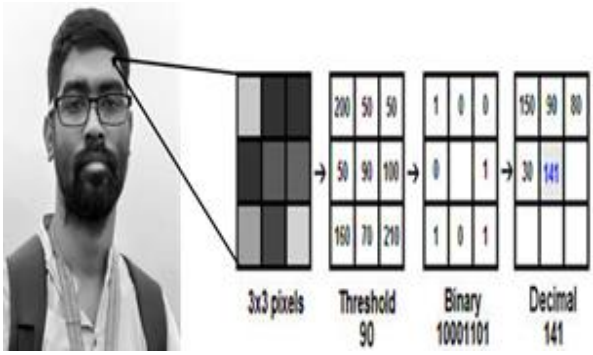

Fig - 4: LBP Operator.

Here, 8 points in the 3x3 neighbourhood are compared to generate 8-bit binary numbers in Figure 3. We got the middle pixel point of the window by changing the 8-bit binary number into the decimal and it was used to display the texture feature of the region. Later it was noted that a fixed neighbourhood fails to encode details varying in scale. The algorithm was improved to use the different numbers of radius and neighbors, now it was known as circular LBP.

$$LBP(x_c, y_c) = \sum_{p=0}^{p-1} s(i_p - i_c)2^p \qquad (1)$$

The grey value i_p of p neighbourhoods of pixel C, the radius of which is R and i_c is the grey value of the pixel C. The algorithm makes the LBP operator no longer limited to fixed radius and neighbourhood and can meet the needs of more different sizes and texture features. For each pixel of an image, it computes its LBP eigenvalues. Then these eigenvalues can form the LBP feature spectrum and the LBPH algorithm uses the histogram of the LBP characteristic spectrum as the feature vector for classification. It divides a picture into several sub-regions, then extracts the LBP feature from each pixel of the sub-region, establishing a statistical histogram of the LBP characteristic spectrum in each sub-region, so that each sub-region can use a statistical histogram to describe the whole picture through several statistical histogram components. The advantage is to reduce the error that the image is not fully aligned with a certain range.

2.3.Dataset Creation

We have designed our database with 500 images for a single ID and the ID's represent a person who would be recognized.

It was created based on face detection and made various facial expirations and postures to a detected face. At the image accusation period, the captured images are converted into grayscale images and stored in a folder named "Dataset" while the grayscale images are required for features extraction normalized that images for proper recognition. The normalization process is applied to remove noise and to set an alignment in all images of the Dataset.

2.4.Recognition by Raspberry pi

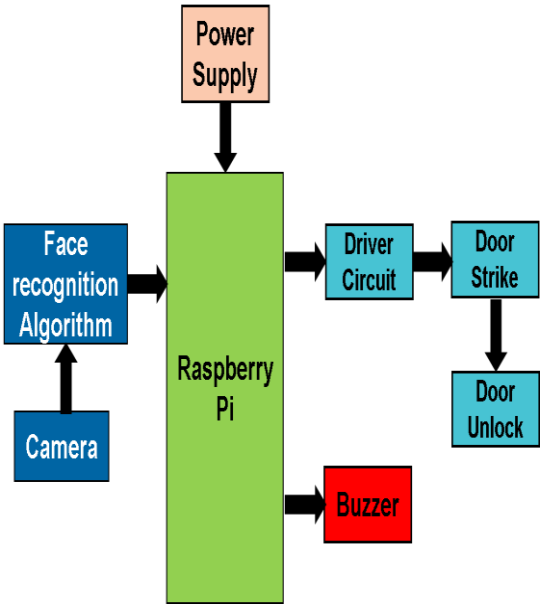

Fig - 5: Block diagram of the proposed system.

In our system, raspberry pi is the processing unit where Open CV- Python are run in its GPIO pins and control the system. The camera is connected with the Raspberry pi and it acquires face data in the system. While the face is recognized it means the face is matched with the "Dataset" images then it switches solenoid door lock by NPN transistor and Relay. If the face doesn't matches with the dataset then the GPIO switches the Buzzer and it alarms the system.

3. SYSTEM SETUP

3.1.LBPH Algorithm

To perform the face recognition system here the Local Binary Pattern Algorithm has been applied. The LBP operator is used in local features through Local Binary Pattern acts which shorten the local special arrangement of a face image [10]. The LBP operator is the number of binary ratios of pixels intensities within the pixel of center and it's around eight pixels. It can be shown equation 1.

