Face Recognition for Biometric Door Unlocking System

Mrs. S. P. Balwir
Assistant Professor
Department of Electronics Engineering
Dr. Babasaheb Ambedkar College of Engineering and Research, India

Ms. Kajal Chaudhari
UG Student
Department of Electronics Engineering
Dr. Babasaheb Ambedkar College of Engineering and Research, India

Ms. Kanchan Akre
UG Student
Department of Electronics Engineering
Dr. Babasaheb Ambedkar College of Engineering and Research, India

Mr. Abhijeet Golliwar
UG Student
Department of Electronics Engineering
Dr. Babasaheb Ambedkar College of Engineering and Research, India

Mr. Anurag Lokhande
UG Student
Department of Electronics Engineering
Dr. Babasaheb Ambedkar College of Engineering and Research, India

Abstract

This paper describes the design and implementation of secure locking using raspberry pi 3 model B for door unlocking to provide essential security to our homes. The work starts with the introduction of face detection followed by detail study of Viola Jones Algorithm. For object detection we used Haar feature based cascade classifier which is an effective face detection method. For face recognition we used the technique of Eigen faces which was proposed by Sirovich and Kirby for efficiently representing pictures of faces using principal component analysis. Raspberry pi is used for signaling servo motor which controls door locking and unlocking.

Keywords: Haar Feature, Raspberry Pi, Eigen Values, Cascade Classifier, Open CV

I. INTRODUCTION

Face recognition is a part of digital image processing. It can avoid problem such as noise & signal distortion. With increasing terrorist activities and augmenting demand for video surveillance, it was the ideal need to come up with an efficient and fast detection and tracking algorithm. Many real time face tracking systems have been developed in the past.A Face Recognition System is a system which automatically identifies and/or verifies the identity of a person from digital images or a video frame from a video source. We use OPEN CV library that can be formulated as given images of a scene identify or verify one or more persons in the scene using a stored database of faces.

The basic flow of the face recognition system starts with capturing of image by pi camera. The feature based system classifies the face based on simple feature. System matches the captured images with data base images. In the decision box the result of the matching is taken whether the face matches or not. It can serve as a vital measurement tool for behavioral science.

II. RELATED WORK

Our project system can be operated in two different sections, first one for capturing and creating a data base and the other section is to capture the image which will be used for identifying or comparing the images in the database. Here in the second section we use Eigen faces methodology of face recognition for finding the matches. Camera module is Pi camera interfacing to the raspberry pi module. It is used for capturing an image and send captured image to the Raspberry pi module.

The basic block diagram of the Raspberry pi based face recognition system for door unlocking is shown in fig 1.When image taken by the raspberry pi it is compared with Eigen face image. At first when we capture the image to create a data base raspberry pi module capture six types of the images to create a data base in the system and this data base is compared with the live captured image. After comparing two images output is positive/negative.

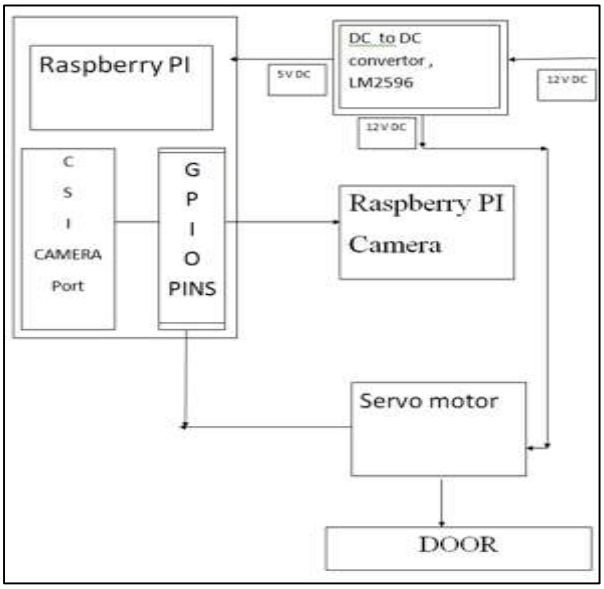

Fig. 1: Block diagram of Raspberry pi based face recognition system for door unlocking

