Smart Home Appliance Control over Wi-Fi

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Declaration

I declare that this thesis is my own work and has not been submitted in any form for another Masters, Degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

Name of the Student: Signature of the Student

H.W.K.Erandi Wijerathne

……..
Date:

Supervised by: Signature of the Supervisor

Mr.Saminda Premaratne ……
Date:

Dedication

This dissertation is dedicated to my beloved parents, my teachers, my friends who gave me endless courage and support to achieve my task and goal in completing the research project.

Acknowledgment

My heartiest thanks go to my supervisor Mr. Saminda Premaratne for the guidance, assistance, encouragement, valuable bits of advice on improving the research and providing this opportunity to carry out this research project.

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Abstract

The major purpose of this solution is to increase home security. Nowadays people are not staying at home for long hours and it becomes an issue for their loved ones who stays at home. Especially grand adults and children need more attention than the owners could be able to provide. This solution will provide a smart solution to the people who interest in having a security solution with new technologies.

The owner will notify via an email or message to the mobile phone if a person appears in front of the camera. If it is a family member, the owner will catch his/her arrival if not the owner will notify stranger's arrival. As well as owner can light up a bulb when a person comes in front of the camera. This reaction can be applied to in front of gates, as well as anywhere user wants. If the house owner needs to focus on more about children/senior adults safe will keep those near staircases when they try to use light up a bulb, then make a more secure environment.

Another advantage of this solution is it helps to get updates about home security when they are far away from residency. For this solution only need the Raspberry pi device and wi-fi connectivity and connected cameras and devices which will be going to control per the results. (Bulbs). Because the user will be notified who appears in front of the camera needs to store the family related people's images with various angles and under different range of lighting conditions. Standard of the images stored in the device will provide accurate results and the algorithm has used to identify images will identify the persons who appear with a darker background and some facial changes.

Keywords: Face detection, Home security, Raspberry pi, Internet of things, Smart home, WiFi

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Abbreviations

IoT	Internet of Things
PLC	Power Line Communication
IEEE	Institute of Electrical and Electronics Engineers
NFV	Network Function Virtualization
PC	Personal Computer
IP	Internet Protocol
V	Voltage
USB	Universal Serial Bus
SD	Standard Definition
OS	Operating System
GPIO	General Purpose Input Output
LED	Light Emitting Diode
CSI	Camera Serial Interface
P	Pixels
HD	Hard Disk
Fps	Files per Seconds
OpenCV	Open Source Computer Vision Library
VM	Virtual Machine
CRAN	Calorie Restriction with Adequate Nutrition
SMS	Short Message Service
RGB	Red, Green, Blue
BGR	Blue, Green, Red

Chapter 1

1. Introduction

1.1 Prolegomena

A residence is, which uses devices which connect with the internet to enable the remote monitoring and management of appliances and systems, such as lighting and heating can be called smart home or home automation. The targeted aim of this concept is providing security, comfort, energy efficiency and supportive by allowing them to connect with smart devices as well as give control as IoT. According to fast-moving technologies, IoT is the basement of this concept as well as it becomes the easiest way of controlling the home under the fingertips of the house owner.

When considering the history of the smart home concept communication protocol (X10) for home automation introduced in 1975 and this topic becomes popular among the technical and non-technical world. This way based on a wired system as well as could be able to send a signal along an electric wire to the home. It sends a command to turn on at a specific time. In 2005 home automation company called Insteon introduced technology that wireless signals and combined electric wiring. Even X10 got some involvements other protocols like Zigbee and Z-Wave, it remains as a widely installed communications protocol up to these days.

Apple, Google, and Amazon also recently introduced their own smart home products including their platforms. It proves the importance of the way of every aspect of life has entered the domestic space of human living today. Light bulbs to dishwashers which means it has successfully influenced already. But those high-quality products aimed the cost benefits from the users then most people cannot afford as well as the features come with these products are doesn't want for normal users since it has multiple as well as complicated functionalities.

As mentioned in the above paragraphs this IoT is not a new technology to the world of technology. Based on those concepts aimed to create a unique product which can be introduced to the Sri Lankan market with higher performance. This smart home concept is can be introduced to the market successfully if understands the user requirement. Then considered to implement this solution based on user requirement and the current incidents happening in Sri Lanka was motivated to introduce such a system which can be more helpful to the country.

According to Sri Lankan crime records, it proves domestic crimes have been increased all over the country. Specially considered number of sexual exploitation of children as well as under sixteen age female rape incidents has been increased according to the records provided by Sri Lankan police department. For this research, it would be the great impact of studied 2017, 2016, and 2015 crime records to get an in-depth idea. When analyzing those record, it proves there are a considerable amount of complaints were happened in the victim's homes. So, this was a major motivation factor of doing this research because needed to introduce a smart solution for home security and wanted to make an influence for these crimes by empowering Sri Lankans to against the child abuse.

Except for these crimes there were considerable home robberies reported in the past three years. Analyzing those record was the most affected motivation for doing this research as a responsible Sri Lankan who studies Information Technology. The main ambition of this research emphasis through this clarification of the records provided my online source related to Sri Lankan crime records.

