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Face Recognition (Image Processing) based Door Lock using OpenCV, Python and Arduino

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***Abstract:** This is the era of Technology; this era belongs to us. The word Internet of Things will be like our new family member soon, it can be implemented in different aspects of our daily lives to make the result accurate and desirable. The term Face Recognition and detection is like an ocean of research and innovation with the applications of image analysis and algorithm-based understanding which can be called as computer vision. Security is a right which no one can deny and justify this right lots of works and researches are taking place in this world. With the development of IoT home security has been developed in recent years with different advancements. We have, Face Recognition as our project. Facial recognition involves the detection and identification of the image. It uses an image capturing technique in the system. The camera catches the facial picture and compares it with the image which is stored in the database. If the picture is matched with the database the gate will open or else a notification will be sent. The recognition algorithms will be from the OpenCV library.*
***Keywords:** Face Recognition, Image Processing, Internet of Things, OpenCV, Image Capturing*

I. INTRODUCTION

In these contemporary times, home security is the necessity for the progress of humanity as a whole which in turn will help make our lives smart, so the concept of facial recognition to gain access to our homes is an idea that will be used to make our homes more secure. A facial recognition system is a system which collects facial images and authenticates the identity of a person through the digital camera. The human face is a vital part in our living memory that defines a person, its first identity. Using the human face as a key, biometric when meet the wave of innovation results in the marvellous consideration in a while because of its potential for a wide range of utilizations.

The face recognition follows a framework called facial acknowledgement framework. A facial acknowledgment framework is a framework which collects the facial images and checks the identity of the man using camera. It is an application which is perfect for checking a man from a computerized image. One way to do this is by choosing a facial component from the picture in the face database. It differs from the other biometrics confront acknowledgement that are iris, palm/mark acknowledgment which may involve the physical interaction of the user with the system, but the face acknowledgment will not require any kind of physical interaction of the user with system.

The entire system can be made up using the Arduino board that will be connected to the computer system for the camera and power management with the Servo at the door for the movement of it during granting the access to the user with the Wi-fi module Esp8266 for the TCP/IP protocol. The entire system has a vague use and will provide the security which is one step ahead from the conventional methods.

Home and personal security cannot be ignored now, we cannot trust the conventional methods namely types of lock or a manual latch at the door, we need something more and innovative. So, to solve the problem we need to make things better and efficient. Image processing (Face Recognition) will provide a better security feature than the conventional access system may be through RFID or passwords because it's intrusive.

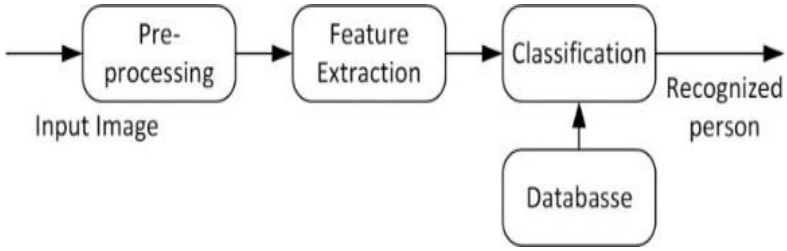


Fig. 1. The Conventional Process

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A. Detecting Faces

Face detection is used nowadays in many kinds of applications like smartphone cameras, human-computer interaction, social media and surveillance. It can be done using various pre-trained models which can do the heavy lifting for us to detect faces. Here the framework that we have used is OpenCV. This framework has an in-built Face Detector that works in roughly 90-95% of clear photos of a person looking forward at the camera OpenCV was started at Intel in 1999 by Gary Bradski to accelerate research in and commercial applications of computer vision in the world and, for Intel, creating a demand for ever more powerful computers by such applications.

