Intelligent Criminal Detector

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Module: 6CS007 Project & Professionalism

By

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Abstract

Face recognition has become one of the most interesting and powerful science areas in the last 20 years. The reasons for this are the need for automated identification and security devices, the interest in the human visual system for facial recognition, the development of a human-computer interface, etc. Face recognition is now a common field in computer vision technology, is usually used for network security and access control systems, but is also effective in many other multimedia data processing fields. It has uses ranging from defense and monitoring platforms for vivid operations. Face recognition system is important in banks, airports, hotels, and other organizations for consumer screening. Face recognition can be used for criminal face identification. Crime records usually provide specific information about a single person along with a photograph. To detect any criminal, we get some identity for a certain person. Although a criminal detection system is a relatively new area, we can use it for Hotel security. These days, there are many criminal cases related to Hotels such as murder, physical attack, sexual assault, robbery inside the hotel, and terrorist attack. The project's essence is to develop and implement an intelligent criminal detection system with low production cost and considerable accuracy. In this project, developed a face recognition system with additional features for criminal detection. At present, there is a lot of face recognition in intelligent cameras. However, there are no emergency alert systems to the system admin when a criminal entering the Hotel premise. Also, I planned to give the control of doors and gates to the system admin via wifi. Because like this situation, time is very important behalf protection of lives and properties. The main task of the project is face recognition using a predefined criminal database. Here planned to use YOLOv2 model, Keras Xception and Tensorflow, p5.js, Numpy, PILS, OpenCV libraries. Also, I used the NodeMcu for Wi-Fi-based door controlling. The human face is a complex phenomenon with a high degree of change in shape, which causes identification of the face a hard challenge in computer vision. Accuracy and speed of recognition are the key problems in this field. Then by using Keras Xception model, predict images, feature extraction and fine-tuning and it used to train the labeled data set. OpenCV is a common infrastructure for computer vision and to improve machine perception to retrieve real time detection.

Acknowledgement

First of all, I would like to give special thanks to my supervisor, Mr. Rajeewa Dharshana, and to the reader, Mr. Dhishan Dhammarachchi, for their enthusiasm, encouragement, informative feedback, helpful knowledge, practical advice, and never-ending ideas that have helped me hugely at all times in my project. Their deep knowledge, vast experience, and professional skills have helped me to achieve this project successfully. This project would not have been achievable without their support and advice. I would also like to take this opportunity to express to the University of Wolverhampton for accepting my project proposal for the graduate program. Finally, I would also like to thank my parents and friends who have encouraged me at all times when parts of my project have failed.

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01 – Introduction

1.1 Background

Fingerprint, eyes, DNA and face can be used for recognition. Face recognition is one of the best methods that can use for people recognition. The face is our primary emphasis on social relations, where personality and feeling are communicated primarily. Digital cameras quickly accessed and the requirement for protection improved the value of the technology. The facial recognition is natural and easy-to-use than other biometric technologies. A facial recognition system uses an image database which matches a particular image to a reference if a match occurs. This project is aimed to identify the criminals in anywhere but here mainly focused the hotel systems to use this. In this system, there are storing the images of criminals along with their details and retrieve the information stored in the database.

A person can identify the face instantly, and a completely different procedure is needed for the computer. A facial recognition system can automatically recognize the faces in photographs and videos. There are two modes in the face recognition system called face detection and face recognition. For the output of a facial processing system, face detection plays a major and crucial role. The issue of face detection is complex because of any possible changes of appearance caused by lighting changes, facial expressions, occlusions. Furthermore, faces with varying scales and positions, with plane rotations have to detect. The picture size is always very high, processing time has to be very short and limitations must normally be met in real-time. In recent years, designing and using parallel algorithms in image processing has also improved. The facial recognition is related to finding out if there are faces in a given image and returns the direction of the image and also the content of each face when present. It's the first level in a fully automated method analyzing the faces with data. Ex:-Identity, gender, expression, age, race and pose.

When a criminal case occurring the hotel premise time is very important behalf protection of lives and properties. Another task of the project is to make it possible for administrators to lock the door without using the keys and without having to be on the scene to lock it. The door lock has internet access via the nodemcu Wi-Fi module. The admin can use the mobile phone anywhere in the world to control this door lock system.

Figure 1 - Basic Flow diagram of face recognition

1.2 Aim of the Project

To identify the recognized criminals when they entering the Hotel premises.

1.3 Academic Questions and Objectives

1.3.1 Academic Questions

How to protect our hotel premises from the recognized criminals?

1.3.2 Objectives

- Search for problems of security in the Hotel premises.
- Identify the solutions for security problems.
- Choose the technologies for Face recognition, Alert service and WIFI based door controller.
- Choose the devices for Face recognition, Alert service and WIFI based door controller.
- Develop and test prototype.
- Implement a prototype in the chosen location and test.

1.4 Scope

Nowadays the hotel industry is facing very huge problems with their security. Here security is related to hotel peoples and hotel properties. These days, there are many criminal cases related to Hotels such as murder, physical attack, sexual assault, robbery inside the hotel, and terrorist attack.

Although a criminal detection system is a relatively new area, it can use for Hotel security. This project mainly focused on a smart criminal detection system with low production cost and considerable accuracy. Face recognition is part of the part of AI and Machine learning. Here I used the YOLOv2, Keras and Tensorflow as the main module for face recognition. First I trained the images set and took the about 80 - 100 images per person. Then used that training dataset for face detection and face recognition. Further designed an emergency alert system to the system admin using SMS and email.

In this project, main purpose is protect the hotel premises from the criminals. A second task of the project is to allow administrators to lock the door without any key and no need to be on the scene to lock it. The door lock is accessible through the Wi-Fi module of Nodemcu. This door lock mechanism can be operated by the administrator on the smartphone anywhere in the world.

1.5 Structure of the Report

Chapter 1: Chapter 1 gives an overview of the project based on the academic question. Special emphasis is given to describe the security problems & difficulties faced by the Hotel industry and how this project helps to resolve those security problems. So in chapter 1 discuss the project background, academic question, project aim and objectives, project scope.

Chapter 2: In this chapter discuss the general description of where the literature was found in the area of the project. Also, discuss broadly the similar projects found, functionalities of the indicated projects and its limitations using Harvard referencing.

Chapter 3: In this chapter discuss how to project is going to build. Here broadly discuss the project under plaining, analysis and requirement gathering, designing, implementation and testing.

Chapter 4: Detailed description of the academic findings, sample code and test cases are presented in Chapter 4.

Chapter 5: Chapter 5 gives the general discussion with conclusions, project limitations, critical evaluation and recommendations for further work in the criminal recognition system.

Also, in the end, an appendix is added to the report references, bibliography, user manual, diagrams and coding.

02 – Literature Review

2.1 Introduction

In this era, AI and Machine learning technologies are developing very fast. Face recognition can take the under these technologies and it is the most challenging topic in computer vision today. Due to developments in face modelling and analysis techniques, recent years have seen a big improvement in this sector. When we consider the IT industry very large companies like Facebook, Google are developing their face recognition modules for their products. We can see the google use their FaceNet face recognition module for google photos and Facebook use their deepface face recognition module for Facebook auto-tagging option.

Stan Z. Li & Anil K. Jain are the editors and they wrote a very valuable book called “Handbook of Face Recognition”. This book has released on the based on two major sections. The first section has highly accurate, complex algorithms and systems for face recognition. The second section has the latest study that is of relevance to facial recognition scientists in image and object representation and matching. The book is for professionals and students who are preparing to work in face recognition or who wish to learn the state-of-the-art in face recognition. It presents references for engineers and scientists who work in the image processing field, computer science, biometric identification and protection, blogs, machine learning, media and computer games industries. “The book consists of 16 chapters, covering all the sub-areas and major components necessary for designing operational face recognition systems. Each chapter focuses on a specific topic or system component, introduces background information, reviews up-to-date techniques, presents results, and points out challenges and future directions”. (Li and Jain, 2005)

Computer vision is a fast-expanding field, due in part to simpler and more powerful cameras, in part to inexpensive computing resources and part to the maturing view algorithms. OpenCV itself plays a part in improving the vision of computers by helping millions of people to function more effectively in vision. When we consider about face recognition OpenCV act a major role even these days. “Learning OpenCV” is another very important book for researchers. That book was written by Gary Bradski and Adrian Kaehler. This book shows an OpenCV tool kit that helps the readers to do something fascinating and enjoyable in computer vision easily. They provide a better knowledge of how algorithms work, which helps the reader to build and modify programs for vision and remind of structured computer vision explanations. Finally, using this book it's easier to understand complex algorithms and their related mathematics. (Bradski and Kaehler, 2008)

Face recognition in computer vision is a trendy area of research and also has wide importance to identify and recognize some important characteristics. Liping Yuan, Zhiyi Qu, Yufeng Zhao, Hongshuai Zhang and Qing Nian who were the authors introduced a convolutional neural network based on TensorFlow for face recognition in 2017 IEEE 2nd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC) at china. They found that unregulated conditions, including side appearance, expression of the face, lighting condition, affect the accuracy of identification, and have low performance in traditional technologies, hence introduced the deep learning technology. A Convolutional Neural Network (CNN) based on TensorFlow, an open-source deep-learning system, was introduced for facial recognition based on face detection. Also, this conference paper has shown that the proposed technology has better accuracy and good processing speed in a complex environment. (Yuan et al., 2017)

"Deep Learning for Computer Vision: Image Classification, Object Detection, and Face Recognition in Python" this is a very valuable book for developers, researchers, students who like to learn advanced technologies like computer vision, image processing, object detection and face recognition. Jason Brownlee is the author of this book and he has a PhD in Machine Learning. This book has designed major deep learning technology that is directly relevant to computer vision problems. Also, gives the broad theoretical and practical knowledge about these technologies and there are plenty of examples to practice them. Image Data Preparation, Convolutional Neural Networks, Image Classification, Object Detection and Face Recognition are some sub-topics of this book and the author has widely discussed R-CNN, YOLO, Keras and Tensorflow under object detection and face recognition sub-topic. (Brownlee, 2019)

OpenCV is an open-source library which includes several hundreds of computer vision algorithms. "The OpenCV Reference Manual" This is a free issue document by opencv.org. In this document broadly discussed about OpenCV. OpenCV basic, Image processing, high-level GUI, video analysis, machine learning, data structures, camera calibration and face recognition with OpenCV are some of the main topics included in this document. (The OpenCV Reference Manual, 2013)

2.2 Similar Projects

- Lahiru Dinalankara from Faculty of Science and Engineering, Plymouth University has developed a face detection and recognition mini-project undertaken for the visual perception and autonomy module at Plymouth University. It discusses the innovations present in the Open-Computer-Vision (OpenCV) library and the methods used to apply them using Python. In this project, he was used the Haar-Cascades for face detection and Eigenfaces, Fisherfaces and Local binary pattern histograms were used for face recognition. This is a very good project but when it is using for real-time recognition it has some accuracy problems. (Dinalankara, 2017)

- Abdelmgeid A. Ali, Tarek Abd El-Hafeez and Yosra Khalaf Mohany from Department of Computer Science, Faculty of Science, Minia University, EL-Minia, Egypt have introduced an accurate system for face detection and recognition through research and it has published Journal of Advances in Mathematics and Computer Science under DOI: 10.9734/JAMCS/2019/v33i330178. This research presents the identification of faces in a live stream using the Local Binary Pattern (LBP) with processed data. That's mean they have used the OpenCV inbuilt face recognizers for their research. First, they detect the face, skin, eye, nose using a combination of Haar cascade files with LBP. This method also can be used to develop a dataset of faces and names for recognition. Like many projects, this system also has the accuracy problem when it is using in live stream and researchers hope to use eye iris for face recognition in the future. (Ali, El-Hafeez and Mohany, 2019)

- D. Mary Prasanna from Department of ECE (DECS), G.Narayanamma Institute of Technology & Science for women, Hyderabad, TS, India has done research called "Development of Real-Time Face Recognition System Using OpenCV". This is real-time automatic face detection and recognition system. This system can be used by registering the employees or students of an institution with their faces as an access management device, and then it really can identify individuals by recording their photographs of faces when they entering and exiting the building. The program has a graphical user interface (GUI) on a computer, it initially recognizes the faces captured from a web camera. Also, she has used many open-source tools for this project like Ubuntu, open face, python. But this system can detect and recognize only frontal views of faces, it can't detect or recognize the side appearance of the faces. (Prasanna, 2017)

- Human faces are a complex entity with a high degree of appearance variation that makes facial recognition a challenging computer vision issue. Accuracy and speed of recognition are the major issues in this field. Alireza Chevelwalla, Ajay Gurav and Sachin Desai from Department of Computer Engineering, Rajiv Gandhi Institute of Technology have done research called “Criminal Face Recognition System”. The research aims to test face detection and recognition technologies and provide a complete solution with a highly accurate, good response time and an initial step towards video monitoring. Also, they have proposed a solution for criminal face recognition based on different face rich databases in terms of subjects, pose, emotions and light. They presented different issues about the method of face recognition, such as lighting and background conditions. But sometimes this proposed system has accuracy problems and they hope to develop the face recognition application which is less vulnerable to incorrectness, failure and performs well regardless of the skin colour. (Chevelwalla, Gurav and Desai, 2015)

- Face recognition means to identify the face from a digital image. An important method for processing the large volume of data is the Deep Neural Network. The convolutional neural network is one of the most popular facial detection tools. Reny Jose from Marian college kuttikkanam, Peermade, Idukki, Kerala has done a research called “A Convolutional Neural Network (Cnn) Approach to Detect Face Using Tensorflow and Keras”. In this research, he has used a deep convolutional neural network (CNN) to extract features from input images. Keras has used for implementing CNN. Also, D‟lib and OpenCV have used for aligning faces on input images. He has used a pertained model and custom data set for face-recognizing. (Jose, 2019)

- “Object Recognition using Tensorflow and Convolutional Neural Network” this is a research article which is published on the International Research Journal of Engineering and Technology (IRJET). This research has done by Shreyansh Sharma and Harshit Panndey from School of Computer Science and Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India. For several useful purposes, we can use the technology of object recognition to improve digital information. For all these purposes a fundamental requirement is the detecting various kinds of objects in a given picture. In this research, they have done the object detection Using TensorFlow, which is an open-source artificial intelligence library developed by Google. In this research, they developed a model to recognize a single object of an image with an accuracy of 67% and hope to develop the multiple models to detect the different type of objects. (Sharma and Panndey, 2020)

03 – Methodology

3.1 Planning

3.1.1 Identifying Business Values

Crime is one of the economic and social vices of this century. The country itself cannot mitigate this threat because of a shortage of money to employ or hire sufficient manpower with the skills necessary to avoid its recurrences. Technological development has come a long way to reduce crimes.

