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SMART DOOR UNLOCKING SYSTEM

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Abstract - *Nowadays, home automation is trending as it makes life easier than the conventional systems. In the present world situation people use the traditional lock and key system to secure their houses. As a result of enhanced civilization and modernization, the humans' demands more comfort to their lives. Thus, automatic doors are one of the examples that bring comfort and ease in their daily life. This paper presents a low cost, Internet of Things (IoT) based Smart Door Unlocking System using Raspberry pi where Haar Cascade algorithm is used to detect faces. It is an innovative access control system.*

Key Words: **Raspberry pi, Picam, Facerecognition, IoT, OpenCV, Haar Cascade Algorithm.**

1. INTRODUCTION

Home Automation is a technological solution that enables automating household appliances. It uses a combination of hardware and software technologies that enable control and management over appliances and devices within a home. It minimizes the human efforts and it can be deployed in a lot of fields like military, surveillance application, etc. Nowadays Home Automation starts with Wi-fi or Bluetooth Communication. Smart door locking system is one such home automation device.

Our project proposes a system for capturing images from the Pi Camera in real time environment and process them as we are required using RaspberryPi. It portrays a machine learning approach for face recognition and detection to accomplish this process very quickly with high identification rates using Haar Cascade algorithm in OpenCV library. Face recognition is a method of identifying or verifying the identity of an individual using their face. The framework is modified utilizing Python programming language.The proposed framework distinguishes the faces present in a grey scale and coloured image. Effectiveness of the framework is examined by ascertaining the Face recognition rate for everyone of the database. The results of the proposed system can be used for face detection with high accuracy even from low quality pictures.

2. LITERATURE SURVEY

[1] This paper talks about building a door locking system that can recognize the face of the owner of the house and family members who will have access to pass through the door in the house. It can be done by using face recognition algorithms which are gaining much importance in this era of Artificial Intelligence. The advantage of using face recognition over other identification features like RFID or Passcode is because it is less intrusive. There are plenty of methods for face detection and recognition, in this paper face detection is done based on haar features and face recognition is done based on local binary pattern histogram using OpenCV library. This paper also provides a detailed explanation about kNN image classifier, its working and computational abilities which is used to classify images consistent with their location.

[2]. This paper describes a design of a door locking system to operate the door with a different control. It uses Bluetooth technology, which is easily available on almost every gadget and consumes less power. The design of the proposed system also includes a special feature to increase the security and to make it simpler for use.

[3]. This paper proposes an idea to provide high level security to home by using IoT technology. A standard UBS camera captures the image to spot the person. It's a prototype that identifies the visitor. If the door recognizes the visitor, it will greet them by name, and therefore the door is going to be unlocked. If they are not identified the door will remain firmly locked. This paper talks about four features: security, safety, control and monitoring to home automation. When an unauthenticated user tries to log in, the face will be captured and would be sent as an email.

[4] In this research, it provides a foundation of software and Algorithms that can be used for Image processing and Facial Recognition. software library. The library has a lot of optimized algorithms, which may be utilized in many IOT related sectors including face detection and recognition. Image processing is a mathematically intensive operation that converts the image into desired looking output. Haar Cascade Classifier Algorithm is used to detect the thing that it's been trained for, from the source. The Haar Cascade classifier, detects a single face and crops the face out of the scene. The Eigenface classifier then will try to recognize the cropped face and return the confidence of its prediction at the same time. This paper gives enhanced information about face Recognition and the most used Algorithms for the process. Also, there is high accuracy in recognizing house owner faces and it could realize sending the matched face image to a different Raspberry Pi in time and provides a good output.

[5] has proposed a GSM based door lock security system using PIC platform. By using a gear motor, a 5-digit password has been used to lock or unlock the door. If the user enters the wrong password for 3 consecutive times a warning is sent to the owner.

[6] This paper describes the objectives to design the face detection system. The objectives include: 1. To design a real time face detection system. 2. To utilize the face detection system based on Haar classifier. 3. To develop face detection system using open CV. 4. Users could operate screen to pick entering the house by recognizing face or entering password. For face recognition, a picture is going to be captured by camera and pre-processed and converting, resizing and cropping, then face detection and recognition are performed. This development scheme is cheap, fast, and highly reliable and Raspberry pi takes less power and provides enough flexibility to suit the need of various people.

[7] The proposed system in this paper is a wireless monitoring and control system using ZigBee network protocol and based on digital door lock. The project was developed as four modules- ZigBee module, digital door lock module, human detection module, and ZigBee relay module. The ZigBee module supports wireless sensor networks and ZigBee tag identifies the access objects. This model can be used as an access monitoring and control system, in real market for home networking system, and also as a connection between mobile phone and home networking system.