B. Recognize Face

Recognizing a face is a vital part in any process, this consist of basically three stages which are look-in, ID, and authentication. In these three parts authentications i.e. confirming a face image from the dataset in the database is the most authoritative part of an algorithm. If the verification stage returns a positive result, only then access is approved to the user otherwise it is denied. Identification is also an important part of an algorithm, which can be done by various methods such as Eigen Face, Fisher Face, LBPH methods end etc. The above Fig.-1 shows the complete superficial process that takes place during the facial recognition process when the input is given in the form of the human image from the camera. The image after its captured will processed to figure out the essential features that may match the user of the system, the accuracy of the system may vary and it can be configured according the requirement of the user. Each human face has some unique defined feature that is called the particular identification of the face that are extracted from the image and are clustered. Different users provide the key dataset and all of them has unique facial features the system classifies the real time user with the features of various user that are stored in database and when the image is matched with a particular dataset then the access is granted.

II. MOTIVATION

The motivation of this project is to use the Face Detection and Face Recognition Techniques to develop an advanced and robust algorithm that can provide the home security more efficiently.

1) Implement a more reliable way in door lock system.
2) Eliminate intrusion threats by making the user aware about them.
3) Hassle-free and user-friendly way to access the door. Technologies Used
4) Coupling Hardware and Software for better Security Feature
5) To come up with more innovative solution than the conventional method.
6) Broadening the horizon of the application of the face recognition technique

III. SCOPE

The main focus of this project is to come up with the optimum solution to the problem of human safety and his/ assets with the support of Technology. The project has been created using the OpenCV Python library along with the integration of Hardware and Software, which goes like the webcam sends video frames to OpenCV running on a Windows PC. If OpenCV detects a face it will track it and calculate its centre's X, Y coordinates. The coordinates are then passed on to the Arduino via a serial USB connection. The Arduino controls the movement of the webcam with the help of two pan/tilt servos to follow the detected faces. OpenCV (Open Source Computer Vision) Library is an open-source library that includes several hundreds of real-time computer vision algorithms. The image processing C++ code samples are provided with the OpenCV library. The images of the users are pre-entered in the database to allow the access to the specific user, the admin will get a notification in the form of SMS if an unauthorized person tries to access the door, this has increased the security and has solved a problem which was faced from a long time with the application of Internet of Things.

IV. RELATED WORK

A lot of research is currently carried out by experts of the computational field. The previous works that we found were using different face detecting algorithm to detect the face of the user. There has been ample amount of research that has been taken place in the domain of Face Recognition and its various techniques and algorithms The previous works that we studied were using template matching algorithms to recognize face of the user. Various algorithms such Eigen Faces or Fischer Faces face recognizer were installed in the systems. Some systems were affected the presence of the light in the room and some were independent of it. Author Harnani Hasan has used Eigen Faces algorithm for his system in it, a Magnetic Door Lock System was made using face recognition. On the other hand, authors Ratnawati Ibrahim and Zalhan Mohd Zin published their work on the congruent topic. In their work, they used the algorithm of Principal Component Analysis and Template Matching to recognize face.

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Studies by Somjit Nath, Paramita Banerjee proposed "Arduino Based Door Unlocking System with Real Time Control". This approach implemented with RFID codes to scan for unlocking the door. So, when a person wants to enter the door, he needs to scan the card then he gains access to that door. If he misplaces that card he cannot access through that door and there is a chance of insecurity that anyone can access to the door.

Studies by Charoen Vongchumyen, Pakorn Watanachaturaporn, pattaya proposed "Door locking system via web application". In this approach, a web application is designed to monitor the door. There is a drawback in this system: when someone hacked and got security code then hackers can easily access to that room.

Study by Suchit Shavi proposed" Secured Room Access Module". In this approach a keyboard-based door unlocking system is implemented with a micro controller. So, the user needs to enter his password to unlock the door. In this approach is secured when compared to the previous models and well used in today's world. Even though this system is secured there might be a drawback: If someone observes your password, they can gain access to that door by using the same password you have entered.