In security systems, facial recognition methods are usually used and it can be related to all other biometrics, like fingerprint or eye iris recognition systems. Face recognition uses the face of a person to recognize and verify the person correctly from a digital image or a video source. It has now become popular as a business identification and marketing tool. Using this criminal face recognition system, a business can get more advantages. Basically this proposed system can be used in hotel premises. As the Sri Lankans last year we faced a cruel terrorist attack associate with the hotel premises. In that time if the hotels had a criminal face recognition system we can protect the many lives and properties from the terrorists.

If a hotel premise uses this face recognition system for their hotel and customers security, they can get many advantages over other biometrics. It is non-intrusive. Although certain biometrics need the participation and understanding of the situation to carry out recognition or verification, such as looking into an eye scanner or putting your hand on a fingerprint reader, even without the involvement of the person, facial recognition can be done. This is a very big advantage for the hotel industry because any guest doesn't like to waste their happy time doing these unnecessary things. So hotel management can establish this criminal face recognition system in their hotel. After the hotel network security admin can investigate their whole hotel premise using CCTV cameras and if there is any criminar he can get further actions. Not only hotel premises, but this security system can also be used in government or private offices, parliament, shopping malls, airport, harbour and many other famous places.

3.1.2 Feasibility Analysis

3.1.2.1 Technical Feasibility

When considering this project more than 80% of the project uses advanced technologies like computer vision and image processing. Although in the backend this criminal face recognition system uses the advanced technologies in the frontend it is a very user-friendly system. If any hotel premise uses this system the network security admin no need to use any special effort. Because this intelligent criminal detector works automatically via CCTV and computer resources. If the system can find any criminer in the hotel premise it will send the SMS, an email automatically to network admin and police station. Also, this whole system has built-in the hosting service, so the hotel no need any hardware or software to run the system. There are two system loggings in this system one for police or CID and one for customers (in here the hotel). The customer logging has limited features only monitoring and notification service, but police logging has monitoring, notification, criminal details adding and removing features.

3.1.2.2 Financial Feasibility

More than 80% of this project uses the software. Hardware uses for only remote control door system. The cost for that prototype hardware system as follows.

Component	Quantity	Unit Price (LKR)	Total Price (LKR)
Solenoid Door Lock (12V)	1	1190	1190
Relay (5V)	1	60	60
Jumper Wires	10	100	100
NodeMCU	1	700	700
Total Cost			2050

Table 1 - Financial Feasibility

3.1.2.3 Organizational Feasibility

Facial recognition is a technology of biometric features that can uniquely recognize or verify a human by analyzing and comparing the facial features of the person. The technology has been used mainly for safety reasons, but now other fields also like to use the face recognition technology for their day today usages.

Basically, this proposed system can be used in hotel premises. Not only hotel premises, but this security system can also be used in government or private offices, parliament, shopping malls, airport, harbour and many other famous places. In many countries, the police department maintains a face database that can be used to match any criminal person to the criminal face recognition database. Previously, thumbprint identification system has been used to identify any criminal person. However, due to unlimited information from the internet, many criminals are knowledgeable about thumbprint recognition. Therefore, they become more cautious about leaving thumbprint by wearing gloves.

It is easier to track down burglars, thieves and trespassers using this criminal face recognition system via public or private CCTV camera networks. This system is not limited to detecting criminals. Also, it can use to find missing children and seniors. The use of criminal facial recognition system at airports has been shown to improve protection and also speed up procedures like check-in. The South Wales police in the UK use cameras installed on vans to make it easy to track the crowds.

Retail crime prevention is another benefit of facial recognition. “The retail industry loses an estimated $45 billion every year to shoplifters and other retail crimes, with very little to counter it with. Now, companies like FaceFirst are helping retailers use facial recognition to detect previous offenders and alert security officers”. (Thakur, 2019) Finally, if used properly and proportionately, criminal face recognition will help safeguard the people and increase national defence.

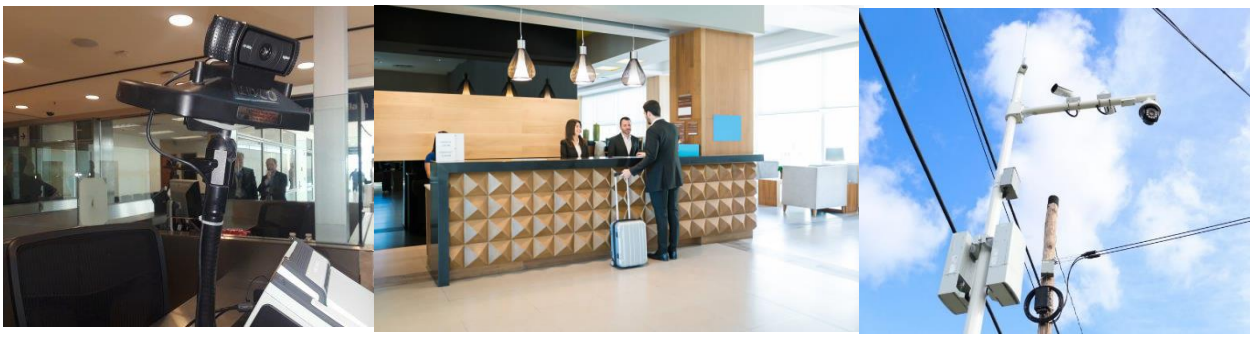

Figure 2 - Suggestion places for the system Source: (News, 2019)

3.1.2.4 Legal Feasibility

This criminal face recognition system based on the police department of the country. Because every country has a criminal database and it maintains by the police department. So this face recognition model can train by the police department. Otherwise, it can give this whole system to the third party IT Company. But it must be a very legal and secret process. Because the personal details of the persons are privacy things and anyone can't misuse it. So for better security process it is suitable building and maintaining this system by the police department. Also, this system can be hack so there must be used a very strong password. Implementing a criminal face recognition system in a public place is a very difficult thing and has to get legal permission.

3.1.3 Work Plan

Task Name	Duration	Start	Finish
Milestone 1 - Project Proposal Submission	**21 days**	**5/7/2020**	**26/7/2020**
Define project topic and allocate with supervisor	7 days	5/7/2020	12/7/2020
Literature review and analysis	7 days	12/7/2020	19/7/2020
Project Proposal	7 days	19/7/2020	26/7/2020
Milestone 2 - Preparation and Programming	**93 days**	**26/7/2020**	**30/9/2020**
Obtain requirement skills	42 days	26/7/2020	13/9/2020
Choose relevant hardware and components	14 days	2/8/2020	16/8/2020
Design a process chart	7 days	16/8/2020	23/8/2020
Training part of face recognition model	30 days	1/9/2020	30/9/2020
Milestone 3 - Development and Testing	**42 days**	**27/9/2020**	**8/11/2020**
Design of final prototype, web UI and App	14 days	27/9/2020	11/10/2020
Development of the prototype	14 days	11/10/2020	25/10/2020
Testing of the prototype	14 days	25/10/2020	8/11/2020
Milestone 4 - Evaluation and Report Writing	**111 days**	**13/9/2020**	**27/12/2020**
Project report writing	90 days	13/9/2020	3/1/2021
Final prototpe testing	7 days	6/12/2020	13/12/2020
Critical evaluation and conclusion	7 days	13/12/2020	20/12/2020
Define positive and negative sides	7 days	20/12/2020	27/12/2020

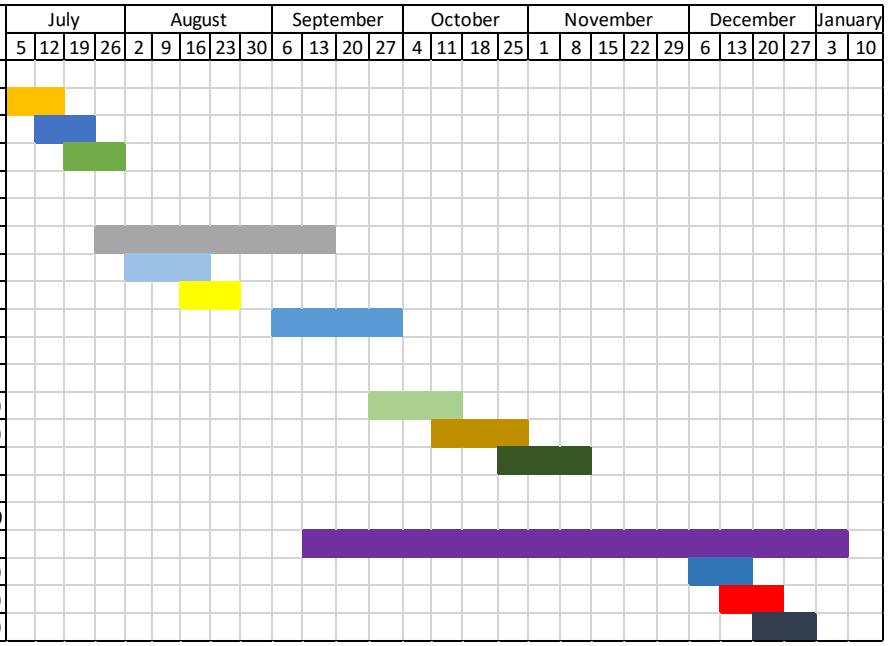

Table 2 - Work Plan

3.2 Analysis and Requirement Gathering

3.2.1 Analysis

The analysis process enables us to develop a viable technical solution to our academic question before making it into a reality. The method of designing is a systematic approach, which consists of four phases.

1. The purpose of the criminal face recognition system - The aim of this phase is evaluating the declared purpose of the system and how to success that purpose through facial recognition. This critical evaluation can question the purpose or meet the expectation. An example could be to prevent a terrorist from attacking a hotel complex.

2. The methods to achieve the purpose - This process aims at analyzing and questioning the methods to achieve the purpose of using technology such as facial recognition. The process defines the technique followed by a computer system or human operators to achieve this purpose. As an example, a hypothetical way to achieve the purpose of preventing a terrorist from committing an attack to a hotel premise could be to control, when accessing the hotel, that the face of the guest relates to a digitally printed photograph associate with a valid pass in the system, and this photograph or the identity of the guest is not contained in a police database. But doing such a thing is not appropriate for the hotel premise because access control is not suitable for a hotel and it can cause a customer unsatisfaction as well as breaking the hotel brand name.

3. The usage of face recognition technology to achieve the purpose - This phase aims to query the usage of face recognition to attain the purpose without mentioning the particular technology. In the example of the hotel premise, face recognition can be implemented at the entrance used by guests to get access to the premise. When the guest arrives at the entrance, the CCTV camera automatically gives the real-time transmission to the backend workstation and it can analyze the face of the video. This process is then used in the criminal database to automatically check whether or not a person with that face has a reservation. It this phase the face recognition system should work perfectly. Also, it should work accurate, free of bias and secure overall. Also, it should be safely managed the related criminal database.

4. The implementation of criminal face recognition in a suitable system - This process aims to examine the application of criminal face recognition by analyzing the program's technical information. So the advantages and risks of the system can take as main things of this phase.

These four phases can take as major analyzing stages of the criminal face recognition system. So each of these phases must be described and analyzed for customers of this system.

3.2.2 Requirement Gathering

Criminal Face recognition is a method of identifying or verifying the identity of a criminer using the face. This system can be used to identify a criminer using real-time video. In here, for the prototype used the several persons as the criminals. Because can't get the real criminal's details from the police department and can't use the real criminals for the system testing. So used the six-person faces for the training model and used 50 to 120 faces images from one person.

In real-world police departments can use face recognition frequently. Police can gather photographs from prisoners and associate them with databases of local, national, and international facial recognition. Because every time does these illegal things by previously listed criminals. As well as can use this criminal face recognition system to identify the criminals in images taken from CCTV, traffic cameras and social media like Facebook/Instagram.