[8]This paper discusses a GSM based digital door lock security system where the design has built-in NFC capabilities that would become the key to open the door through logical link control protocol which matches the user's password to unlock the door. To identify the users a system that uses logical link control has been proposed that is based on NFC in a smartphone.

3. PROPOSED APPROACH

The technologies used in this project primarily are Face recognition and Internet of Things (IoT). Face recognition is used to identify the faces of the person near the camera and IoT is used to operate the lock. IoT is used to integrate and manage the working.

3.1 Face Recognition

Software Requirements

OpenCV

OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was basically built to provide a common infrastructure for computer vision applications. OpenCV makes it easier for businesses to use and modify the code. OpenCV is used for all sorts of image and video analysis, like facial recognition and detection, photo editing, advanced robotic vision, optical character recognition, and a lot more of applications.

Image Processing

Image processing is performed on an image in order to extract useful information from it. An image is a two dimensional matrix (3-D in case of coloured images) which is defined by the mathematical function f(x,y) where x and y are the two co-ordinates horizontally and vertically. The value of f(x,y) at any point gives the pixel value at that point of an image, that describes how bright the pixel is or what color it should be. For a grayscale image, the pixel value is represented as a 8 bit integer that ranges from 0 to 255. The pixel value denotes the brightness of the pixel. As a convention, 0 depicts black and 255 depicts white. The different shades of grey are represented by the range between 0 to 255.

Whereas for color images, the pixel value is represented as a vector of three different numbers separated as red, green and blue components. These three different components are often stored as 'grayscale' images known as color planes that have to be recombined when displaying or processing.

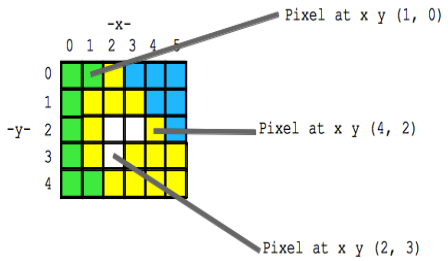

Fig -1: Representation of an image as a matrix

Once it is known how to represent the images, we then focus on the image processing side and specifically with OpenCV and python. Sub-tasks in image processing could be categorized as follows:

- **Image acquisition:** Storage, transmission, digitalization/quantization, compression, encoding/decoding.
- **Image Enhancement and Restoration:** For improvement of pictorial information.
- **Information Extraction for:** For further computer analysis.

Haar Cascade Algorithm

Object detection using Haar feature-based cascade classifiers is a detection method proposed by [9]. It is a Machine Learning based approach in which the cascade function is trained over a lot of positive and negative images and then used to detect objects in other images .Here in case of face

recognition, the algorithm requires a lot of positive images(images of faces) and negative images(images without faces) to train the classifier. Then the features are extracted from it. For this, haar features shown in the below image are used. Each feature is a single value obtained by subtracting the sum of pixel values under white rectangle from the sum of pixel values under black rectangle.

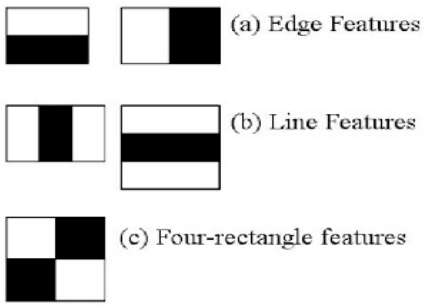

Fig -2: Haar Features

In order to solve each feature calculation that requires a lot of computation, a simple solution called integral images was introduced. It simplifies calculation of sum of pixels, to an operation involving just four pixels .Also among all the features we calculated, most of them are irrelevant. So we need to select the best feature out of these.

For this, each and every feature is applied on all the training images.For each feature, it finds the best threshold which will classify the faces to positive and negative images. Then the features that best classifies the face and non-face images with minimum error rate is selected .Still applying all the final features on an image to check if it is face or not is a little inefficient and time consuming.(Take each 24x24 window in an image)

Hence the concept of Cascade of Classifiers was introduced in which instead of applying all the features on a window, the features are grouped into different stages of classifiers and applied one-by-one. If the window fails at any stage, it is discarded and no further stage is checked. Whereas, if it passes, the second stage of features is applied and the process continues. The window which passes all the stages is a face region.

Hardware Requirements

Raspberry Pi

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It's capable of doing everything one expects a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games. The Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array of digital maker projects.

The RPi model that we have used in our project is the Raspberry Pi 3 Model B. The RPi 3B is the earliest model of the third-gen Raspberry Pi. It has a Quad-Core 1.2GHz Broadcom BCM2837 64bit CPU and a 1GB RAM. This single board computer has a BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board, and a 100 Base Ethernet. This RPi has a 40-pin extended GPIO. It has 4 USB 2 ports, 4 Pole stereo output and composite video port, and supports Full size HDMI. RPi 3B supports connecting a Raspberry Pi camera through the CSI camera port. A DSI display port for connecting a RPi touchscreen display and Micro SD port for loading the operating system and storing of data. The RPi 3B has an upgraded switched Micro USB power source up to 2.5A.