Research by M. Kashif Shaikh, Syedannas B Mazhar proposed "Comparative Analysis for a Real Time Face Recognition System Using Raspberry Pi". This approach did an analysis of various algorithms on the face recognition system. This analysis took LBPH (Local Binary Pattern Histogram), Fisher Faces, Eigen Faces Algorithms for comparison and checked with different processors to know time complexity and accuracy of various algorithms. This approach is most secured and without matching face no one can access that door.

AUTHOR	TITLE	PROBLEM TACKLED	FEATURE	DRAWBACKS
Sourav Roy, Nasir Uddin, Md Jahidul Kabir, 2018 [1]	"Design and Implementation of the Smart Door Lock System with Face Recognition Method using the Linux Platform Raspberry Pi".	Linux platform for tackling face recognition in doors.	Rasberry Pi for door opening.	Detection in congestion.
J. W. Lee, C. D. Kee, and U. K. Yi,2012 [2]	"Face Recognition Based on Magnetic Door Lock System Using Microcontroller".	Microcontroller used for face recognition.	Controlled face recognition access.	Other better ways were later invented.
Toshihiro Mori, Takashi Suehiro and Tetsuo Tomizawa, 2017 [3]	"Development of Intelligent Automatic Door System".	Automated locks instead of normal locks.	Face recognition locks.	
Harnani Hassan, Raudah Abu Bakar, Ahmad Thaqib Fawwaz Mokhtar,2012 [4]	"Face recognition-based door unlocking system using Raspberry Pi"	Cost effective.	Feasible for most people.	Efficiency.
C. J. Chen, B. Wu, W. H. Lin,2014 [5]	"Embedded image capturing system using Rasberry PI"	Cost effective	Feasible for most people	Efficiency.
Suchit and Shanvi, 2016 [6]	"Secured Room Access Module"	Theoretical analysis.	Theoretical analysis.	Theoretical analysis.
H. Xu and H. Li,2017 [7]	"IoT based Home security through Digital Image Process Algorithms."	Locking system other than traditional locks.	Innovative ways to secure home.	Diversity.
J.-G. Wang, C.-J. Lin, and S.-M. Chen,2017 [8]	"Real-Time Implementation of face recognition system"		Face recognition system.	Later faster and better technologies were discovered.
Shavi Suchit 2017 [9]	"Secured Room Access Module 2017."	Only study Module.		
Umm-e-Laila, Muzammid Ahmad Khan, Muhammad Kashif Shaikh and Syed Anas Bin Mazhar. 2017 [10]	"Comparative Analysis for a Real Time Face Recognition System Using Raspberry Pi".	Cost Effective.	Feasible.	Efficiency.
A. Beatrice Dorothy, Dr. S. Britto Ramesh Kumar J. Jerlin Sharmila, 2017 [11]	"IOT based Facial Recognition Door Access Control Home Security System"	Facial Recognition Door Access Control.	Successful demo model.	Only implemented till demo model.
Omkar Pawar, Prathamesh Lonkar, Randhir Singh, Vivek Salunke, Prof. D.M. Ujlambkar, 2019 [12]	"Door Lock System using Facial Recognition".	Efficient.	Still in use.	
Zaier Zaidi, Essam Radwan and Rami Harb,2017 [13]	"Development of Face Recognition on Raspberry Pi for Security Enhancement of Smart Home System".	Cost Effective.	Feasible.	Efficiency.
Tejas Saraf, Ketan Shukla, Harish Balkhande, Ajinkya Deshmukh, 2018 [14]	"Automated door access control using face recognition."	Increased efficiency.	Congestion was removed.	Still in use.
Samuel Lukas, Aditya Rama Mitra, Ririn Ikana Desanti, Dion Krisnadi, 2017 [15]	"Student attendance system in classroom using face recognition technique"	Unconventional way to record attendance.	Use of technology in recording students attendance.	Convergence rate was low.
Ratnawati Ibrahim and Zalhan Mohd Zin, 2016 [16]	"Study of Automated Face Recognition System for Office Door Access Control Application"	Unconventional way to record office attendance.	Innovative way to maintain office attendance records.	Later, efficient ways were discovered.
Lerato Masupha, Tranos Zuva, Seleman Ngwira, Omobayo Esan Tshwane, 2013 [17]	"Face Recognition Techniques, their Advantages, Disadvantages and Performance Evaluation"		Theoretical analysis.	
Yong Ma, Xiaoqing Ding, 2019 [18]	"Robust Real-Time Face Detection".	Efficient	Still used.	
Janarbek Matai, Ali Irturk and Ryan Kastner, 2018 [19]	"Design and Implementation of an FPGA based real-Time Based Face Recognition System".	Extremely fast.	FPGA based.	High cost.