3.3 Designing

3.3.1 Physical Design

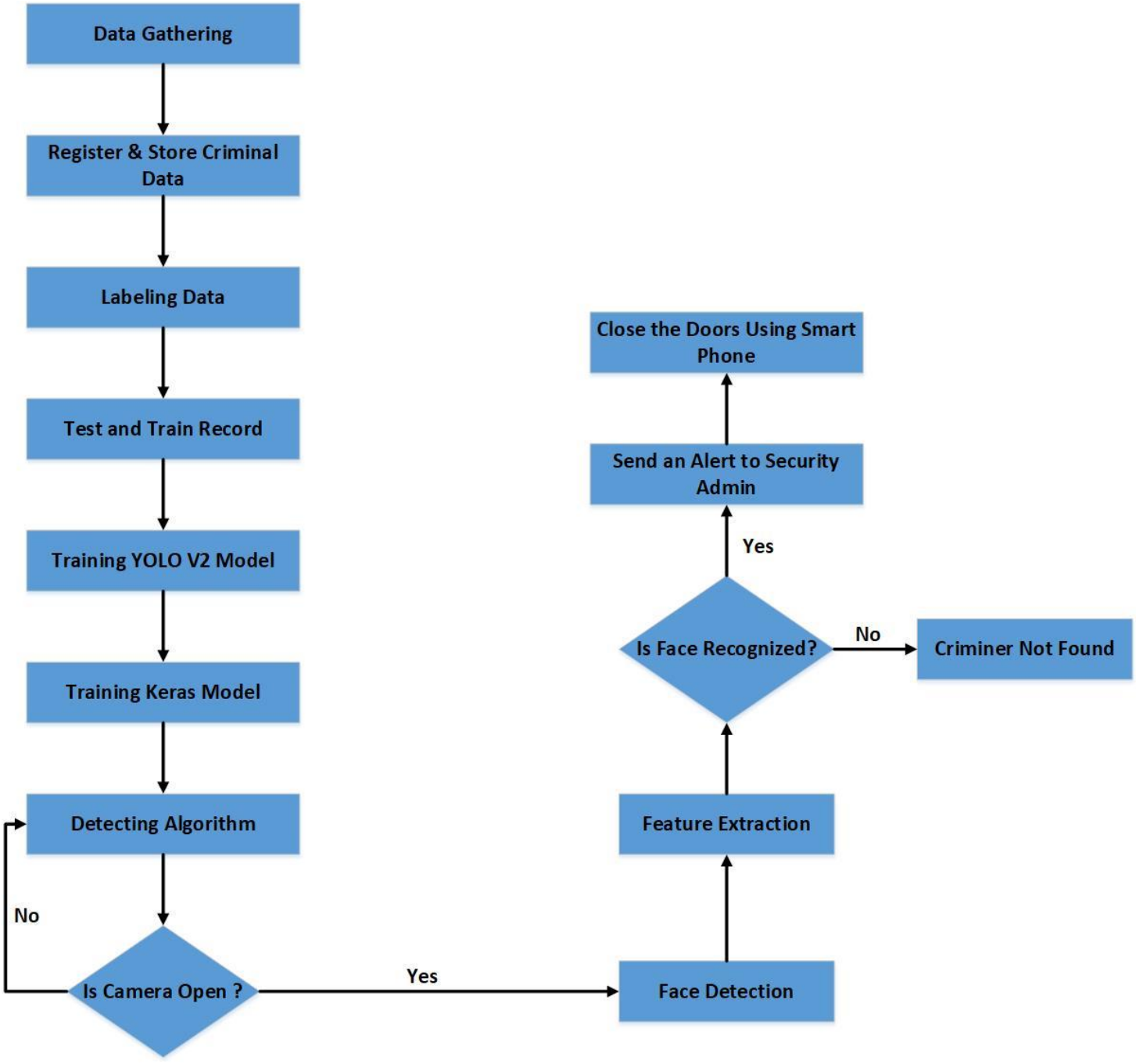

Figure 3 - Flow Chart

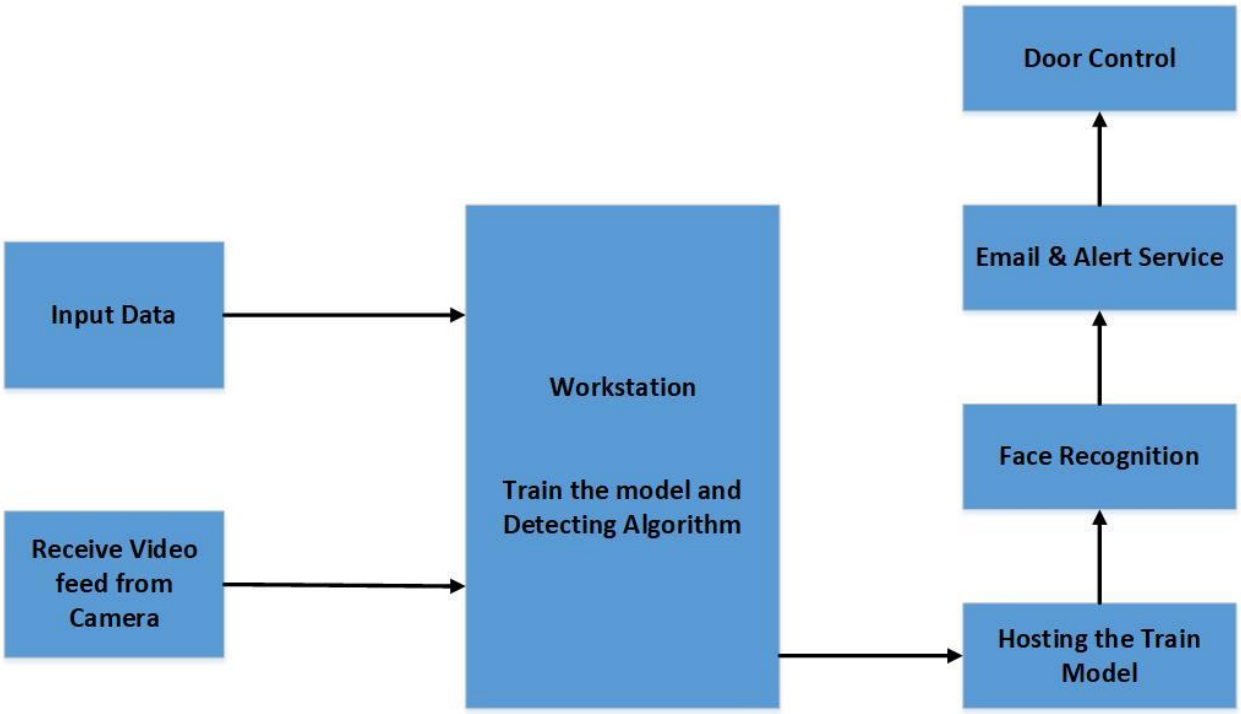

Figure 4 - Block Diagram

More than 80% of this project is software based and door lock part is the hardware part and below has the wiring and Assembly diagram.

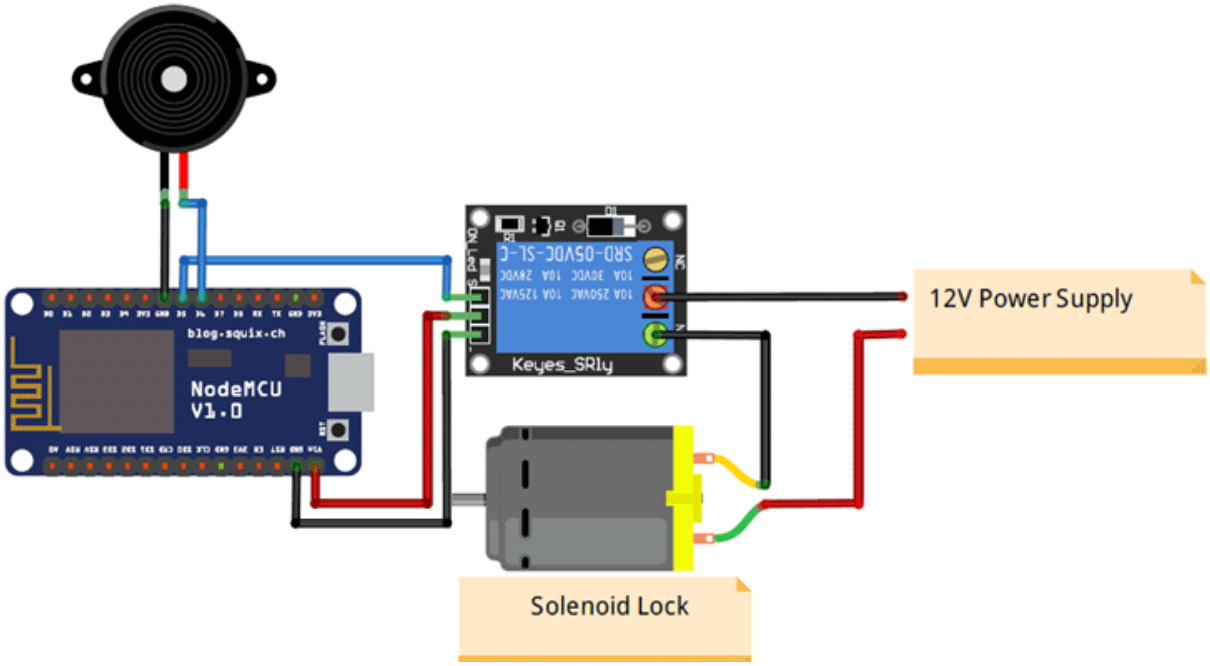

Figure 5 - Wiring and Assembly diagram

3.3.2 Architecture Design

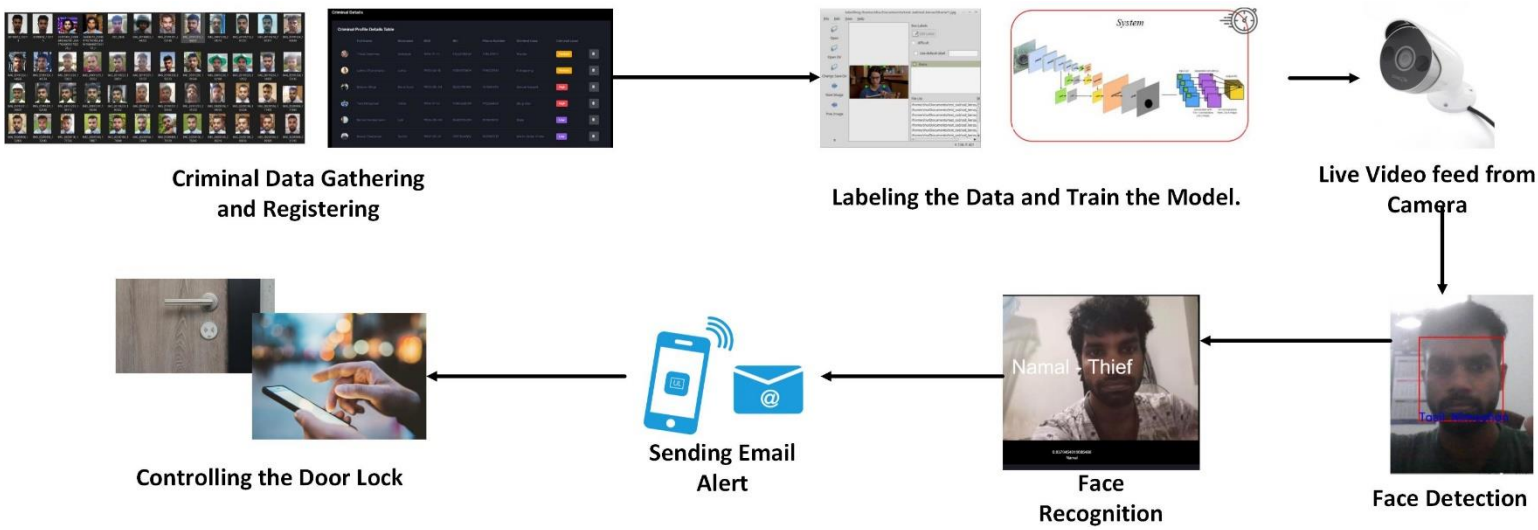

Figure 6 - Architecture Design

Above has indicated the whole system architecture. There is a camera focus on the guest entrance door in the hotel premise. When the guest arrives at the entrance, the CCTV camera automatically gives the real-time transmission to the backend workstation and it can analyze the face of the video. This process is then used in the criminal database to automatically check whether or not a person with that face has a reservation. If the system found there is a criminal face in the live video feed, the system will generate an automatic email and SMS alert to system security admin. After that system admin can take a decision that our hotel is now in security trouble, so important parts of the hotel should protect behalf of the protection of lives and properties. So admin can close some doors using his mobile phone.

3.3.3 Interface Design

When this system used in the real world, additionally criminal face recognition the system should work with a user friendly interface. Then anyone can use the system easily. The training model, criminal data SQL database and web user interface are hosted in “HEROKU” platform which is a cloud platform as a service (PaaS) that supports many programming languages. Also, developers use it to release, maintain, and expand the modern applications. It is stylish, customizable, and easy to use.

