FACIAL RECOGNITION BASED DOOR LOCK

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BSc.IT (Semester 5)

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I. ABSTRACT

In today's technologically advanced world, security and privacy hold the utmost importance. They are the backbone for the triumph of new inventions and innovations. Security and data breaches are faced at every level and have showcased the crucial need of extra precautions. Advanced and updated technology is the exemplary way through which we can combat these issues. Facial recognition is one such step that can help strengthen the security that biometric systems have to offer. It is a process through which a face can be detected and identified. This helps approximate the captured face prints with the ones recorded in the database.Facial recognition provides the most security when compared with other measures such as fingerprints or passwords. This is because larceny of faces is much more difficult. The time and accuracy provided by facial recognition in real time is considered as one of the pivotal reason for its growth.

In this project, the captured image will determine whether the solenoid lock should be opened or not.The project uses raspberry pi 3 model B to unlock an electrical solenoid lock when a face is identified by the Open CV recognition algorithms. The Raspberry Pi camera module will help capture images that will be analyzed and compared and successfully unlock the solenoid for an authorized person only.

Keywords: Facial Recognition, Raspberry Pi, OpenCV Library

II. INTRODUCTION

As the world goes though technological advancements and becomes more and more connected through IOT and smart devices conventional and basic security measures fall behind. This paves way for more security innovations that can help backup these inventions and stop data breaches from causing any hindrance.

Biometrics uses factors that are unique to an individuals like fingerprints, faces and voice.However even these factors can be duplicated due to technological advancements. It is now fairly easy to create a fake fingerprint or duplicate voice. However duplication and larceny of faces is not as easy. Therefore, facial recognition proves to be the best option for optimal security.

Facial recognition is a process of identifying and confirming a persons identity using their facial features. Facial recognition uses the following steps:

a. Face detection: This is the process of locating and detecting the facial features of the person that is in line with the camera.

b. Face analysis: This is the process of analysing the person's face and reading the geometry of their features. Like distance between eyes, contour of the lips etc.

c. Data conversion: The data collected in the second step is the converted from analog information to Digital information. It creates a sort of mathematical function to help store the data in the form of a faceprint.

d. Comparison: The faceprint is then compared with the ones stored in the database.If the face matches the solenoid lock unlocks otherwise it stays locked.

This project uses Raspberry Pi which is a single board computer that can run n number of programs and help create various projects.The simplicity and ease of access has made it the UK's best selling computer. The Raspberry Pi when connected with a camera module becomes the ultimate choice for this project as it not helps capture images but also assist in facial recognition and identification without any additional device through OpenCV.

OpenCV (Open Source Computer Vision) is the library that helps bring the project to life. It is a computer vision library that uses EigenFaces method for facial recognition developed by Intel and supported by Willow Garage. It is a free and Open Source library under BSD license. It focuses on real-time image processing.

OpenCV will help with identification and comparison of images while the relay module is connected to the Solenoid lock through the Raspberry pi and will help control the lock by supplying it with adequate power only when an authorized person is identified. This will create a smart and secure door lock model that will help solve the security issues created by normal mechanical locks.

III. HARDWARE REQUIREMENT OF THE PROJECT

A. Raspberry Pi 3 Model B

Raspberry Pi 3 Model B is the first model of the third-generation Raspberry Pi.It has a Quad Core 1.2GHz Broadcom BCM2837 64bit CPU with 1GB RAM. It provides wireless LAN and Bluetooth Low Energy Connection and comes with 40-pin extended GPIO, 4 USB 2 ports , a full size HDMI and CSI AND DSI ports for connecting camera and touchscreen display.

It is a small Single-board Computer developed by Raspberry Pi Foundation in the Uk on 24th February 2012. It is essentially a small sized computer that is capable of performing everything that a desktop computer can do. For this project, the CSI port is used to attached an external camera onto the Raspberry Pi.

B. 5MP Camera Module

The camera module is attached to the Camera Board that plugs into the CSI port of the Raspberry Pi.It records video in 5MP resolution at 30 frames per second and has a sensor in the fixed focus module.

The module is attached to the Raspberry Pi through a ribbon cable that has 15 pin. This is the camera module that will help capture and stream video for facial recognition. It is the latest version 1.3 designed by the Raspberry Pi Foundation.

C. Relay Module

A relay module is a switch operated by an electromagnet that decides whether current can flow through or not. It can control low volts like 3.3V or 5V. The module has channels which aids the communication between sender and receiver.

A relay module has a 5V relay, Transistor, Diode LEDs , Resistors and terminal blocks built into it. It gets its power signal from a microcontroller which is the raspberry pi in this project.When powered on ,the relay can open or close a circuit.