Table 1- Related Works

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V. PROJECT DESCRIPTION

A. Goal

The Goal of our project is to increase the security measures for the personal use and to go one step above the conventional door locking. It will not just increase the security feature it will also free the User from worrying about forgetting the password or the key of the door. The Data Set image will be provided to the system which will act as a key to access and get inside.
This Face Recognition Technique can also have its application in the Vault door to keep all the precious assets safe and secure from any unauthorized access.

B. Simulation

1) Classical Face Recognition Technique

The basic face recognition technique for our system includes-

a) *Phase 1:* Pre-processing: Pre-processing of the image refers to the gathering of the image data from the camera module. But we do not need to save whole image in the dataset. We will only need a part of the face from whole captured image. For this, we will have to detect the area of the face in the image. A short code for face detection is developed. This code is also useful for other modules in the system. This detected part of the image will be cropped and saved in the data folder. Also, care has to be taken to align the images if they are shot from a different angle.

b) *Phase 2:* Feature Extraction: Once we have got the images for training, we can use the image algorithm to learn on this dataset. Depending on the size of data samples, the accuracy of the classifier will vary. In this phase, we will generate local binary patterns as we discussed earlier in the paper. We applied the LBP method on image pixels by thresholding the 3×3 neighborhood of each pixel with the center value and considering the result as a binary number. Finally, we applied the histogram method to concatenate the new cells description and obtain a new representation for each training image, which helps to reduce the computation time.

c) *Phase 3:* Classification: This phase is nothing but the testing of our face recognizer. We will do a real time video check to verify the correctness of the trained model. Whenever a new face is as an input to our model, it will first extract its features and generate binary patterns same as we did for the training images. After its completion, the input is given to the trained recognizer to classify the image according to its training. This phase exploits the powerfulness of the classifier. OpenCV- It has the advantage of being a multi-platform framework; it supports both Windows and Linux, and more recently, Mac OS X. OpenCV has wide aptitudes it can seem awesome at foremost. A good consideration of how these approaches work to get good results when using OpenCV. Fortunately, only a select few need to be known beforehand to get started. OpenCV's functionality that will be used in the face recognition is controlled with some modules. Following is a short description of the following. CXCORE namespace, it comprises elementary data type definitions, linear algebra and statistical methods, the persistence functions and the error handlers. CV namespace comprises the method of image processing and camera calibration or setting methods. The computational geometry functions are present here as well CVAUX namespace is labelled in OpenCV's documents as comprising outdated and experimental code. The simplest interfaces for face recognition technique exists in this module. The code behind them is dedicated for face recognition, and they're broadly used for that purpose. ML namespace covers machine- learning edges.

2) *Software Design:* The flowchart of the proposed face recognition system. First, it reads ultrasonic sensor to detect the human presence, which could be set to check every second (configurable). If the human presence is detected, then the camera will capture the face image. The face detection routine will localize and segment the face region only. The face image is then fed in to the face recognition routine. If the recognized face is detected, the system will unlock the door by turning of the magnetic lock. After 30 seconds (configurable), the system will lock again the door by turning on the magnetic lock. The system will then start from the beginning.

3) *The Process Flowchart:* There are several processes that take place from the start till the validation to provide the access or a denial can be presented through a flow diagram involving various stages and that takes places internally and externally in the system i.e Face detection or the opening and closing the door.