III. FACE DETECTION AND RECOGNITION PROCESS

Images are generally classified based on the value of simple features. It is advantageous to use features rather than using pixels as feature based systems operates much faster than pixel based systems. Ad-hoc domain knowledge which is very difficult to learn using a finite quantity of training data can be encoded using features. Generally, we use three types of features for face detection procedure, namely two-rectangle features, three rectangle feature and four-rectangle feature. Two-rectangle feature is the difference between the sums of the pixels within two rectangular regions. The regions are of same size and shape and are horizontally or vertically adjacent, as shown in figure 2(C, D). A three-rectangle feature calculates the sum within two outside rectangles subtracted from the sum in a center rectangle, as shown in figure 2(B). Finally a four-rectangle feature computes the difference between diagonal pairs of rectangle, as shown in figure 2(A).

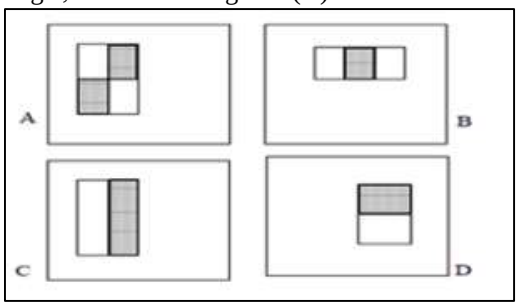

Fig. 2: (a) shows four-rectangle feature, (b) shows three rectangle feature, while (c) and (d) shows two-rectangle features.

For face recognition the technique of using Eigen faces was developed by Sirovich and Kirby for efficiently representing pictures of faces using principal component analysis.

The following step summarize the recognition process:

- Initialisation: The training set of face images were acquired and value of eigenface was calculated which defines the face space.
- When a new face image is encountered ,calculate a set of weights based on input image and the X
- Eigen faces by projecting the input image onto each of the Eigen faces
- Determine if the image is a face at all by checking to see if the image is sufficiently close to 'face space'.
- If it is a face, classify the weight pattern as either a known person or as unknown.

IV. INTEGRAL IMAGE

A summed area table is a data structure and algorithm for quickly and efficiently generating the sum of values in a rectangular subset of a grid, in the image processing domain it iss also known as an integral image. Rectangle features can be computed very rapidly using an intermediate representation for the image. The formula for calculation of integral image is as follows. The integral image at location p, q contains the sum of the pixels above and to the left of p,q.

$$mm(p,q)= \sum_{p'\le p} \sum_{q'\le q} m(p',q')$$

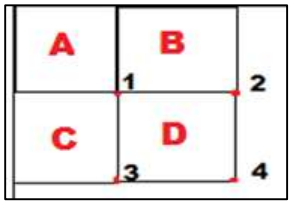

Fig. 3: Integral image

Fig 3 Integral image at location 1 is the sum of pixels in region A; at location 2 sum of pixels in region A+B, at location 3 C+A and at location 4 A+B+C+D Where mm(p,q) is an integral image and j(p',q') is the original image. Using the following formula,

$$k(p,q) = k(p,q-1) + m(p,q) \quad \text{(2)}$$

$$mm(p,q) = mm(p-1,q)+ k(p,q) \quad \text{(3)}$$

Where k(p,q) is the cumulative row sum k(p,-1) = 0 and mm(1,q)=0) the integral image can be computed from one pass over the image.

V. HAAR CASCADE

Object Detection using Haar feature-based cascade classifiers is an effective object detection method proposed by Paul Viola and Michael Jones in their paper, "Rapid Object Detection using a Boosted Cascade of Simple Features" It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images. Here we will work with face detection. Initially, the algorithm needs a lot of positive images (images of faces) and negative images (images without faces) to train the classifier. Then we need to extract features from it. Each feature is a single value obtained by subtracting sum of pixels under white rectangle from sum of pixels under black rectangle. the first feature gives the difference in pixel values of the upper region of face that is in between the region of the eyes and upper cheeks, it shows the darker eye region than the cheeks. The second feature gives the comparison between concentration in eye region & nose region. Finally the difference between diagonal pairs of rectangles is given by four-rectangle feature.