D. Solenoid Lock

A solenoid lock is an electromagnetic lock that uses a latch for electrical locking and unlocking. The solenoid lock only unlocks when it receives power.

E. 12V Power Supply

A battery is a a collection of cells in a serial or parallel pattern that converts electrochemicals into electric energy.

Since the Solenoid lock requires 12V power a custom 12V battery pack is created using three 4V cells and a battery holder.

F. Jumper cables

These are wires that have connecter pins at each end that allow all the above mentioned components to connect to each other.

The project uses both female-to-male and male-to-male cables for connectivity.

IV. SOFTWARE REQUIREMENT OF THE PROJECT

A. Raspberry Pi OS

Raspberry Pi OS formerly called Raspbian is the OS that is used bu the Raspberry pi. It is a Debain-build operating system.It was released in 2015 and is the official primary operation system for all raspberry pi computers. It offers a full desktop environment that can be installed on a laptop pc or even just a display with additional mouse and keyboard connections.

B. Python 3

Python is a general purpose and high level programming language that supports object oriented concepts.It was created in 1990 and is available under the GNU general public license. Python 3 is the newest version of the python programming language. This language is the prime selection for this project as it is easy to write, debug and interact with.

C. OpenCV

OpenCv is the library used to detect and recognize faces.This library along with more python libraries will help with detecting and identifying faces.It is a image processing tool that can perform vision tasks. It is supported by multiple languages like python, java , c++ etc. but for this project it is used along side python 3 libraries.

D. dlib package

Dlib is a toolkit that contains algorithms and tools of machine learning that work in real-time.It has an open source license which allows us to use the toolkit free of cost.It requires no prerequisite or existing configurations, it is a complete and independent toolkit.

E. face_recognition module

face_recognition is a library that is used to recognize faces that are visible through the camera. It is a python library that can perform face recognition even on saved photos. It uses the dlib package to perform the recognition and has a 99.8% accuracy.

F. imutils

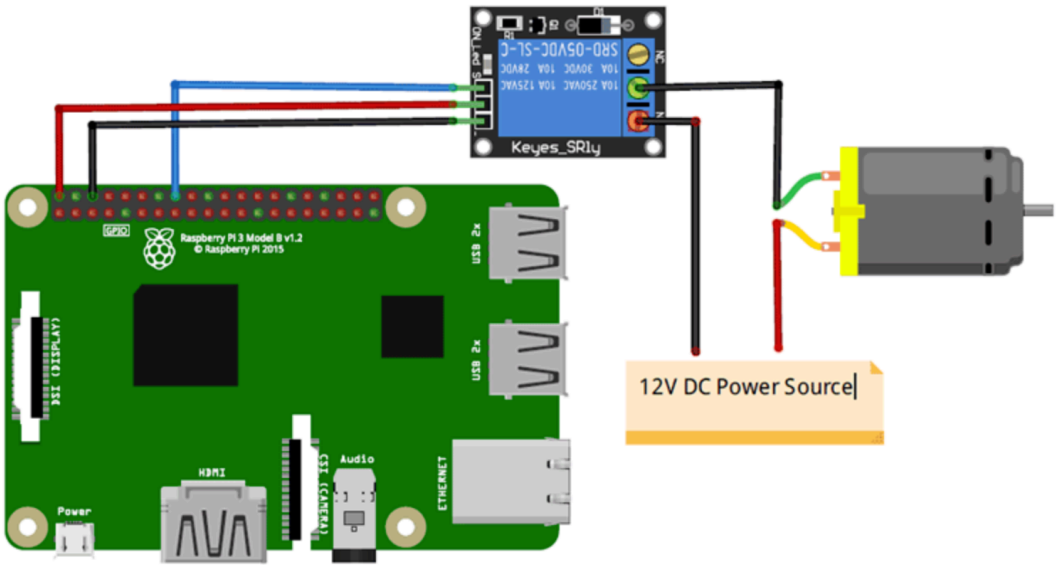
imutils is a series of functions that backup basic image processing functions in python. It is an additional library that has to be installed before coding.With the support of OpenCV, it can execute functions such as image translation, rotation resizing, and display Matplotlib images.

G. pillow

pillow is a library that adds image processing abilities to the basic Python interpreter.It is built on top of the Python Image Library and is a necessity foe image processing. It supports all types of images like jpeg, png, gif etc. It can perform image archives ,image display and image processing through image resizing, rotation and transformation.

V. MODEL

Following is the circuit diagram of the project. This shows how all the hardware components are connected together to create the project.