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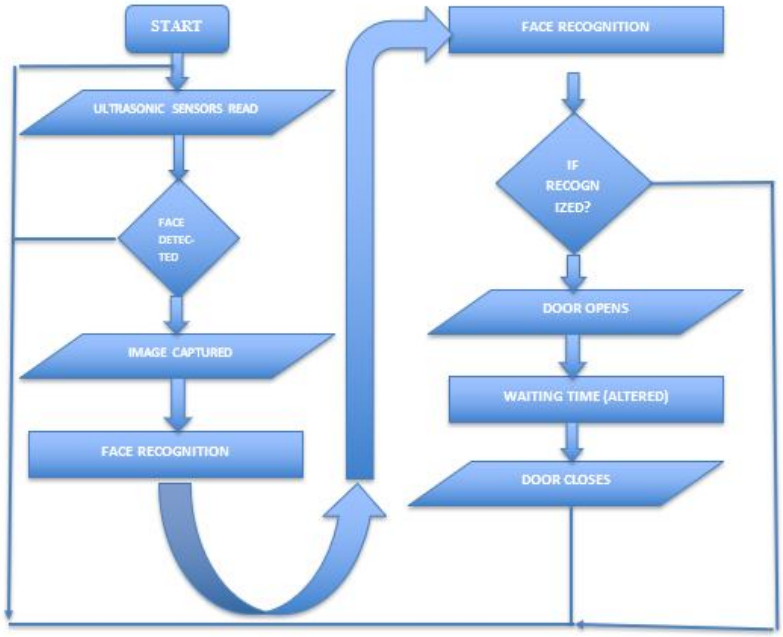


Fig. 2 Flowchart- The processes involved in the face recognition system

4) *The Proposed face Recognition Algorithm:* The face detection algorithm will detect and segment the face from the overall image. Then, it does the necessary aligning and further cropping and conversion from color to grayscale. The eigenfaces feature vector will be extracted from this process. After that, the classification algorithm will do an analysis to compare the input feature vector with the database, in which it will decide whether the input face image is similar with the registered face image. If it is recognized, then the system will turn on the servo motor to unlock the door.

The Algorithm works like this:

1) Step 1- Start
2) Step 2-The image will be detected and the segmentation takes place Includes- Align then Crop
3) Step 3-Convert the image in Grayscale
4) Step 4 - Preprocessing on the Gray scaled image Significant features Extracted
5) Step 5- If "User" Classification, Else, Denied
6) Step 6- Algorithm works on image
7) Step 7-Identified User.
8) Step 8-Stop