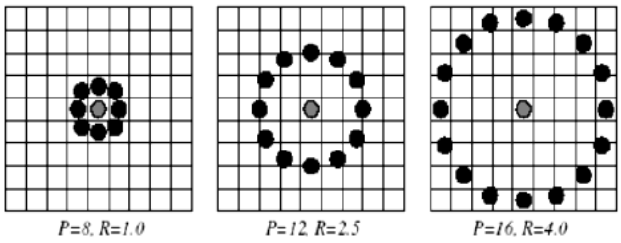

Fig - 6: Circular LBP operator.

The algorithm works as the process below, at the beginning of the process the temp should be 0 and I is the number of training for each images at that time H=0, it initialize the pattern histogram. Next step is to calculate the model levels of LBP and keep the corresponding adding by bin1. After that get the greatest LBP feature during each face image and merge with the unique vector. Then it's time to compare the feature with the stored face images in 'Dataset'.

In order to receive the feature vectors, the pattern for each pixel is obtained and for representing all faces efficiently, the image has to be subdivided into K2 regions [11]. A histogram with each potential label is composed. Each bin in a histogram gives the information about a pattern. While the feature vectors can be obtained from the histograms. So we can say that each regional histogram hold of P (P − 1) + 3 bins: P (P −1).

For the image (N x M), the feature vector is designed with the help of calculating the LBP code for all pixels (X_c, Y_c) with $X_C \in \{R + 1,\dots ,N - R\}$ and $Y_C \in \{R + 1,\dots, M - R\}$. If an image is divided into k × k regions, then the histogram for region (kx, ky), with $kx \in \{1 ,\dots, k\}$ and $ky \in \{1, \dots, k\}$,

$$H_i(k_x, k_y) = \sum x, y\, I\{LBP_{PR(x,y)} = L(i)\},$$
$$i = 1, \dots .p(p-1) + 3 \qquad (2)$$

$$x \in \begin{cases} \left\{R+1, \dots \dots \dots . \frac{N}{K}\right\} Kx = 1 \\ \left\{(Kx-1)\left(\frac{N}{K}\right)\right\}+1, \dots \dots N-R & Kx = k \\ \left\{(Kx-1)\left(\frac{N}{K}\right)\right\}+1, \dots \dots kx\left(\frac{N}{K}\right) & \text{else} \end{cases} \qquad (3)$$

$$y \in \begin{cases} \left\{R+1, \dots \dots \dots . \frac{M}{K}\right\} Ky = 1 \\ \left\{(Ky-1)\left(\frac{M}{K}\right)\right\}+1, \dots \dots M-R & Ky = k \\ \left\{(Ky-1)\left(\frac{M}{K}\right)\right\}+1, \dots \dots ky\left(\frac{M}{K}\right) & \text{else} \end{cases} \qquad (4)$$

Now,

$$I(A) = \begin{cases} 1, A \text{ is True} \\ 0, A \text{ is False} \end{cases} \qquad (5)$$

In equation (5), L is the label of binary I, if the condition is true then it became 1 and if not true it means not matched with features then I (A) is 0. Then it goes to the next step.

3.2. Circuit Setup

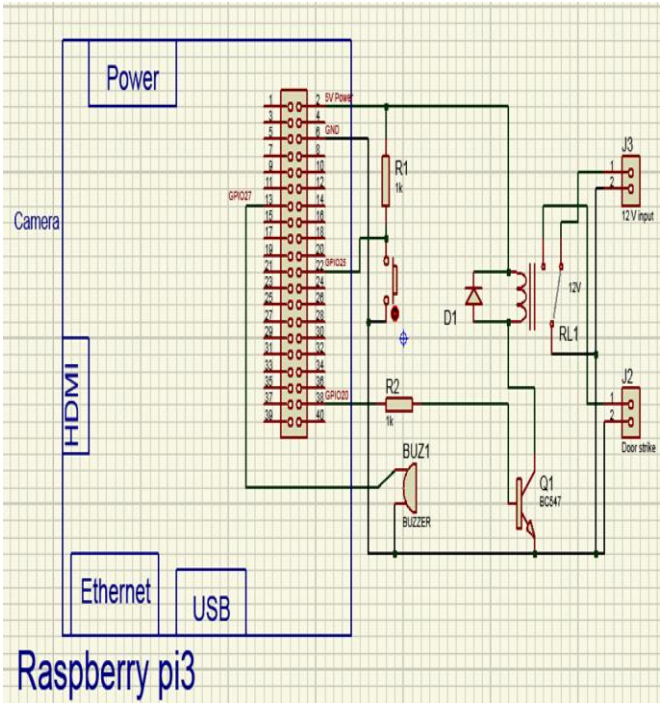

Fig - 7: Circuit Diagram of the system.