Fig. 4: Haar Features

VI. TRAINING

A. Preparation of the training data

For training a boosted cascade of weak classifiers we need a set of positive samples (containing actual objects you want to detect) and a set of negative images (containing everything you do not want to detect). The set of negative samples must be prepared manually, whereas set of positive samples is created using the capture-positives.py application.

B. Negative Samples

Negative samples are taken from arbitrary images, not containing objects you want to detect. These negative images, from which the samples are generated, should be listed in a special negative image file containing one image path per line.

C. Positive Samples

Positive samples are created by the capture_positives.py application. They are used by the boosting process to define what the model should actually look for when trying to find your objects. The application supports two ways of generating a positive sample dataset. You can generate a bunch of positives from a single positive object image. You can supply all the positives yourself and only use the tool to cut them out, resize them and put them in the open cv folder.

VII. RESULT

The algorithms are applied on captured image after the process of face detection and recognition, if output is positive then "Hi I Found (name of person in database)" message is displayed otherwise "WARNING-user is unknown." Message is displayed. After execution of the program another loop is added in the program where the servo motor unlocks the door after recognizing the face.

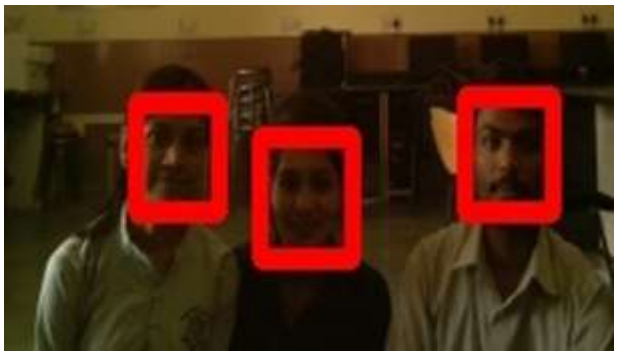

Fig. 4: Positive Image

Fig. 5: Negative Image

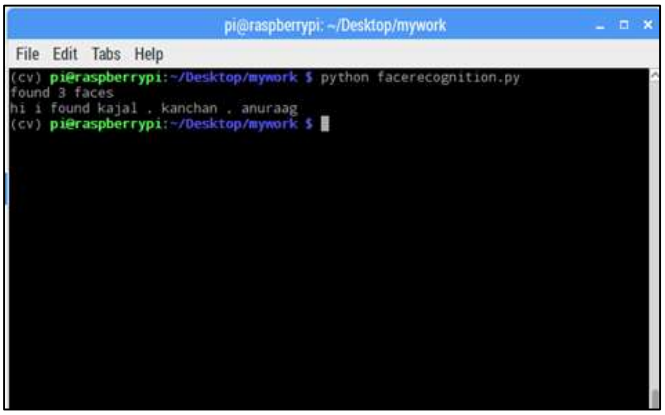

Fig. 6: Result for Positive Image

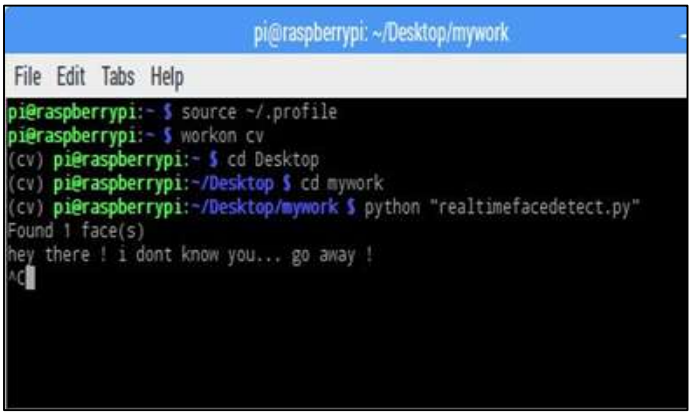

Fig. 7: Result for Negative Image

The design of face recognition system using Raspberry pi is smaller, lighter and with lower power consumption, so it is more convenient than the PC-based face recognition system. Because of the open source code, it is free to do software development. We use Principle component analysis algorithm for the face recognition and detection process.

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