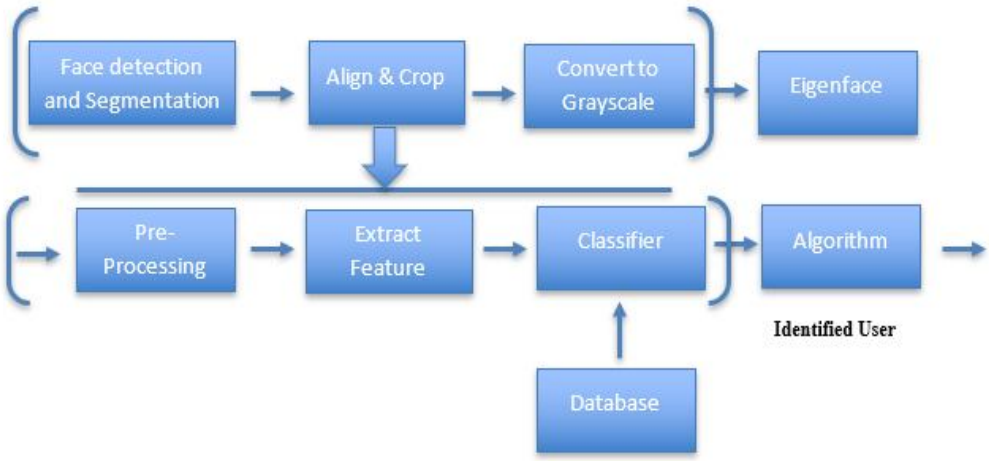


Fig. 3 When the User is Standing at the Gate

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5) Hardware Design

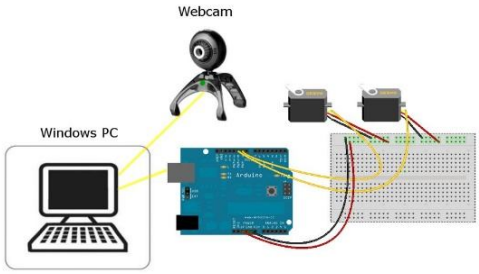


Fig. 4 The Hardware Implementation

6) Implementation: The prototype of face recognition security system. The box contains the Arduino Board, Servo Motor, Esp6266, Capacitor, LEDs and the power input and output. The prototype will be placed beside a door and connected to a lock which is turned off/unlock when the authorized user accesses the system. If unauthorized personnel try to access the door will stay locked. On the software part, Arduino UNO is used as the operating systems for. Next the Python and OpenCV library was installed for the algorithm implementation. To train the faces into the library, we use the "train.py" algorithm in the OpenCV library. The training data should be loaded into the script. These images will be captured using the code "capture- positives.py". This code will continuously capture images into the training data folder. Sets of 10 images for each person is trained at a time and "train.py" script is executed. Sample of the training images. The training data given will produce an output named "training.xml" file which contains the positive data processed into it.

7) Experimental Testing of the System: Here in the image below is the captured Trained image of the User that was stored in the system as the key for the door, the particular User can now get the access through the door.