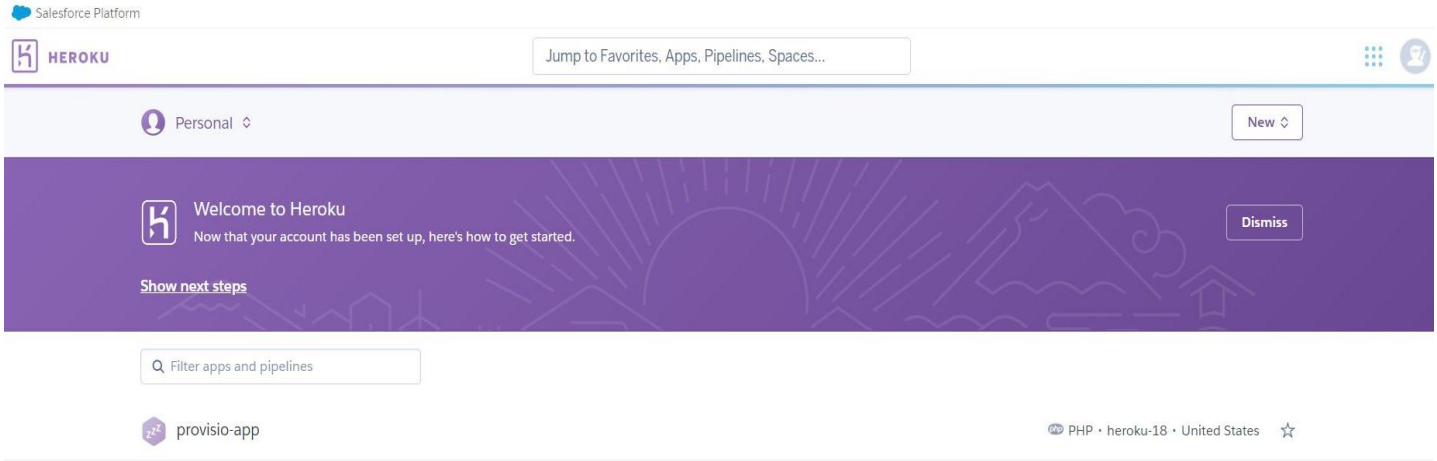

Figure 7 - Heroku Platform

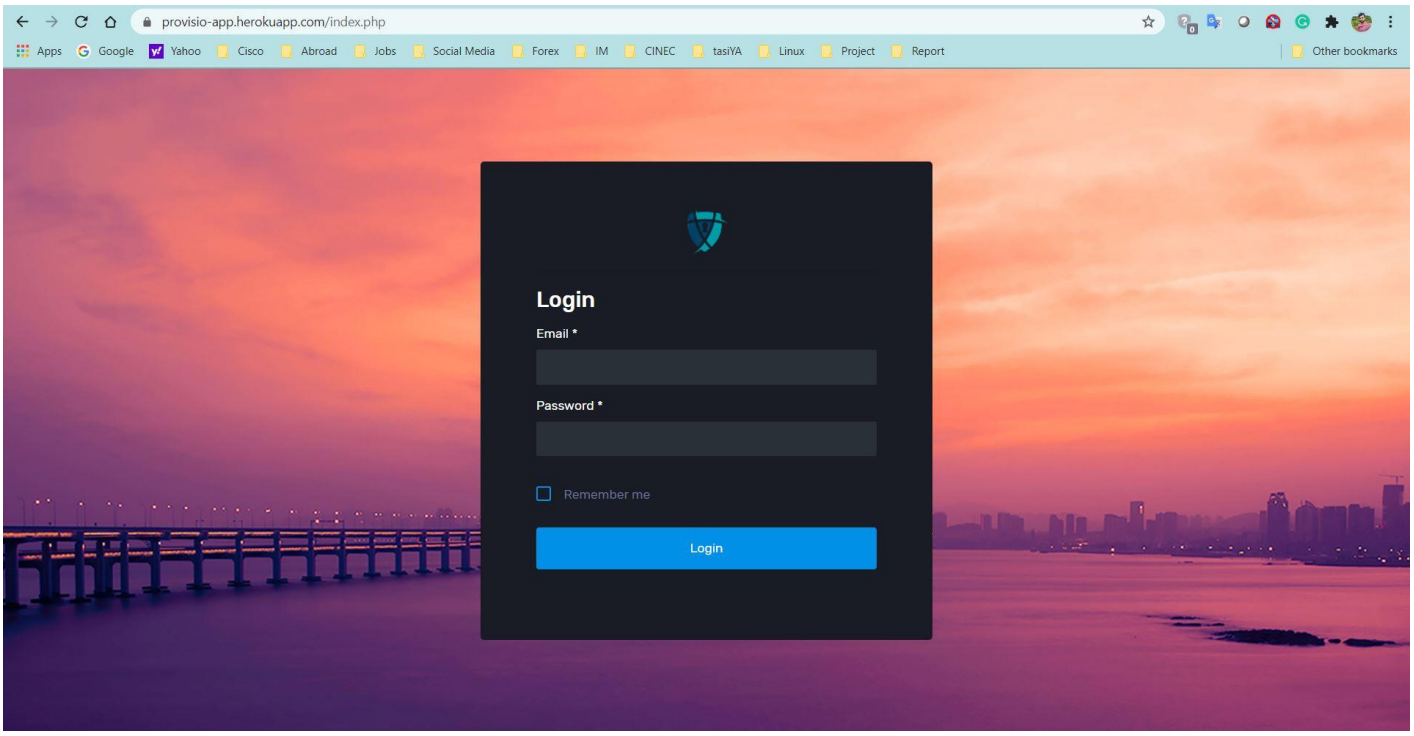

Figure 8 - Login User Interface of the System

PHP, HTML and JavaScript programming languages are mainly used for the web user interface. Also, there are two login mails called admin@gmail.com and officer@gmail.com. It has two different options for these emails. admin@gmail.com has reserved for system developers and authorized persons who in here police department. Also, this email has reserved for more features like criminal face recognition, adding and removing criminals from the database. officer@gmail.com has reserved for customers, in this case, hotel security admin. This email has reserved limited features only criminal face recognition and viewing the criminal database.

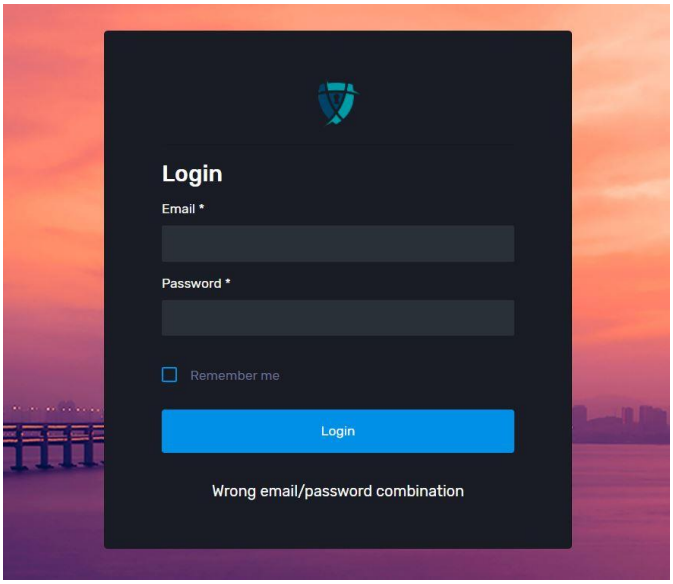

Figure 9 - Trying for wrong logging

Figure 10 - System Logo

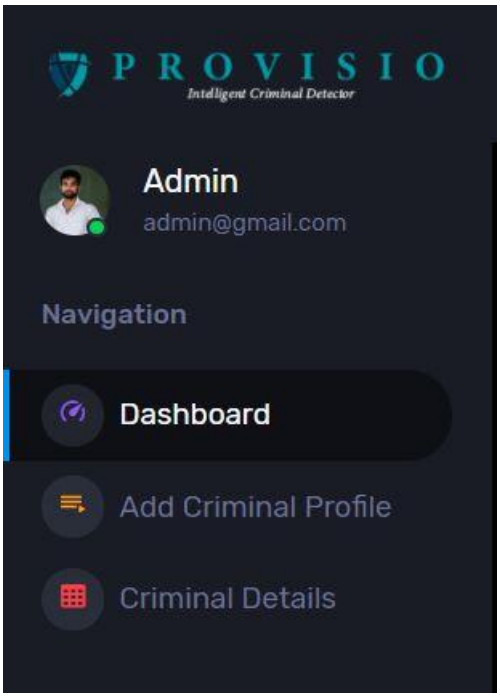

Figure 11 - Features for admin logging

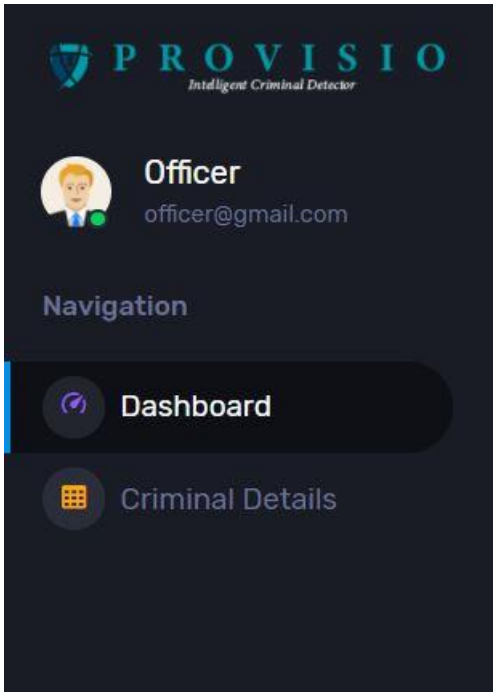

Figure 12 - Features for officer logging

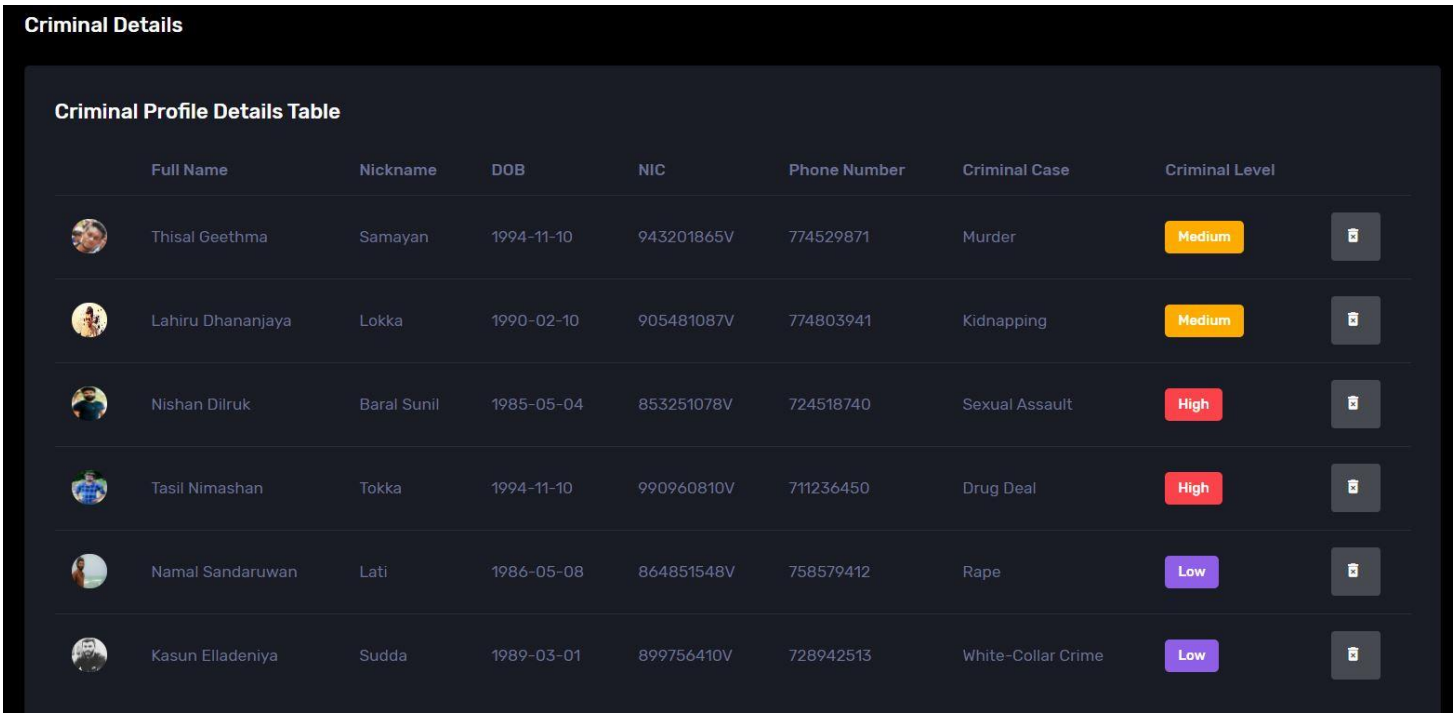

Figure 13 - Criminal Database

As a prototype in this project is used the six-person details for criminals. After the entering of criminal details, those data will save in the MySQL database which is hosting in “HEROKU”. After the face recognition, the system will show the detection history right side of the web user interface.

Figure 14 - Detection History

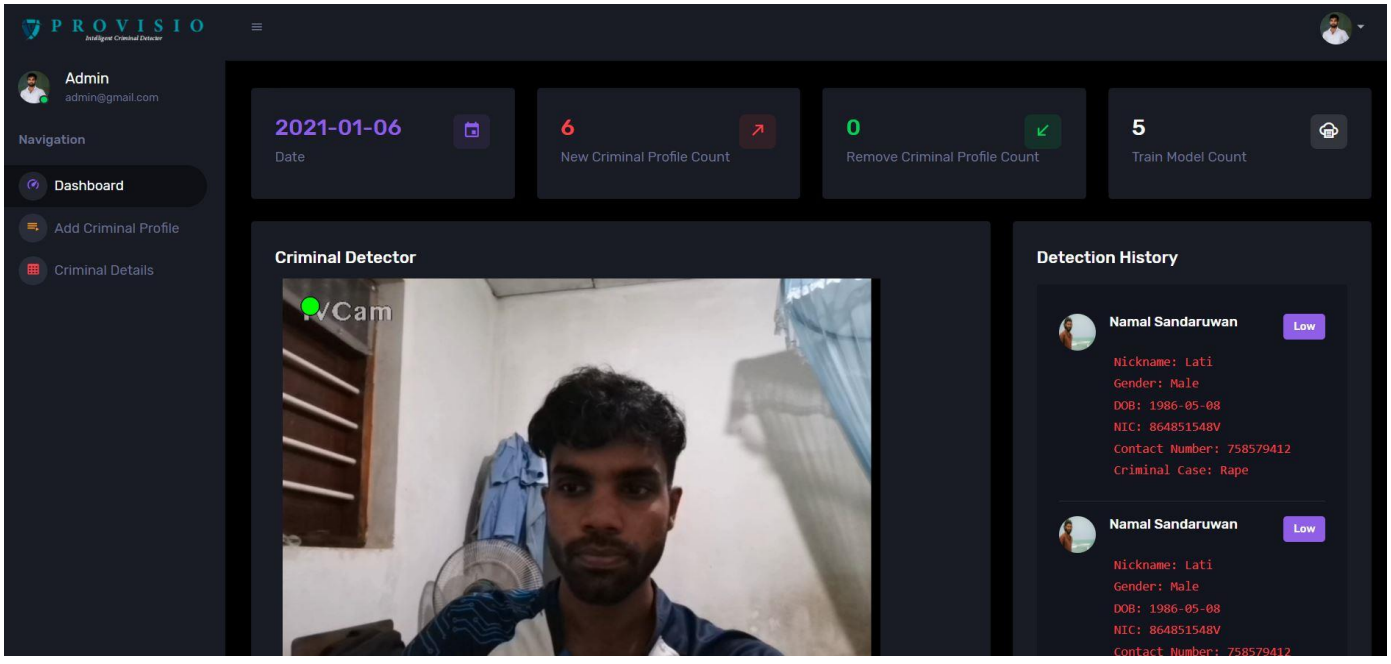

Figure 15 - Full Web User Interface

If the admin wants he can use or monitor the system using a smartphone or tablet. But in this scenario, it is not practical.

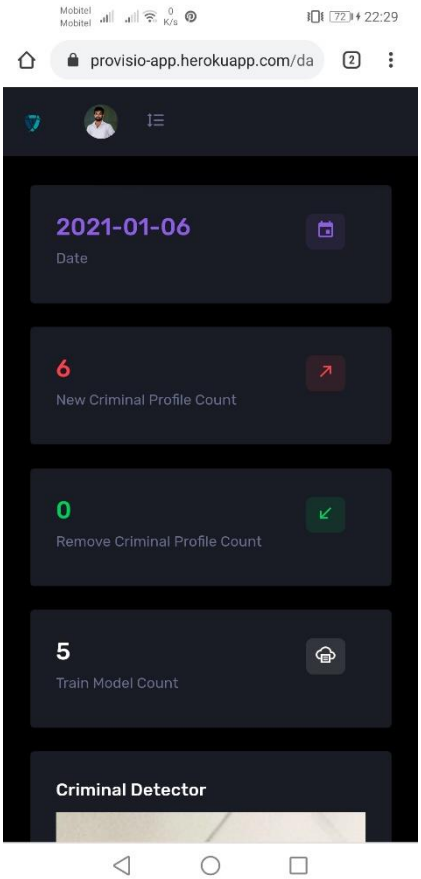

Figure 16 - The system using a smartphone - 1

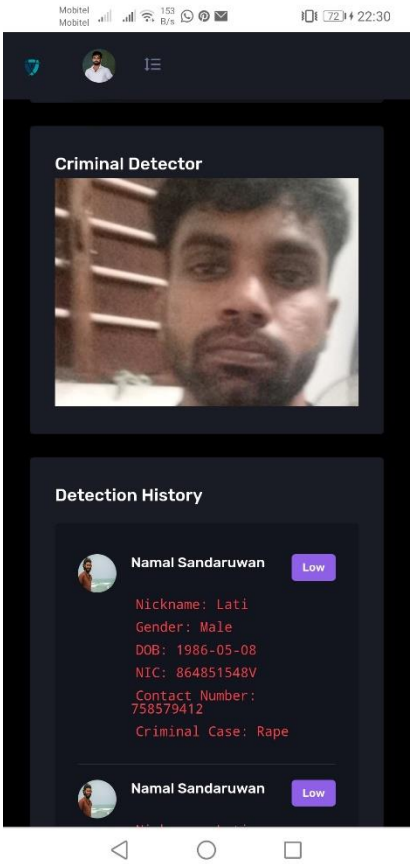

Figure 17 - The system using a smartphone - 2

Other than the criminal face recognition system, there is also remotely door control system in this project. For that part, it has also the app called “My Hotel Security”. It is developed using the MIT app inverter, which is a visual development tool that helps anyone to develop fully functioning mobile and tablet applications. Also, it’s logging database and functional database is hosted in Google Firebase.