Basically, this solution is going to be successful in face detection in different lighting as well as scaling areas as well as identifying people who come in front of the camera and do the necessary action to prevent the harmful attacks if it may in the un trust environment for the user. When this product development starts from the beginning to the end thoroughly considered about the cost, simplicity, accuracy as well as usability.

After finishing the research as the stage of development is done did various types of evaluations with the users to make it more reliable.

1.2 Background and Motivation

A country like Sri Lanka is in a high stipulation of the security system when considering house incidents also proves that necessity. However, there is no such product in the market can be used to match the situation.

1.3 Problem Definition

There is a high possibility of preventing crimes if there is a system which can be able to keep an eye with the home as well as control the home remotely.

1.4 Hypothesis

According to the requirement gathered as mentioned above made some hypothesis to build the solution. This research based on developing home security system specially it focused to face detection and provide an action according to it. So the Raspberry pi model and the Raspberry camera are used to implement the system by considering it will easy to demonstrate the research idea as well as it will fulfill the cost-effectiveness.

1.5 Aim

The main aim of the system is the provide accurate, secure and low-cost home appliances controlling system.

1.6 Objectives

• Support to minimize the in-house criminals which engage with the kids and female individuals
• Identify the faces with high accuracy
• Send the identified person details to the house owner within a few seconds
• Control the home appliances even user is far away from the home

- Provide a solution to the house owners with low cost and more accurate
- Implement a solution using the latest technologies and improve the accuracy
- Make people's life more secure and easier

1.7 Summary

This chapter provides a brief introduction of the over role research topic as well as clearly mention the background and motivation factors of doing it. As per the mentioned in this chapter it has described problem definition clearly and hypothesis which is base to make the foundation of the system. Aim and objectives of the proposed tool also mentioned emphasizing the research idea.

There are eight chapters has been included in this dissertation and need to cover all the desired aspects clearly to understand. Chapter three is based on the literature review which is done by the earlier of the research. It was useful to understand the gaps and technologies of existing products related to the research. When do the literature survey related to the research title it is easy to identify the technologies that can be identified to begin the development. Chapter three has been described clearly and deeply theoretical background of the research.

Forth chapter attentions on the recitation of the process of implementing the research and its background issues. Chapter five describes the analysis and design part which guides to implementation successful than in chapter six provides all the implementation details related to the project. Through chapter seven it discusses the about the testing and evaluation results statistically. Finally, chapter eight provides the conclusions and directions for future work should be addressed in the next researchers.

Chapter 2

2. Current Development and Challenges

2.1 Introduction

First chapter point outs the portrayal of the general undertaking depicted in this document. This section gives a basic survey of the writing in connection to improvements and difficulties in wi-fi and Ardino based systems. Prior research, programming and article audit has been submitted under three primary classifications. Early improvement, present-day patterns, and future difficulties. At last, this section characterizes the examination issue.

2.2 Current Developments

There are more techniques which can be applied to moderate this product according to the research papers. Even though the platform controlled by remote security providers and owners through the internet in this resource [1], can be obtained some idea about the difficulties which will face when implementing the system. This provides an idea about how to work with the microcontroller board, how to create a basic structure of the project, what are the possible mechanism's that can be used and many more details from this resource. As well as its emphasis use of IoT concepts which are related to this area.

The present disclosure provides a controlling a lightning system and as well as there is the lighting control system includes: a primary lighting device having a wireless module and a plurality of secondary lighting devices. The essential lighting gadget and the auxiliary lighting gadgets speak with each other by PLC. The essential lighting gadget is designed to get a control signal through in any event one of the electrical cables and the remote module and send the control sign to the auxiliary lighting gadgets. That will able to apply for the home appliance system. Advantage of

this section is that it is applied for a wireless module which will be much helpful to ensure development successful.

The present invention relates to a novel arrangement of light cells on a flexible or solid background into a smart multi-dimensional light source capable of unlimited configuration, which comprises of a mother cell that is connected to one source of electrical power and gets charged, subsequently charging all the other light cells and thus illuminating the entire light source with unlimited configuration, and which is capable of being wirelessly switched on or off by means of a smartphone device. This gives a thought regarding the multi-dimensional light administration framework which can remotely turn on and off. Even though it has mentioned Bluetooth system, can get an idea and seek some techniques to apply it into Wi-Fi connection.

IoT has become an emerging concept in the area of communication and automation technology. The keen application of IoT can be observed in "Home Automation", where a simple home is transformed into ‘Smart Home' by this technology. The Smart home connects most of the digital devices together and helps to communicate with the help of the Internet network. Only the trouble is that each digital device follows a different protocol for communication and may base on the manufacturer. The primary aim of this report is to furnish an overview of the Internet of Things, connectivity standards and some difficulties/challenges faced in the smart home network[2].

As Wi-Fi is picking up a great deal of energy in the present systems just as in future systems, new bearer - grade necessities are developing to help future client desires and give elite Wi-Fi systems. In this unique circumstance, can be examined a few issues encompassing the structure and advancement of transporter grade cutting edge Wi-Fi systems.