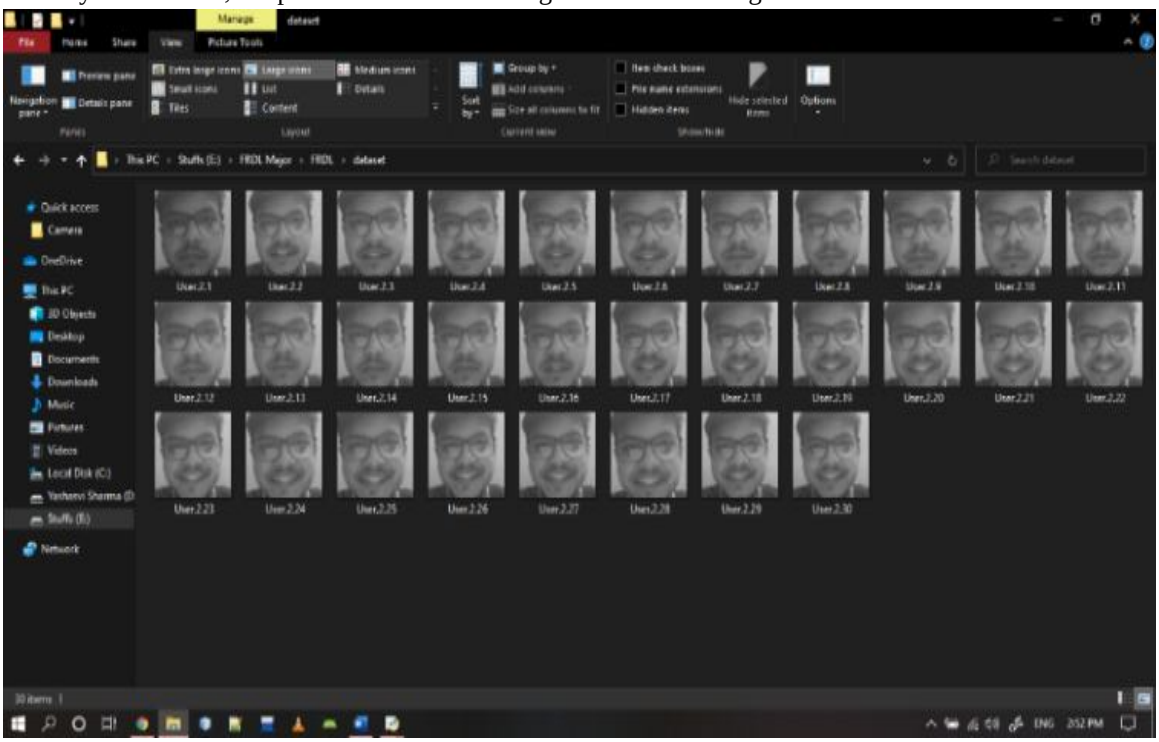


Fig 5 The Data Set Shots of the User That Will be Used as a Key

When the User wants the access to the door again, the System will detect the image and will recognize the authenticity of it from the database it has and it will provide the access.
Here around 30 images are captured once. The following Snapshots show the image detection frame of the User.

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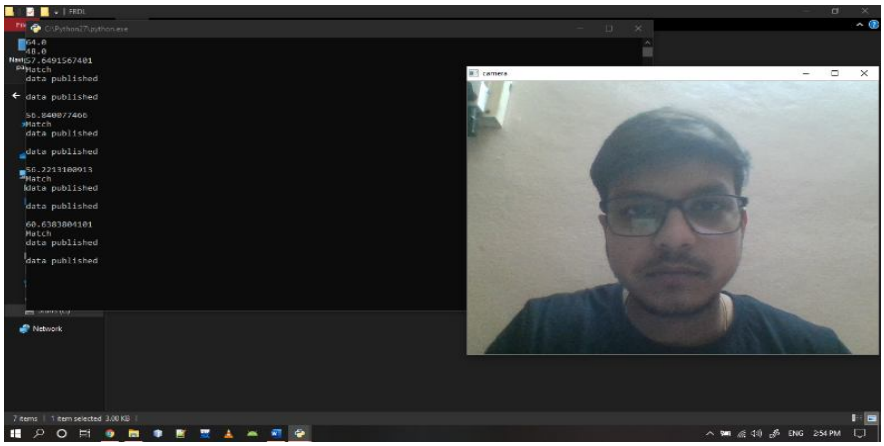


Fig 6 The Image Detection

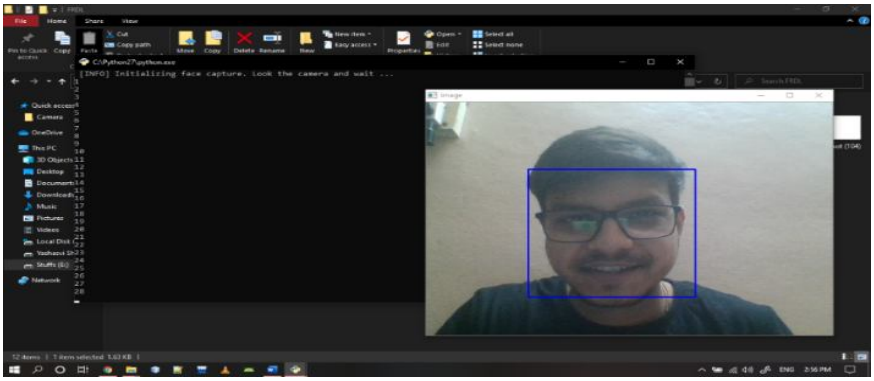


Fig 7 Image Recognition

The image will match with the database the matching accuracy is configurable depending on the quality of the camera we are using and the power management that we can provide.