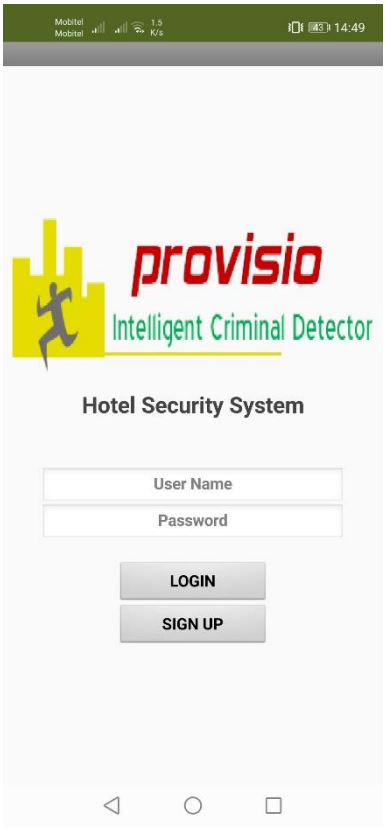

Figure 18 - Logging Interface of the App

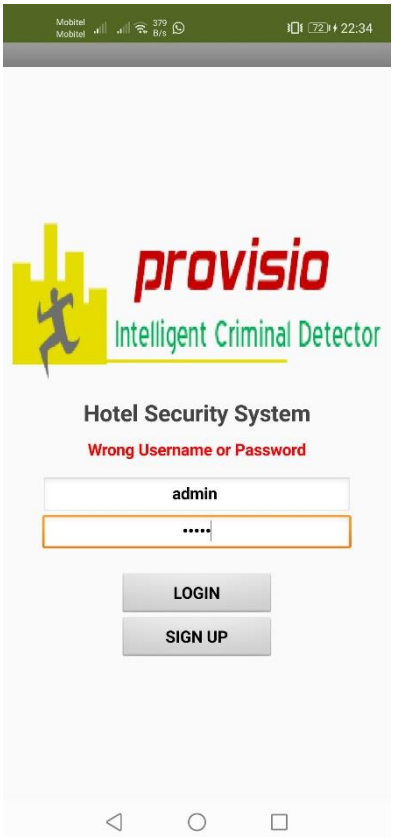

Figure 19 - Access denied for wrong username or password

Figure 20 - Control Interface of the App-1

Figure 21 - Control Interface of the App-2

3.4 Implementation

To develop the system, the machine learning approach has been used. Initially use algorithms to determine the features and for machine learning approaches used python environment. Therefore, to develop the proposed system Python and related frameworks and libraries have been used. Pycharm IDE and Jupiter notebook were used to implement the python related codes. To execute the code, anaconda prompt was used and TensorFlow has been used to work internally.

GPU optimized trained weights for computer vision activities. To use the GPU of TensorFlow, need an NVIDIA GPU. The NVIDIA® CUDA® Toolkit is a popular parallel computing platform and programming NVIDIA model. GPU accelerated CUDA libraries can be used across multiple domains such as linear algebra, graph analytics, image processing and deep learning. In system development, this method has been used to develop models. Google Colab is a platform environment provided by Google where it can use free GPUs. It helps to improve the development of deep learning libraries. In order to develop the system this has been tried previously, but it did not support real-time object detection because there is a scarcity of access to the webcam and it needs to use web APIs to interact with a camera

YOLOv2 608x608 used to develop models, in order to detect and classify images as faces. Firstly, tried with only OpenCV library but compared to it, YOLOv2 model is speedy and has higher image resolution and accuracy than OpenCV. The YOLOv2 608x608 was selected because it is a high speed, realtime detection algorithm (Medium, 2018). There are two models and it consists of classes and inside those classes, thirty filters have been created in each. Inside the model that are using images are cropping and crop faces are detecting using Keras Xception because Keras Xception is a model that developed in the TensorFlow network and it can detect tiny features in an object and it is a top-level model when using Keras (Keras.io, n.d.). When detecting images the system ignores the blur images. Libraries that were used and try to develop the model in the system - NumPy, Keras, matplotlib, pils, Tkinter, OpenCV, TensorFlow.

- Gathered information related to the project - This system can be used to identify a criminer using real-time video. In here, for the prototype used the several persons as the criminals. Because can't get the real criminal's details from the police department and can't use the real criminals for the system testing. So used the six-person faces with details for the training model and used 50 to 120 faces images from one person.

- Created a data set by images of faces (Data Set) - A dataset has been created by taking photographs of about 80 to 120 images per person to identify specific features in the face, in order to train the data set and for testing in different environmental conditions. Data has been created using the pre-processing technique to increase the visual appearance of images and improve the impact of datasets. Here, it does some conversion of high-resolution images to low-resolution images and the images are captured in a wide variety of environments, in association with lighting conditions and background.

- Labeled the gathered data (faces) - After created the data set, labeled the faces separately by using the labelImg tool. LabelImg is a free and open source tool which is an object bounding box in the image.

- Creating train.txt and test.txt - The collected images needed to split into two groups with the purpose of training and testing. After training images, they are able to test using the images that were not used while training to encourage generalization and to prevent overfitting.

- Trained YOLOv2 model - With the intention of developing the models to detect objects as faces, the YOLOv2 608x608 a high-speed real-time detection algorithm has been used. Before training the labeled images, define YOLOv2 files as .data, .names, and .cfg. Configuring.data is the custom class that was created to introduce the image paths such as train.txt and test.txt and contains the categories that are needed to detect. Configuring.names is to fill the contents with the name of the custom class and Configuring.cfg is to define the architecture which is the YOLOv2 608x608 and set batch, set class as one (classes =1) since it is the number of categories needed and set filters as 30 (filters=(classes + 5)*5=30).

- Trained Keras model - To develop the system Keras Xception model has been selected because this model is able to be used for feature extraction, prediction and fine-tuning. This model gets a 0.790 of top-1 validation, a 0.945 of top-5 accuracy and the 299x299 default input size (Keras.io, n.d.). When detecting faces, face images are transferred into invert (grayscale) images, since the faces are having the same colour and in order to get an image feature clearance.

- Detected the criminal faces using an algorithm according to the model - Trained data model is recognized by the camera. According to the face detection algorithm, the system will detect the face. P5.JS has been used to get the computer-aided vision. First using the YOLOv2 model it detects whether the object is a face or not. Through the model, the

object is crop according to the faces. After that, the Keras model is used to detect the faces uniquely.

- Faces are detecting only if there are 80% of accuracy - The accuracy rate of the trained data model (threshold) allocated as 80% and above, in order to recognize the faces.

- Sending the email and message alerts – If there is accuracy for a recognized face using the trained model, the system will a send email and Whatsapp message to the hotel network security admin. A python script is used for this part.

- Controlling the doors – If the admin received an email he can close some doors on behalf of the protection of lives and properties. This part of the project was made as a prototype system. As the main control part used an ESP 8266 NodeMcu board. Also, 12V solenoid door lock, a relay and an AC adapter were used for the prototype. The admin can control the doors (close/open) anywhere in the hotel premise using the app called “My Hotel Security”. MIT app invertor was used for this simple app because it is easy to use, has a GUI block-based interface and support for google firebase. First, the app has a logging interface and it is designed for security purpose. The database of the logging interface has stored the google firebase. When the app gives the command, firebase stored the signal according to it and pass for the NodeMcu board. Every time google firebase gives an interconnection between the app and NodeMcu.

3.5 Testing

3.5.1 Unit Testing

First, gathered six persons face images as criminals. Gathered 50 to 120 images per person and all they were different environment, different light conditions and different appearances. Most of the images were high-quality images and reduced the size using Format Factory software. Also, all images were cropped.

Figure 22 - Resize Image Set

Then LabelImg tool was used for faces label in images. Also, it saves files as XML file format and support YOLO format.

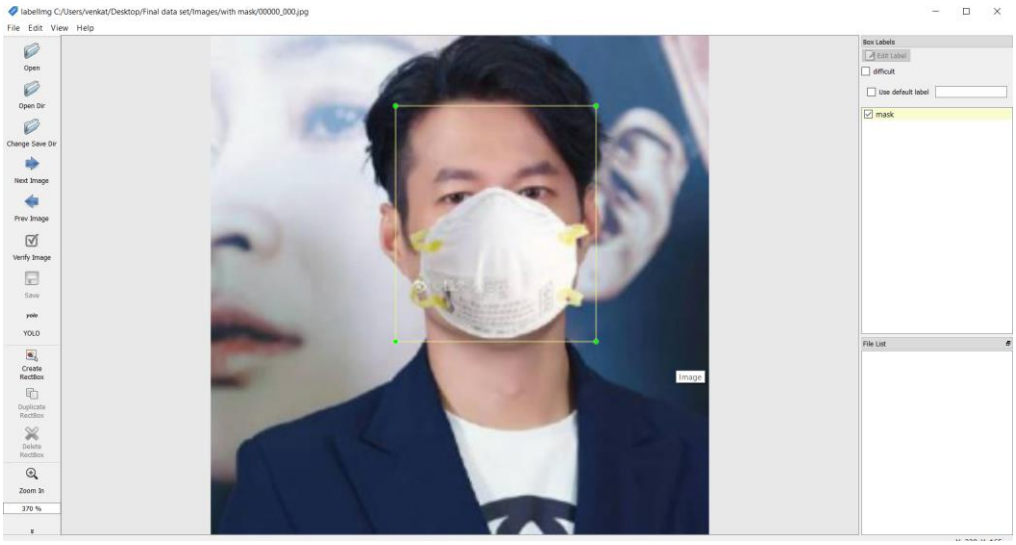

Figure 23 - LabelImg Tool Source: (medium, 2020)

YOLO Model Training

To develop the models to detect objects as faces, the YOLOv2 a high-speed real-time detection algorithm has been used. It gives very high detection accuracy than R-CCN and SSD.Object.data, Obeject.name and Object. Cfg files was created to know how and what to train. Batch =64(every training step has 64 images), subdivisions=8 (this will divide the batch by 8 to decrease the GPU RAM usage), classed=1(detection categories) and filter=30.

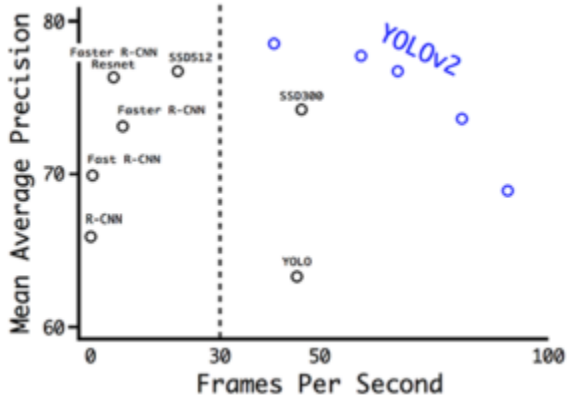

Figure 24 - Speed vs Accuracy Curve for different object detection Source: (geeksforgeeks, 2020)

```
classes= 1
train  = train.txt
valid  = test.txt
names = obj.names
backup = backup/
```

Figure 25 - Making changes of object.data file

After the all YOLO model was trained success fully.

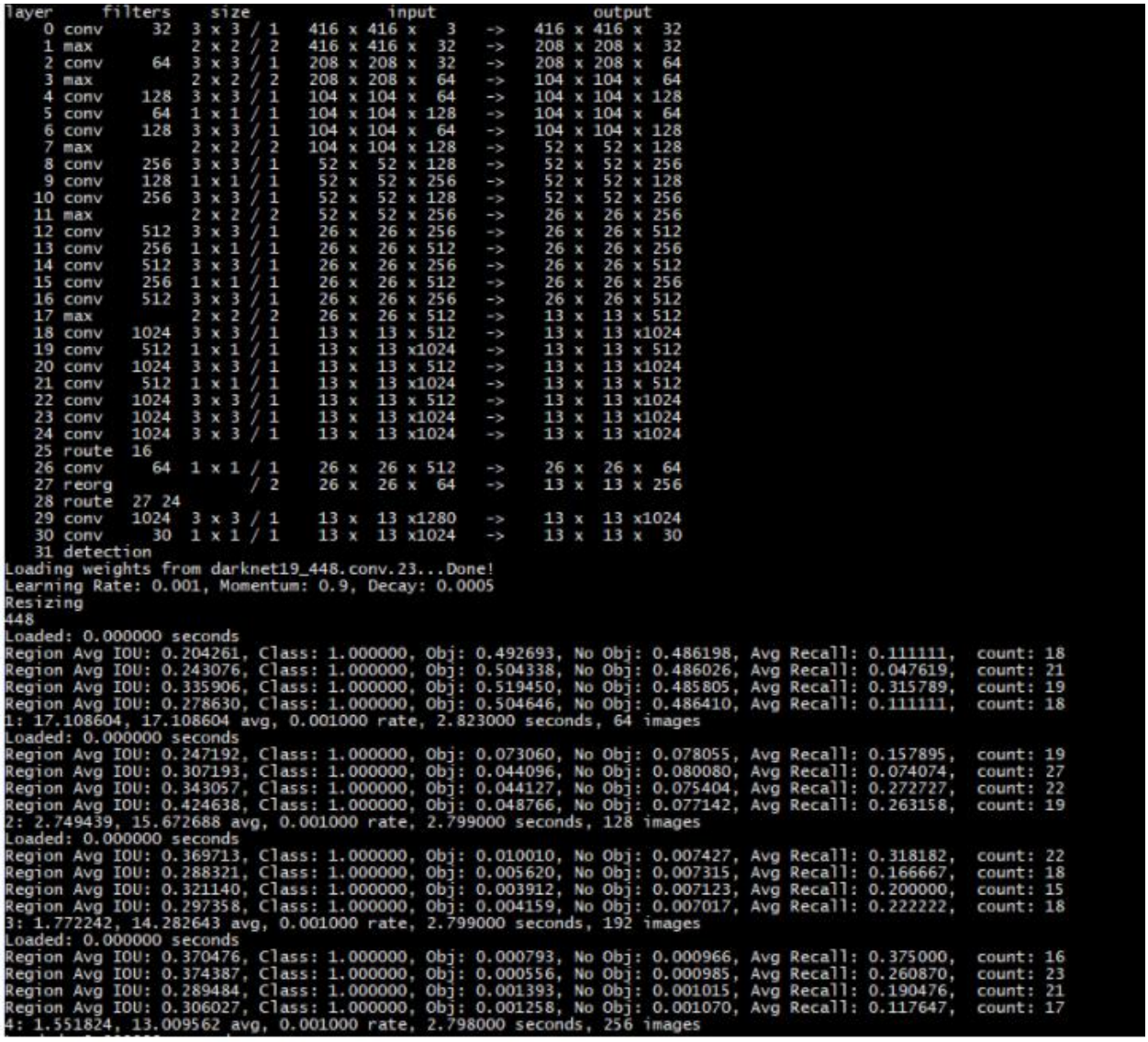

Figure 26 - Training YOLO Model

Door control App making

For this used the MIT app invertor and Firebase used as a database. Using the blocks of MIT tried for the final result of the app.