In the circuit, the raspberry pi is connected with its power adapter and the camera module is connected with it. However, we have used GPIO 2 for 5V supply and GPIO 6 for GND. From GPIO 22 it is connected with a push Button which works for the switch of the recognizer. If we press the pushbutton it will start a loop in GPIO38 and GPIO27. GPIO 38 is connected with the base of the NPN transistor and on it's a relay is connected with its collector side, Emitter is joined to the GND. So when we push the button it starts the camera and it begin recognizing process with the dataset, if it matched with it then it makes GPIO 38=1 & GPIO 27=0, so the solenoid door lock starts via NPN transistor and relay. Over there, an additional 12V power supply is required, so we have used 12v input power with it. Then, the faces do not match with dataset then, GPIO 38=0 & GPIO 27=1, so the Buzzer will buzz and alarm.

4. RESULTS & DISCUSSION

In this experiment, there were individual ID numbers for everyone's faces at face data accusation. The first step was to get face database and then extract the faces with the LBP algorithm and finally get the recognized faced information and observe how it open the door or buzz for unknown faces. For testing, authors collected various face data to see how the system respond to different factors and it used raspberry pi camera module v1 (1080 Px) for data accusation. The face database of ten random people with 31 images for each person was created and stored in the Dataset folder with individual face ID, and the faces were captured and converted into greyscale images of 25x25. Here, only the frontal face is marked in the Haar Cascade Face detection process, so our system saved only the rectangle part from the faces and saved the image with id by converting that image into RGB to Grayscale image.

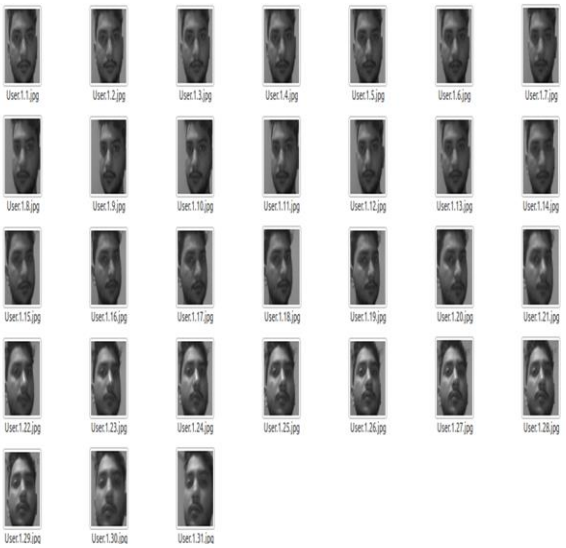

Figure 1: Dataset of known user.

Through the datasets and training algorithm will be able to identify the known face and give permission to enter the room. There is an image below which shows the system has identified the person and given permission to enter the room.

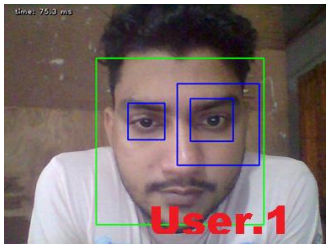

Figure 2: Image of a recognized person.

5. CONCLUSIONS

The arrangement of a facial recognition system using raspberry pi had used the Linux operating system that can make the system littler, lighter and work successfully utilizing lower control use, so it is more convenient than the PC-Windows based face recognition system. Also, it triggers the security alarm for unauthorized persons whose faces data doesn't match with the stored data inside its database. The main concern was to create a face recognition based door access controlling system that would be able to identify knowing persons with their ID, then it will give access to known persons and alarm for the unknown ones.

ACKNOWLEDGEMENT

The authors are grateful to all those people who have supported them throughout this work. A special mention must go to Fahmida Sharmin Jui, Assistant Professor of Southern University Bangladesh who supported the authors with her knowledge, experience and suggestion to write the report. Only her inspiration has made this report easy and interesting. The authors are also indebted to Mr Jewel Dey for his support at in various stages during the information and cooperation to take his picture for this piece of work.

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