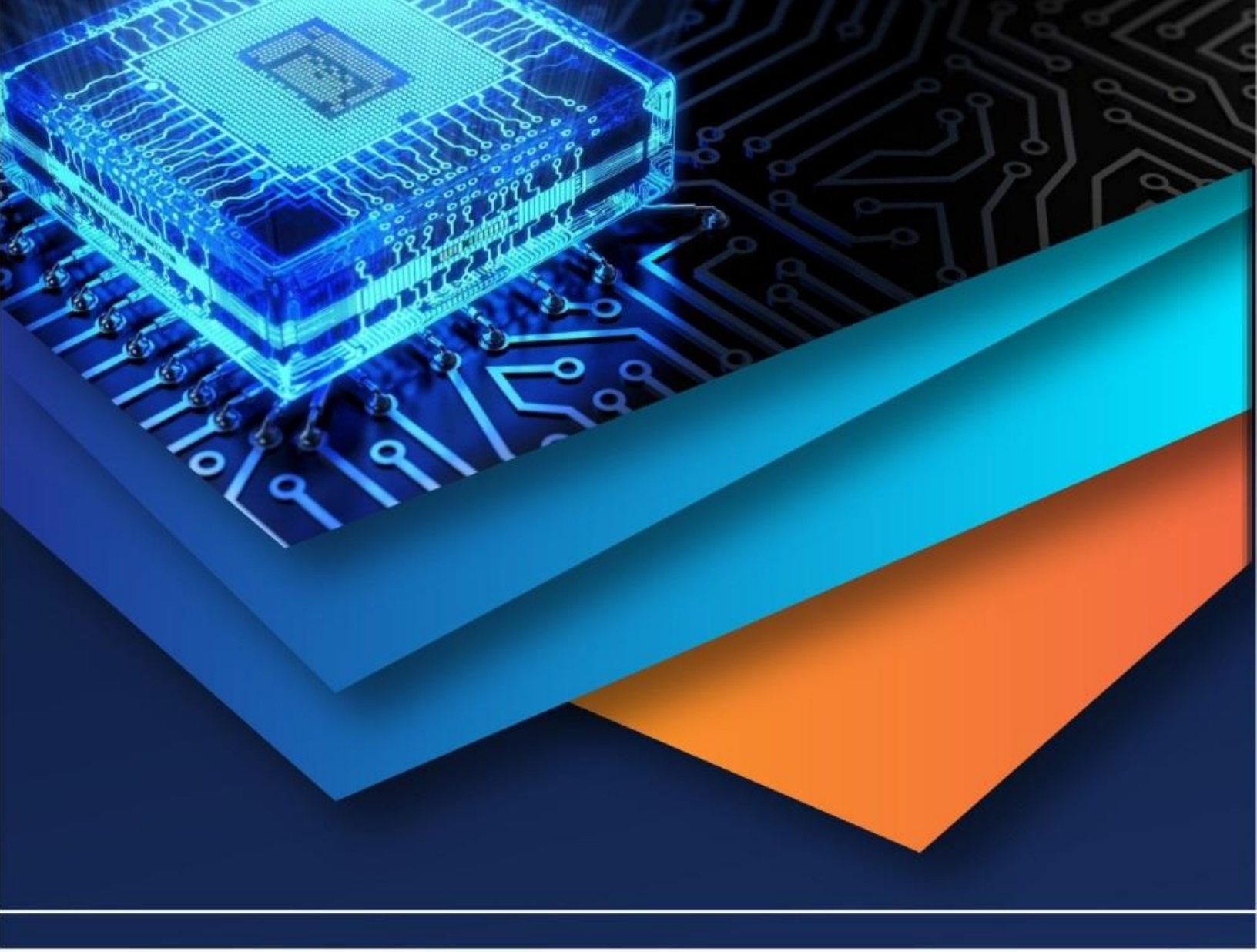
VI. CONCLUSIONS

This paper has presented a Race Recognition (Image Processing) system using Arduino UNO, Python and OpenCV was used to implement the feature extraction and classifier, in which we used Face Recognition algorithm The prototype design for real world implementation has been elaborated, in which the output of face recognition algorithm will lock or unlock the door using the servo motor in the circuit. This proposed system could be connected using Internet to the smart home system for the added security capability.

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[11] (2017) Secured Room Access Module by Suchit and Shanvi, India
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