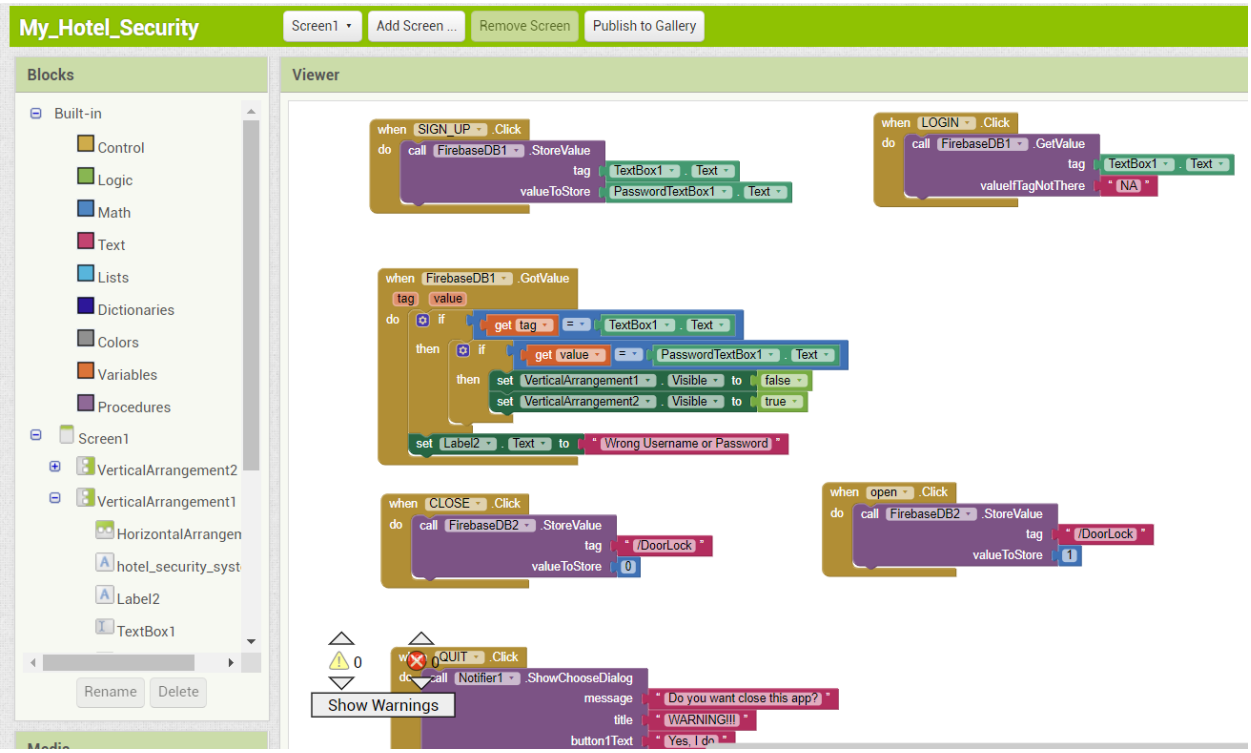

Figure 27 - Blocks of MIT App Invertor

https://iot-door-lock-e9c50-default-rtdb.firebaseio.com/

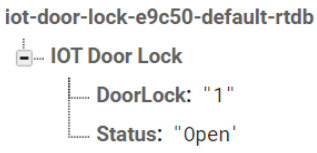

Figure 28 - Firebase for Door Lock Control

https://my-hotel-security-default-rtdb.firebaseio.com/

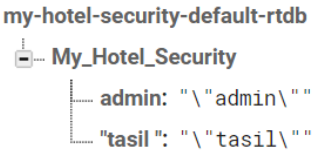

Figure 29 - Firebase for app logging

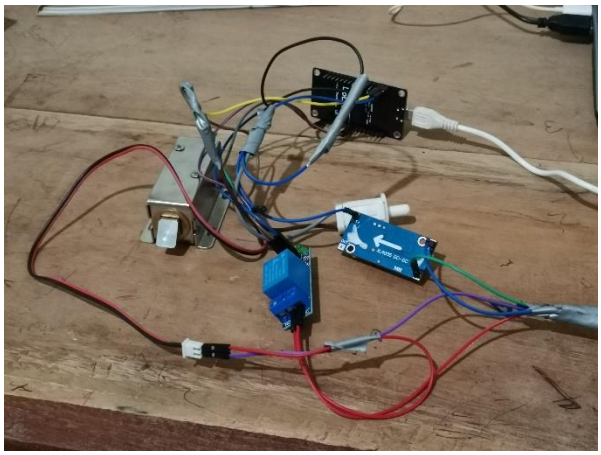

Figure 30 - Testing Solenoid Lock

Database Testing

Previously used the Freehostingeu.com for hosting, database and domain services. But it was very slow and sometime it didn't work correctly. So now using HEROKU for these services and it gives the very excellent free service.

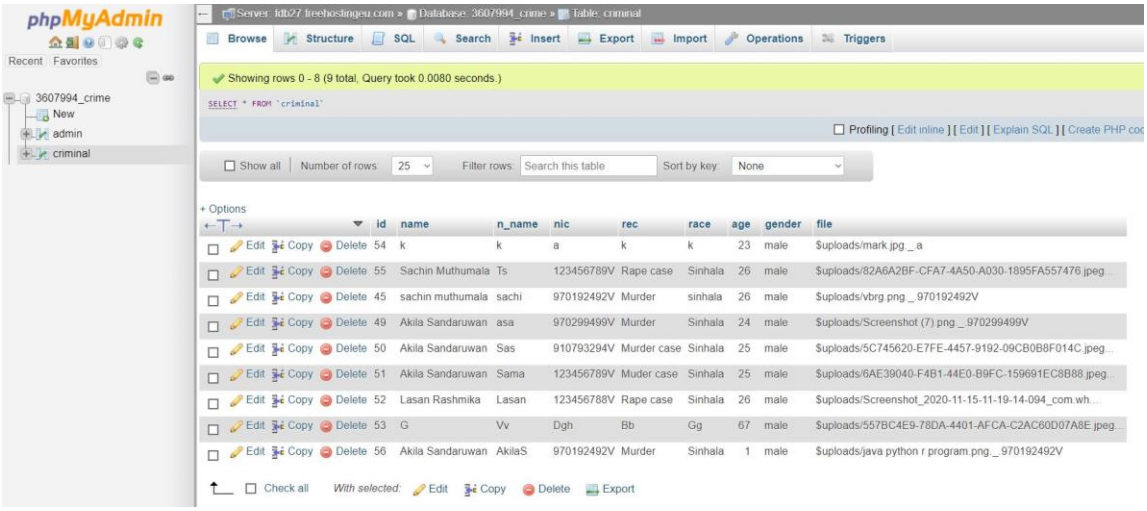

Figure 31 - Hosting service of frehostingeu.com

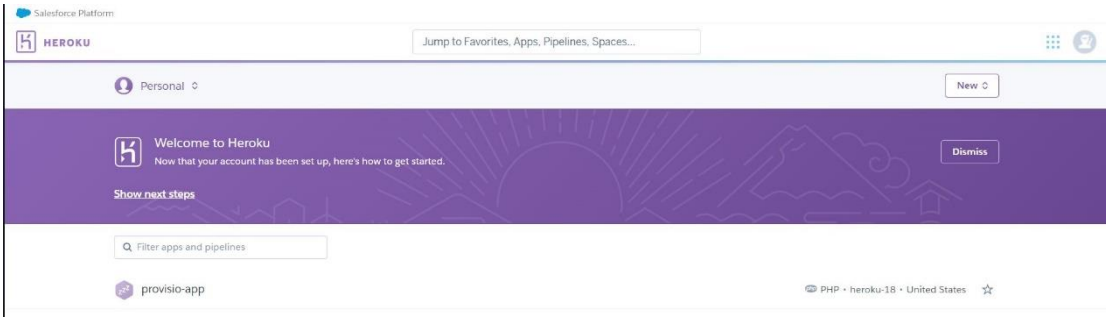

Figure 32 - Hosting service of Heroku.com

3.5.2 Integration Testing

Neural network implementation

The neural network has been implemented with TensorFlow. The YOLOv2 is a real time object detection system and provides more insights about the parameters and working with algorithms. YOLOv2 includes the actual training set, and the test set: test.txt and train.txt files and creating models. The YOLOv2 has great strides towards very multiple localizations of objects and its implementation by using Keras, which is a high-level deep learning library. Classification refers to detecting if a given object is available inside an image or not which is whether the object is a face

or not. Then in the model, it is needed to set classes and filters. In this system, one class and thirty filters have been used. Darkflow is a deep learning library that is used to translate darknet into TensorFlow.

Keras is deep learning models and these models can be used for feature extraction, fine-tuning and prediction. Here, Keras Xception model has been used to image classification and it gets validation accuracy of 0.790 on top-1 and validation accuracy of 0.945 on top-5 (Keras.io, n.d.). Keras Xception model used to detect the features of faces.

Web User Interface

This criminal face recognition system has a very attractive user interface because it gives an easy to the use. For building the interface is used PHP, HTML, JS and CSS. Also, it is hosted in Heroku. MYSQL is used for the database. Checked the interface parts one by one and all are working perfectly.

3.5.3 System Testing

In this section check whether the whole system has met the functional and non-functional requirements. First checked the data gathering part criminal data registering part. All have done correctly. Then did the faces labelling using LabelImg tool and all are ok. The most important and difficult part of the project is training the YOLO and Keras model. Finally, the model gives satisfactory results. The web UI is another important part and difficult part. Checked every steps and section of the user interface all are working well. Sending an email and SMS is another section. Now email part is ok and working well, but sending an SMS is the challenge. Because free SMS gateways are not working well and it gives freely only a few messages. Still trying to solve the problem using a WhatsApp API. Last part otherwise hardware part of the project is the remote control door lock. It has built using nodmcu, firebase and MIT app. It is working well.

04 – Artifact

4.1 Academic Findings

In this project, the academic question was “How to protect our hotel premises from the recognized criminals?”. Finally, the project has done completely and gives all expected results. Now, this system can be used to identify criminals using real-time streaming. Not only the hotel premise but also can use the system in any public place. In here, for the prototype used the several persons as the criminals. Because can’t get the real criminal's details from the police department and can’t use the real criminals for the system testing. So has used the six-person faces with details for the training model and used 50 to 120 faces images from one person.

There is a camera focus on the guest entrance door in the hotel premise. When the guest arrives at the entrance, the CCTV camera automatically gives the real-time transmission to the backend workstation and it can detect and recognize the face of the video. This process is then used in the criminal database to automatically check whether there has or not a reservation for the detected face. If the system found there has a criminal face in the live video feed, the system will generate an automatic email and WhatsApp message to system security admin. After that system admin can take a decision that our hotel is now in security trouble, so important parts of the hotel should protect behalf of the protection of lives and properties. So admin can close the entrance and other important doors using his mobile phone. For door controlling part has built a prototype system. It gives satisfaction results which are controlling (open/close) the door lock using an app. Finally, the software and hardware parts of the project give all the aspect results and answer the academic question.