- The Camera slot on the Raspberry Pi is used to connect the camera module.
- The solenoid lock is connected to the Raspberry Pi via the Relay module, which enables control over the amount of electricity the lock receives. The VCC pin of relay is connected to the 5V pin on the Pi and GND pins of the relay module are linked to the Raspberry Pi's GND pin.
- The relay module's input pin is wired to Raspberry Pi's GPIO23.
- The solenoid lock has a black-wired negative pin which is connected COM pin on the relay.
- The solenoid lock also has a Positive red-wired pin which is connected to the power pin of the 12V battery
- The NO pin of relay is connected to negative slot of the 12V battery.

The below tables shows all the pins used:

RASPBERRY PI	RELAY MODULE
5V	VCC
GND	GND
GPIO23	INPUT

RELAY MODULE	SOLENOID LOCK	BATTERY ADAPTER
COM	NEGATIVE PIN	-
NO	-	NEGATIVE SLOT
-	POSTIVE PIN	POSTIVE SLOT

VI. WORKING

Once the components are connected together, the libraries mentioned in the software requirements are all installed on the raspberry pi.After this the code is written and saved in the appropriate directories in the backend.

The Users directory has the face prints of authentic users stored in it.This will be the faceprint that the captured images will be compared with.

The working of the project can be divided into two: the hardware front-end side that the users will be viewing and the Software back-end side that contains all the coding.

The hardware working of the project is as follows:

As shown in the model, the relay is connected to the solenoid lock via the COM pin. The relay controls the power supply that the lock will receive. The instruction to either supply the power or to cut the power is given to the relay through the connection formed between the Raspberry Pi GPIO23 pin and the INPUT pin of the relay.

Once the model is powered ON the following steps take place:

a. A face is presented in-front of the camera which is scanned for retrieving the faceprint

b. If the identified faceprint matches the one stored in the database, the relay is set to high.

c. When the relay is set to high, the solenoid lock gets 12V power supply which causes unlocks the lock.

d. If the identified face does not match with the stored one, then the relay is set to low.

e. The relay does not allow any power supply to reach the solenoid lock and it stays locked.

The back-end working of the project is as follows:

a. When a person stands in-front of the camera , his/her face is detected from the surrounding using the classifier cascade.

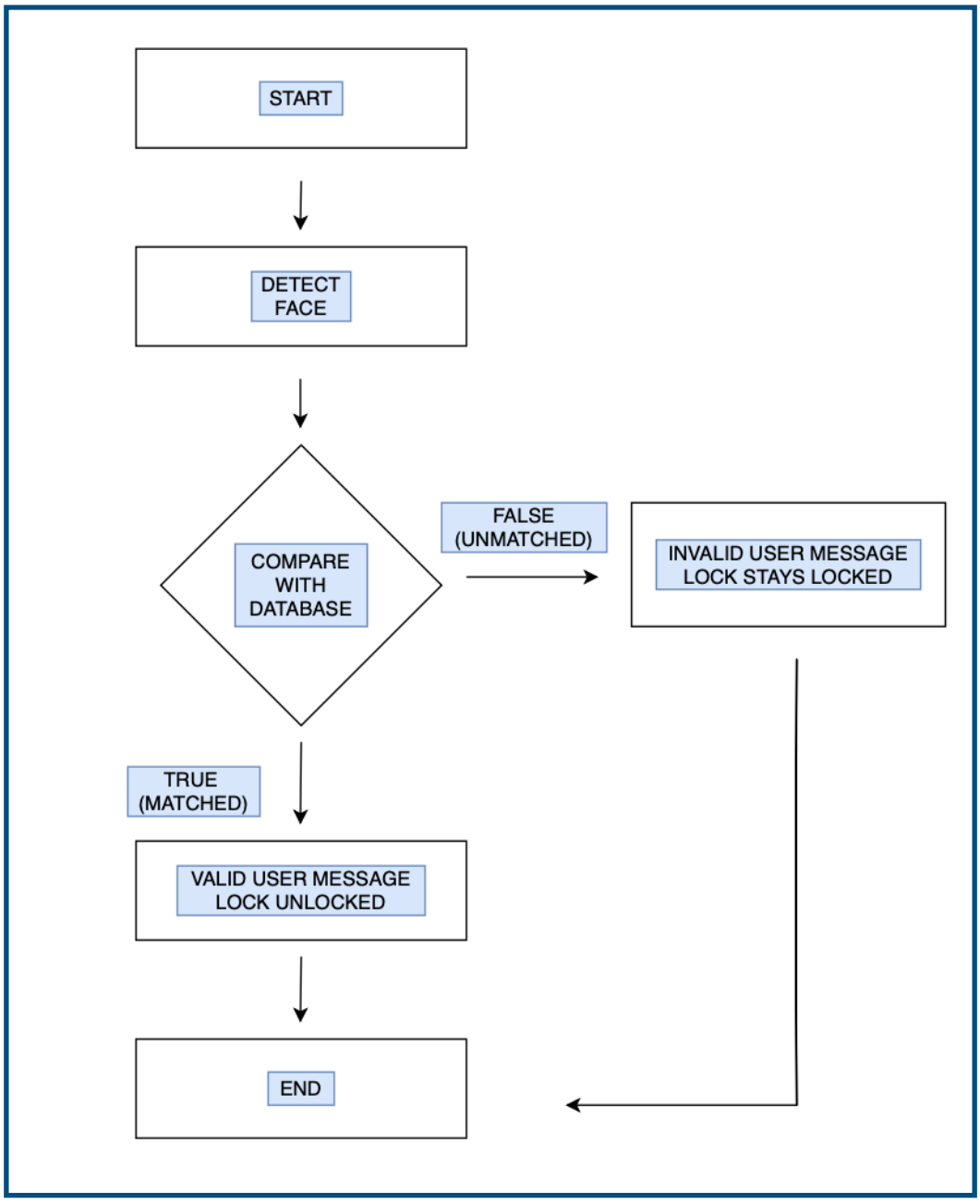
b. The image is converted into a numpy image which gives a faceprint