The RPi requires its own operating system to operate on and run. The official Raspberry Pi operating system is the Raspbian.

Raspbian

This is a free and open-source OS software which is based on Debian GNU/Linux. Raspbian is optimized and recommended software for the Raspberry Pi. It was created as an independent project by Mike Thompson and Peter Green, with the initial build being completed in June 2012. However, since 2015, Raspbian has been provided by the Raspberry Pi Foundation as the primary OS for the RPi. There are several versions of the Raspbian, Raspbian Buster and Raspbian Stretch being the two major ones.

Raspberry Pi Camera

We have used the Raspberry Pi Camera V2 in our project. This camera module has an 8 megapixel camera which is capable of taking photographs of 3280 x 2464 pixels, and also supports 1080p30, 720p60 and 640x480p90 video. It has the Sony IMX219 image sensor which is custom designed as an add-on board for the Raspberry Pi, and also has a fixed lens. The Pi camera attaches to the RPi by way of one of the small sockets on the board upper surface and uses the dedicated CSi interface, which is designed especially for interfacing to cameras.

Servo Motor

The servo motor is used to operate the lock. The motor controls the opening and closing of the lock on the door. This type of electric motor is a linear actuator or rotary actuator that allows for precise control of linear or angular velocity, position, and acceleration. It can push or rotate objects with correct precision. If any movements of the object are required to be done at some specific angles or distance, then

the servo motor is used. It is called a DC servo motor if the power source is DC, otherwise known as AC servo motor when AC power source is used. Servo motor gives a very high torque in small and lightweight packages.

3.2 Methodology

The RPi is powered using its own power source (battery powered). The RPi powers the Pi camera and the motor. The basic functionality of the project is, open the door for the recognized faces, else remain locked.

When a person stands in front of the camera, the camera scans the face of the person and then compares the face in its database. If the face is recognised, that is, if it matches in the database, the door is unlocked and it opens. However, if the face is not recognised, then the door remains locked. The new faces can be later updated in the database by the user. The reading of the face and the recognition process is a part of Face Recognition and Image Processing. The working between the camera and the motor is controlled by the RPi.

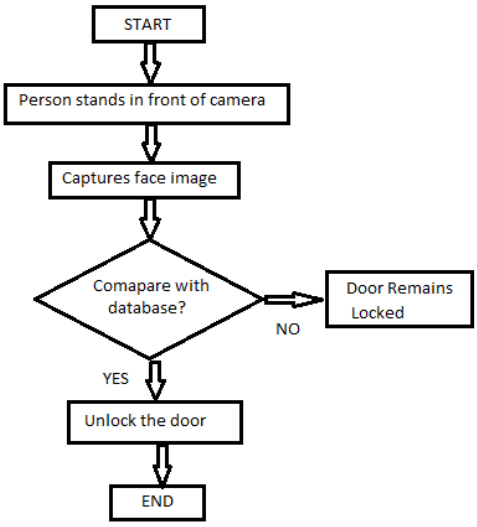

Fig -3: Flow chat for the proposed approach

3.3 Result of Implementation

The figure shows the face recognizer system implemented using the RPi. The RPi is powered by a 5V adapter. Raspbian is accessed remotely from Putty software which is installed on the laptop.

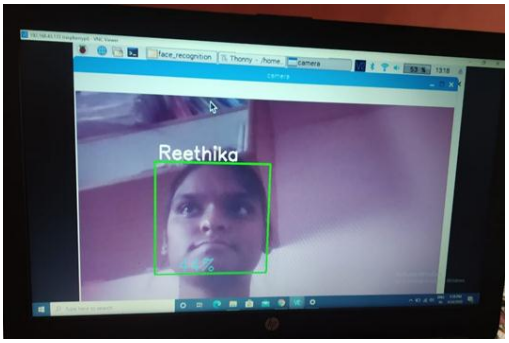

Fig -4: Screenshot of a recognized face

The screenshot of the live video is also shown. When a person comes in the line of vision of the Pi camera, the camera reads the face of the person. For a recognized face, the label (here, name) of the person is displayed. A recognized face qualifies for the condition for the door to open.

If an unknown face is read by the camera, the message unknown is written and the door remains locked.

4. CONCLUSIONS

Smart door lock is currently one of the most popular devices among consumers. The device is affordable, consumes less power, and convenient to use. Nowadays, it is replacing a lot of conventional locks. The system proposed in this paper is a light weight system which can be attached to the door easily.

Using face recognition and IoT, we have proposed an advanced system for door lock to provide access to the user for entering into the house. Since face is a distinctive feature for humans and is intrusion free, it is more secure to use facial recognition to unlock the door rather than worrying about losing keys or forgetting password.

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