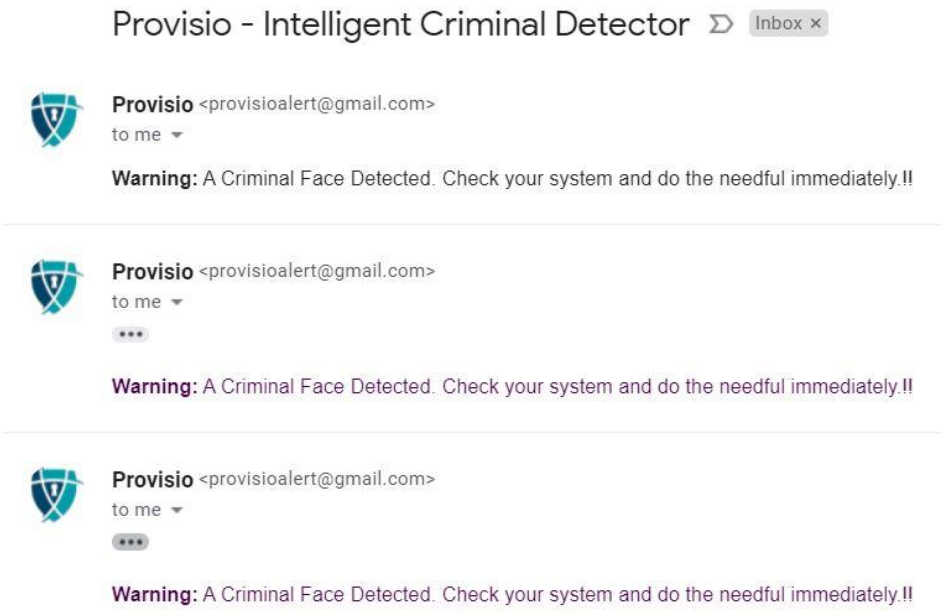

Figure 33 - Email Alert

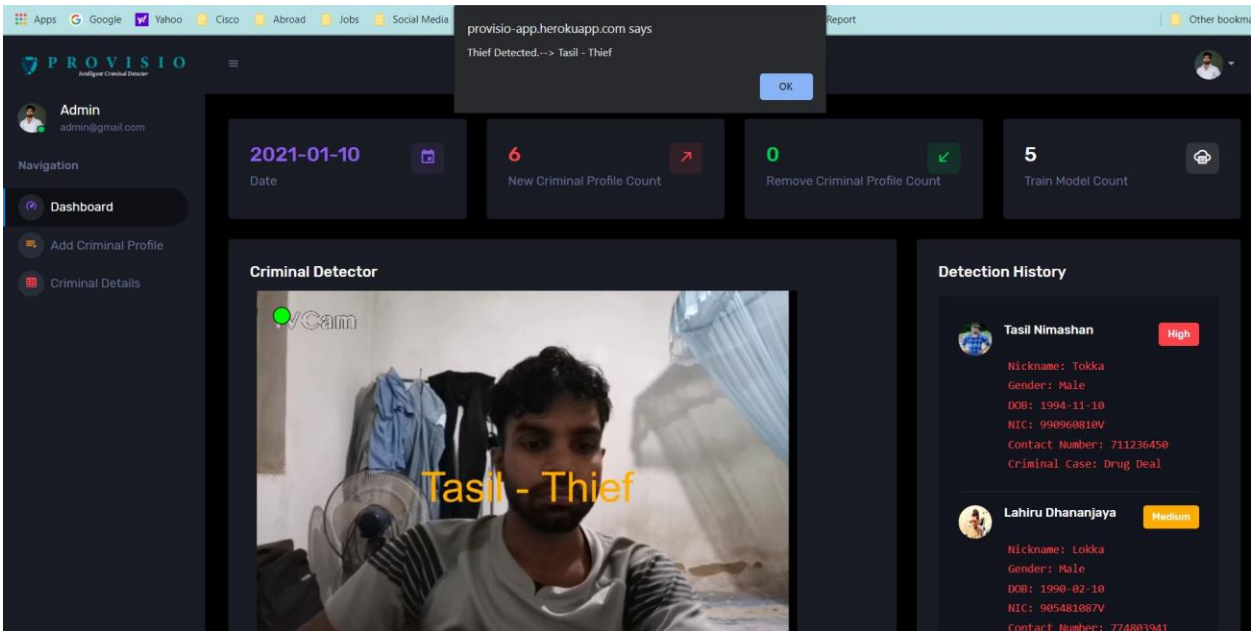

Figure 34 - Final Face Recognition System

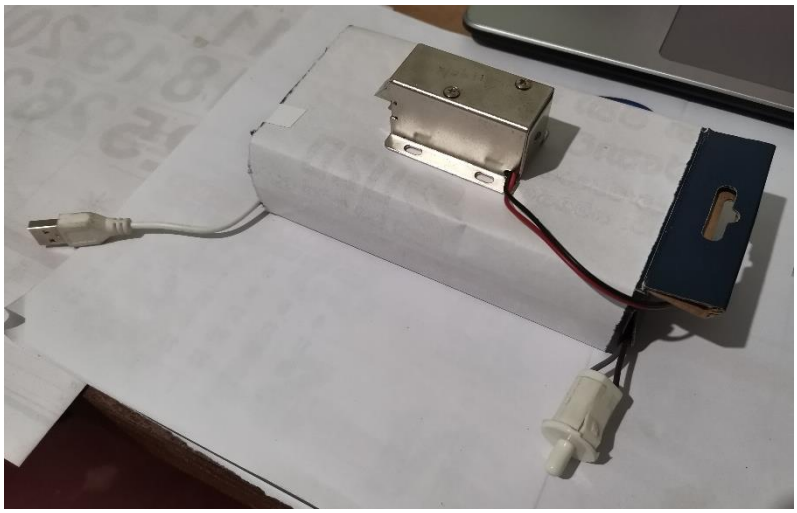

Figure 35 - Final Door Lock System

4.2 Sample Code

Code of IOT part

- First,define the libraries then make the connectivity between NodeMcu and firebase.

```
#include "FirebaseESP8266.h"

#include <esp8266wifi.h><ESP8266WiFi.h>

#define FIREBASE_HOST "iot-door-lock-e9c50-default-rtdb.firebaseio.com"
//https://iot-door-lock-e9c50-default-rtdb.firebaseio.com/

#define FIREBASE_AUTH "MYvkRCAgt1q3T68o6caEOFXpdV5HNQr6jvAwKCw9"

#define WIFI_SSID "Dialog 4G"

#define WIFI_PASSWORD "2GE27BGA2L8"
```

- Giving the control command to the lock with firebase.

```
if (Firebase.getString(DoorLock, "/IOT Door Lock/DoorLock")){
    Serial.println(DoorLock.stringData());
    if (DoorLock.stringData() == "1") {
    digitalWrite(lock, HIGH);
    }
  else if (DoorLock.stringData() == "0"){
    digitalWrite(lock, LOW);
    }
  }
  delay(1);
```

- Door Status checking command.

```
buttonState = digitalRead(button);
 if (buttonState == 1)
 {
 Serial.println("Open");
 States = "Open";
 }
 if (buttonState==0)
 {
```

```
Serial.println("CLose");
 States = "CLose";
 }
Firebase.setString(firebaseData, "/IOT Door Lock/Status", States);
}
```

Tensorflow and Keras

Install TensorFlow Object Detection API

```
cp object_detection/packages/tf2/setup.py .
python -m pip install
python object_detection/builders/model_builder_tf2_test.py
```

Test the installation.

```
python object_detection/builders/model_builder_tf2_test.py
```

Training the Model

```
python model_main_tf2.py \
    --pipeline_config_path=training/ssd_efficientdet_d0_512x512_coco17_tpu-
8.config \
    --model_dir=training \
    --alsologtostderr
```

Generate xml file

```
import os
import cv2
from lxml import etree
import xml.etree.cElementTree as ET

def write_xml(folder, img, objects, tl, br, savedir):
    if not os.path.isdir(savedir):
        os.mkdir(savedir)
    image = cv2.imread(img.path)
```

```
    height, width, depth = image.shape
```

Inverting to Gray scale images

```
from PIL import Image, ImageOps
import cv2
import os
for i in os.listdir('./faces_images/train/'):
    # img = Image.open('./images/train/'+i)
    # inverted = ImageOps.invert(img)
    size = (299,299)
    # grey = inverted.convert('L')
    # grey.save('./test/'+i[:-4]+'.png')
    img = cv2.imread('./faces_images/train/'+i)
```

SQL Codes for criminal Database

```
CREATE TABLE IF NOT EXISTS `criminal_profile` (
  `id` int(11) NOT NULL AUTO_INCREMENT,
  `FullName` varchar(100) NOT NULL,
  `Nickname` varchar(25) NOT NULL,
  `Gender` varchar(10) NOT NULL,
  `DOB` date NOT NULL,
  `CriminalLevel` varchar(25) NOT NULL,
  `membershipRadios` varchar(25) NOT NULL,
  `CriminalCase` varchar(150) NOT NULL,
  `NIC` varchar(10) NOT NULL,
  `Address` varchar(150) NOT NULL,
  `ContactNumber` int(10) NOT NULL,
  `image` longtext NOT NULL,
  PRIMARY KEY (`id`),
  UNIQUE KEY `NIC` (`NIC`),
  UNIQUE KEY `ContactNumber` (`ContactNumber`)
)
```

4.3 Test Cases

The purpose of the testing is whether the functional requirements of the system have been met. The developed system has been tested with some possible scenarios.

Test ID	Test_001
Test case	Verify whether the system identifies a front face
Test steps	1. Log in to the system. 2. Startup the web camera. 3. Stand in front of the camera. 4. Recognize the face
Expected Results	The system should able be to recognize the face correctly.
Actual result	The system was able to identify the face.
Attachment	
Status	Passed

Table 3 - Test Case 01

Test ID	Test_002
Test case	Verify whether the system identifies side faces.
Test steps	1. Log in to the system. 2. Startup the web camera. 3. Stand in front of the camera. 4. Recognize the face
Expected Results	The system should able be to recognize the face correctly.
Actual result	The system was able to identify the face.
Attachment	

	
Status	Passed

Table 4 - Test Case 02

Test ID	Test_003
Test case	Verify whether the system identifies a face with a facemask.
Test steps	1. Log in to the system. 2. Startup the web camera. 3. Stand in front of the camera. 4. Recognize the face
Expected Results	The system should able be to recognize the face correctly.
Actual result	The system was able to identify the face.
Attachment	
Status	Passed

Table 5 - Test Case 03

Test ID	Test_004
Test case	Verify whether the system identifies a face with a spectacle.
Test steps	1. Log in to the system. 2. Startup the web camera. 3. Stand in front of the camera. 4. Recognize the face
Expected Results	The system should able be to recognize the face correctly.
Actual result	The system was able to identify the face.
Attachment	
Status	Passed

Table 6 - Test Case 04

Test ID	Test_005
Test case	Verify whether the system identifies a face with a cap.
Test steps	1. Log in to the system. 2. Startup the web camera. 3. Stand in front of the camera. 4. Recognize the face
Expected Results	The system should able be to recognize the face correctly.
Actual result	The system was able to identify the face.
Attachment	
Status	Passed

Table 7 - Test Case 05

Test ID	Test_006
Test case	Verify whether the system identifies the half-covered faces.
Test steps	1. Log in to the system. 2. Startup the web camera. 3. Stand in front of the camera. 4. Recognize the face
Expected Results	The system should able be to recognize the face correctly.
Actual result	The system was able to identify the face.
Attachment	
Status	Passed

Table 8 - Test Case 06

Test ID	Test_007
Test case	Verify whether the system identifies a face with a facemask and a spectacle.
Test steps	1. Log in to the system. 2. Startup the web camera. 3. Stand in front of the camera. 4. Recognize the face
Expected Results	The system should able be to recognize the face correctly.
Actual result	The system was able to identify the face.
Attachment	
Status	Passed

Table 9 - Test Case 07

Test ID	Test_008
Test case	Verify whether the system identifies a face with a facemask and a cap.
Test steps	1. Log in to the system. 2. Startup the web camera. 3. Stand in front of the camera. 4. Recognize the face
Expected Results	The system should able be to recognize the face correctly.
Actual result	The system was able to identify the face.
Attachment	
Status	Passed

Table 10 - Test Case 08

05 – Conclusion

5.1Important Outcome

Biometrics is a system used to authenticate or recognize the specific physical or behavioural patterns of individuals. Face recognition has become one of the new and advanced biometric techniques. It can operate two modes which are face authentication and face recognition. As a result of increasing the demand for security, face recognition technology is doing a major role in the modern world. When comparing with other biometrics technologies face recognition is natural, non-intrusive, agile and easy to use.

This face recognition system can be used to caught criminals and terrorists, to control the access where security risks are especially high areas and It can also be used for automatic access control system. Also, this intelligent face recognition system is suitable for Law enforcement, Voter Verification, Security, Immigration, prisons and to find out Missing Children and elders. Further, if we want, we can use it for Banking, Residential Security, Internet, E-commerce, and Health Care.

If the system was not a real-time system, we can't stop or prevent an incident before it happens. If the system is user-friendly real-time anyone can easily stop any unlawful or terrorism activities. Here in this project developed a real-time GUI based Criminal Face recognition system and further, it will be useful for developing a real-time face-based Biometric attendance system. This system is using all the facial features and distances. So it gives only a few false positives. In the test cases part, for all the face angles and appearances, it is working well.

5.2 Limitation

Developing an automated criminal face recognition system is very challenging because for the best system need more advanced technologies and all are very complex. As well as have to train very big data and store them securely. So it is difficult to handle them. For better accuracy, we need more photos for one person. Otherwise, the system will not recognize the faces correctly. If the face is near to the camera the system will give good results. So have to use a good quality camera for best results. Also, if the model runs in the localhost we need more powerful workstation because the model uses more RAM and processor. So we can host the model on the internet. But for a good hosting service we have to buy a service. Here has used the Heroku and it gives good services freely. In this project has an emergency SMS service. But in Sri Lanka can't find a free SMS gateway and have to buy a gateway.

5.3 Critical Evaluation

Finally, this intelligent criminal detector has a simple design and it is easy to use. The system is very user friendly and that requires minimum interaction between the users and the system. So making a user-friendly environment, developers can get more financial profit. Because has a high percentage of buying. For good results, using the high-resolution cameras and high-performance workstation is a critical thing. Most of the functions of the system fully automated and so this system is the most suitable method for criminal identification instead of using thumbprint identification. It will run automatically from recognizing, detecting and feature extracting the real-time video. Using the YOLO and Keras with Tensorflow is the best method for face recognition and we can get more accurate results using those technologies. Further, hosting the training model in the clouds is a good option because we no need to worry about looking after the hardware parts and its performance. Using the SMS gateway is suitable than using the GSM module because the system has hosted on the internet. Finally, this project has a door control system and it gives the extra protection for the hotel guests and properties.

5.4 Future Work

In the future, much more research and experimentation are required since this system has been built within a short duration and limited resources. This criminal face recognition system was trained using more images for one person. Because for better accuracy it should train more faces for one person. But in the real world, sometimes police has only a few images from a terrorist and he can be a very dangerous person. So have to identify him immediately and protect public places from him. But training a face recognition model is a challenge because of a few images. So have to research more about training a model using a few images. As well as have to research about train a model using low quality and blur images.

Also, have to develop an algorithm to get the same time multiple live streaming and analyze them with the database. Giving the control of more doors and monitoring them are provided the more security to the hotel premise. There is plenty of data available to recognise faces such as facial expression like pleasure, fear so that we can understand the individual's character and find more about the man who was identified. It will give an advantage to criminal detection. This system is working well in daylight or bright light condition. So want to research about face recognition for night vision cameras. Also, want to train the model to recognize the multiple faces the same time and have to develop the model to identify a face even in a crowd environment. Now system working for slow movements and want to develop for fast movement. For this want the more computational resources.

If the system database can use in the worldwide, can enter the criminal data from any department in the world. It gives more protection to the world from the terrorists. As well as if the system can automatically train itself after the entering data, it gives an advantage for developers. Finally, this is a very interesting and advanced field, using the results of this project can do many research things.