c. This faceprint is compared to the one stored in the Users directory.

d. An if-else conditional statement helps decide whether the faceprint matches using the numpy data. If the confidence is 0 then it means that the face prints match perfectly and the relay is given an input of 1(HIGH) through the GPIO output pin.

e. If the confidence is anything more than 0 then the relay is given an input of 0(low) through the GPIO pin.

VII. FLOWCHART



EXPLANATION:

The above flowchart explains the working of the model. Once the code is running, the camera starts looking for faces.When a face is detected it is compared with that stored in the database, if the face matches, the appropriate welcome message is displayed and the solenoid lock is unlocked. But if the condition is false and the face does not match then invalid user message is displayed, the lock stays locked and the program is terminated.

VIII. COMPARISON

There have been various attempts at creating a facial recognition based door unlock in the past decade. Many different libraries and microcontrollers were used to discover the most effective combination. However, Raspberry Pi seems to be the most efficient and effective choice to make a cost effective and student friendly system.

Out of the various attempts below are two projects that are similar to this project:

A. Facial Recognition Enabled Smart Door Using Microsoft Face API by Karan Maheshwari and Nalini N [6]

In this project, the authors have used the Raspberry Pi 3 Model B+ along with the Microsoft HD live Webcam. The other components are the same : the solenoid lock and battery supply.But Microsoft Face API library has been instead of the OpenCV library.

B. Facial Recognition Door Lock Using Raspberry Pi by Aman Bansal, Anshu Sharaf, Anand Keshri, Abrar Alam, Shruti Sharma [7]

In this project, the authors have used Raspberry Pi 4 and a GSM module to help deliver messages anytime the door is unlocked.

The major differences between the first model and this project are as follows:

1. The referenced model faces an issue of inadequate power supply as they have not included any external power supply to help power the solenoid lock.
2. In addition to that, it used a low-power relay which can only handle low-level voltages which causes circuit failure issues.
3. The referenced model uses Local Binary Pattern Histogram(LBPH) face recognition algorithms which makes the project more adaptable as it recognizes not just the front but also the side profile.
4. It also uses a GSM module that sends message and alerts the user.This increases the overall efficiency and effectiveness of the model.

The major differences between the second model and this project are as follows:

1. The referenced model uses Microsoft Face API library instead of the OpenCV library.
2. The referenced system has an Interactive User Interface which this model and the [A] model lacks.
3. The methodology used in this model was extremely complex and took away from the ease and simplicity of the project.
4. The biggest drawback faced by the authors was that once the solenoid lock was unlocked it stays that way for indefinite time which can cause security issues.

IX. CONCLUSION

As security and privacy was the main objective of this project, the facial recognition approach has definitely helped achieve that with the aid of Raspberry Pi and OpenCV. The project has showcased that faceprint is the optimal choice for biometric based door lock system. It has proved be the most convenient, accurate and effective.

Using OpenCV and python libraries for face detection and identification makes the project fast reliable and cost effective since all the libraries are open source and free of cost.They are also highly accurate and secure which further helps back up the main security goal of the project.

The Raspberry Pi micro computer makes the project portable and independent. The project can be used at any place big or small without any additional requirements.

For future efforts, adding a night vision camera and infrared camera interface can help transform this project to the next level.

X. REFERENCES

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