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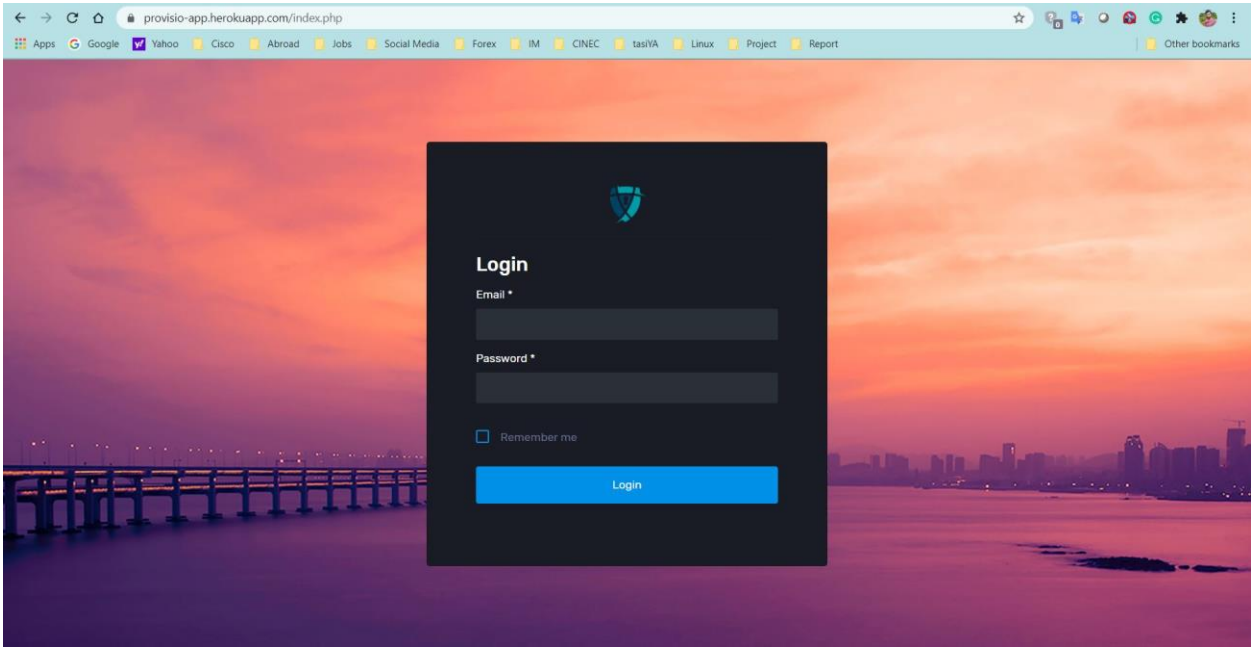
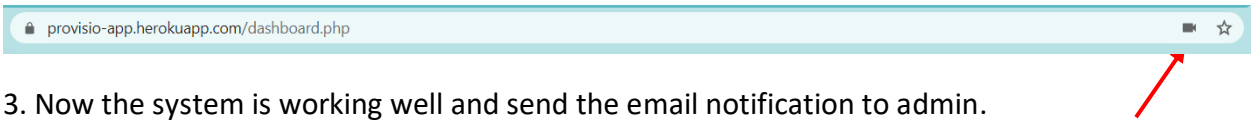
Appendix – A: User Manual

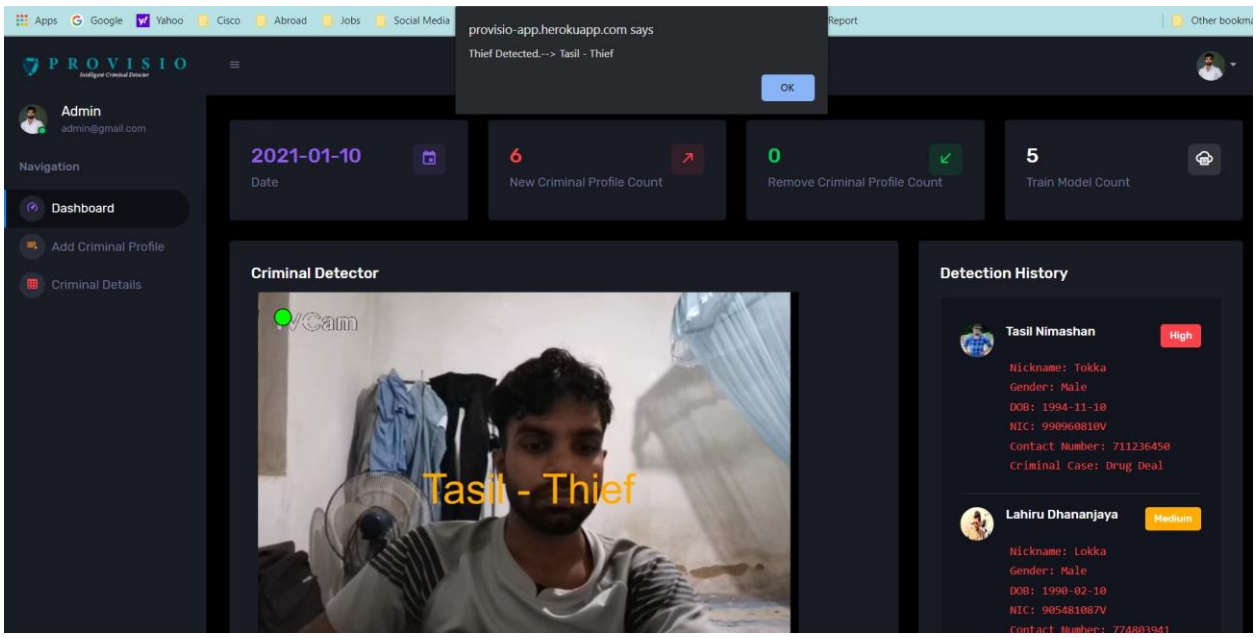
1. First go to the https://provisio-app.herokuapp.com and login to the system.



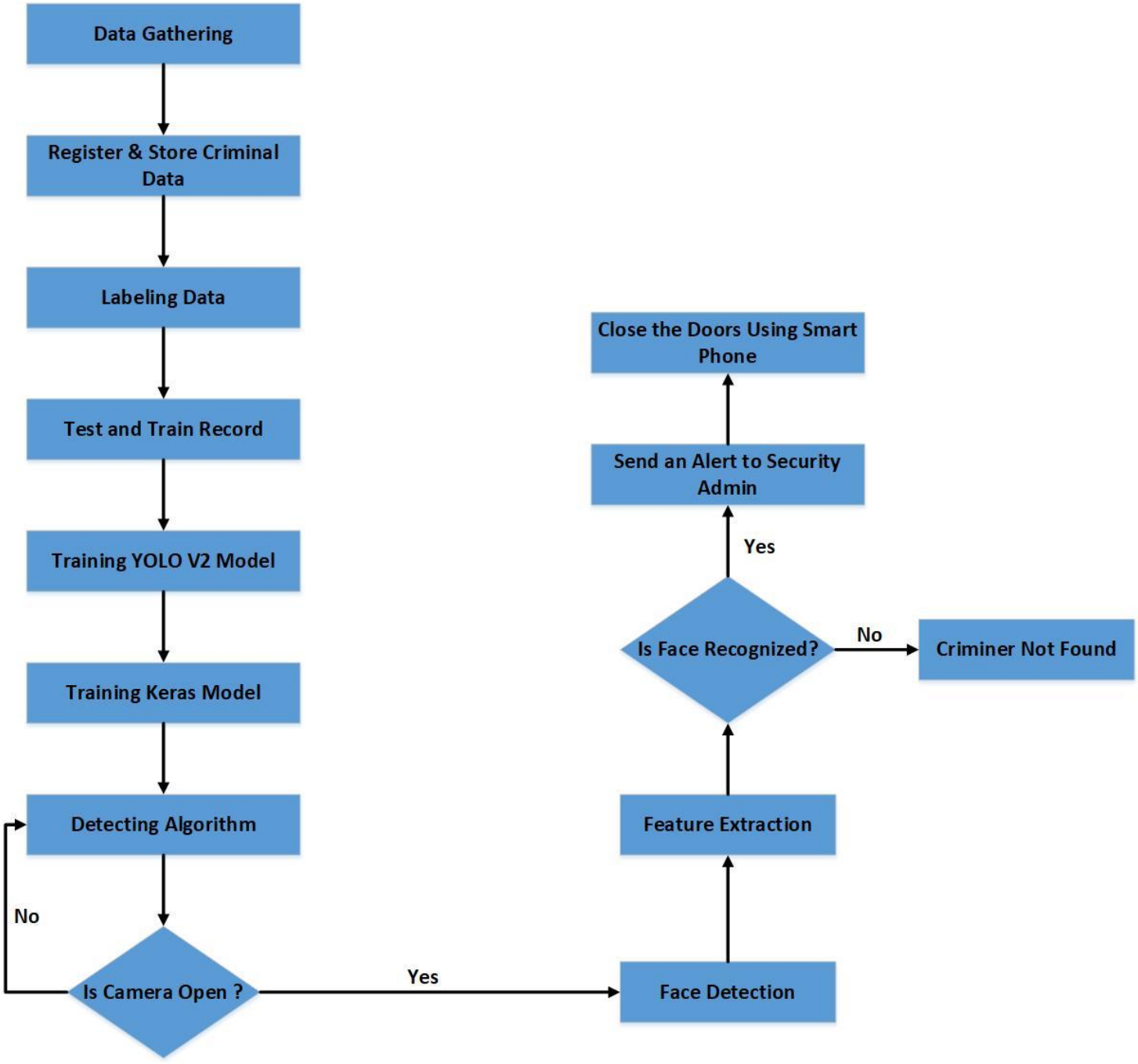
2. Then the system will automatically start. If the web browser blocks the camera access allow it. It indicates the bellow red arrow.



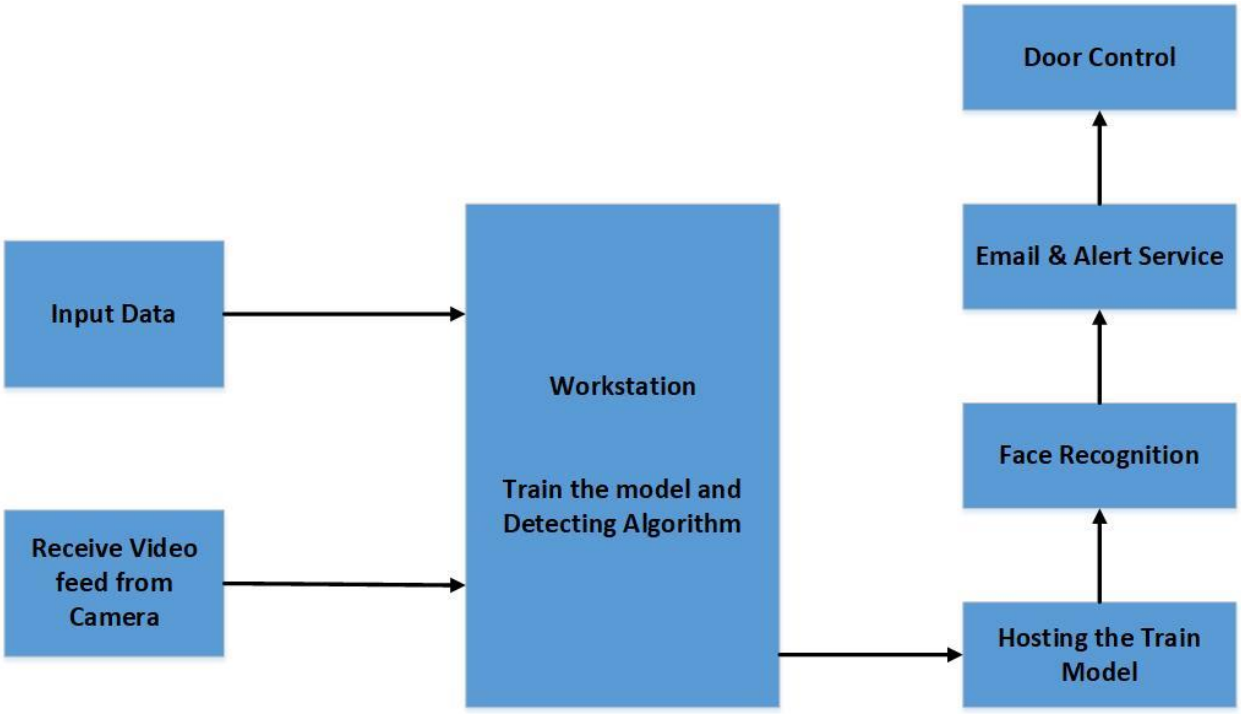
3. Now the system is working well and send the email notification to admin.



Appendix – B: Diagrams



Flow Chart



Block Diagram

Appendix – C: Coding

Code of IOT Part

```
#include "FirebaseESP8266.h"

#include <esp8266wifi.h><ESP8266WiFi.h>

#define FIREBASE_HOST "iot-door-lock-e9c50-default-rtdb.firebaseio.com"
//https://iot-door-lock-e9c50-default-rtdb.firebaseio.com/

#define FIREBASE_AUTH "MYvkRCAgt1q3T68o6caEOFXpdV5HNQr6jvAwKCw9"

#define WIFI_SSID "Dialog 4G"

#define WIFI_PASSWORD "2GE27BGA2L8"

int led = D5;

int button = D0;

int buttonState=0;

#define DHTTYPE    DHT11

FirebaseData firebaseData;

FirebaseData DoorLock;

FirebaseData Status;

FirebaseJson json;

String States = "0";

void setup(){
  Serial.begin(9600);
  pinMode(led,OUTPUT);
  pinMode(button, INPUT);
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  Serial.print("Connecting to Wi-Fi");
  while (WiFi.status() != WL_CONNECTED)
  {
    Serial.print(".");
    delay(300);
  }
  Serial.println();
  Serial.print("Connected with IP: ");
  Serial.println(WiFi.localIP());
```

```
  Serial.println();

  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
  Firebase.reconnectWiFi(true);

}

void loop() {

if (Firebase.getString(DoorLock, "/IOT Door Lock/DoorLock")){
    Serial.println(DoorLock.stringData());
    if (DoorLock.stringData() == "1") {
    digitalWrite(led, HIGH);
    }
  else if (DoorLock.stringData() == "0"){
    digitalWrite(led, LOW);
    }
  }
  delay(1);
buttonState = digitalRead(button);
 if (buttonState == 1)
 {
 Serial.println("Open");
 States = "Open";
 }
 if (buttonState==0)
 {
Serial.println("CLose");
 States = "CLose";
 }
Firebase.setString(firebaseData, "/IOT Door Lock/Status", States);
```