In the main stage, the goal is to improve the Wi-Fi client experience and offer customized and consistent access to Wi-Fi systems and administrations. For this, propose an augmentation to the IEEE 802.11 administration edges to empower setting administration revelation before Wi-Fi affiliation while staying away from channel overhead. Here can be characterized as a lot of extensible administration marks to

interestingly and internationally recognize the most known setting-based administrations. In the second stage, should manage organize engineering and the executive's issues in a cutting-edge bearer Wi-Fi condition. All the more explicitly, first proposed a novel bearer oversaw Wi-Fi design that influences NFV and Edge Cloud Computing ideas.[3].

This online resource mentioned the network architectures and Wi-Fi management issues which will be helping for project security phase. It can obtain some security facts which need to consider and some solutions for such issues. This research has been provided some solutions from this but only obtain the basic idea which needs to focus on the future in my project.

The Arduino Ethernet is utilized to wipe out the utilization of a PC keeping the expense of the general framework to a base while voice initiation is joined for exchanging functionalities. Gadgets, for example, light switches, temperature sensors, mugginess sensors, current sensors, interruption location sensors, smoke/gas sensors, and alarms have been coordinated into the framework to exhibit the attainability and adequacy of the proposed shrewd home framework. The brilliant home application is tried, and it can effectively play out the keen home activities, for example, exchanging functionalities, programmed natural control, and interruption identification, later situation where an email is created, and the alarm go on[4].

Minimal effort and adaptable home control and observing framework utilizing an implanted smaller scale web server, with IP network for getting to and controlling gadgets and machines remotely utilizing an Android-based Smartphone application. The proposed framework does not require a committed server PC concerning comparable frameworks and offers a novel correspondence convention to screen and control the home condition with something other than the exchanging usefulness. To show the possibility and viability of this framework, gadgets, for example, light switches, control plug, temperature sensor, and current sensor have been incorporated with the proposed home control framework.

A framework for use in controlling working elements of a controllable gadget incorporates a Handheld gadget and a halfway gadget in correspondence with the hand-held gadget and the controllable gadget. The hand-held gadget is adjusted to get a motion-based information and to transmit a sign having information illustrative of the motion based info. The transitional gadget has programming for deciphering the information illustrative of the motion based contribution to a sign got from the hand-held gadget into an order sign to be imparted to the controllable gadget wherein the direction signal has a configuration proper for controlling a working capacity of the controllable gadget that is related with the motion based information[5]. Enormous estimated electric home apparatuses an implanted framework with no new extra wiring has been created for home power the executives. By utilizing Power Line Communication (PLC) innovation, electric home machines can be controlled and observed through residential electrical cables. It portrays a PPCOM (PLC Power-Controlled Outlet Module) which incorporates the various AC control attachments, the power estimating module, the PLC module, and a microcontroller into an electrical plug to switch the intensity of the attachments on/off and to quantify the power utilization of connected electric home apparatuses.

This resource helps to get an idea about Power Line communication technology for home appliance. They have presented "PLC Power-Controlled Outlet Module" which incorporates switch the intensity of the attachments on/off and to gauge the power utilization of connected electric home apparatuses. It will be able to get a few ideas which will be helping to develop.

The correspondence with all segments of the framework is finished utilizing an assortment of remote advancements. The framework joins security highlights at the two closures that forestall unapproved access just as allocate benefits to the clients. The total model brilliant home framework was actualized, and it underpins three fundamental administrations: checking the status of gadgets, controlling their settings through setups

that are gadget reliant and occasional warning of the status of gadgets. The model framework has a measured structure that empowers the consolidation of extra segments and administrations[6].

Chapter 3

3. 1. Technology foundation of the solution

3.1 Introduction

In Chapter Two, presented a discussion and analysis of the researcher's work were conducted. Through the analysis, partly identified the research gap to be filled. This chapter going to be discussed the technologies that will use in the proposed solution.

3.2 Technology used for the solution

3.2.1 Raspberry Pi 3 Model B

This powerful credit-card sized single board computer can be used as the main device for this solution development. This device is used for many experiments because of its portability and simplicity. It has a lot of functions and features like Wi-fi and Bluetooth as well as most significantly it can be connected to the monitor and without any dependencies, we can easily use and program because Raspberry Pi comes with a Raspbian operating system. There are so many versions of devices has come out to the market then we use The Raspberry Pi model 3 for this implementation.[7].

Because implementations are driven by python and C++ languages it is easy for the programming using a framework because Raspbian OS supports with those open sources.

This device will up with the 5V micro USB power. So, doesn't need much energy to use this device for the demonstrate the solution task makes easier because of that. There is an Ethernet port so the device can connect directly with any other devices needed this for

As well as raspberry has a micro SD card slot can be used to install the operating system and use this storage for all other programming related works as well as help to keep necessary folders related to the program.

One of the main importance of this device is easy can connect with the camera model. In this suggested solution camera module does one of the major tasks, easiness for the programming as well as offering an expected result is done.

In this device, there are four USB ports which will use to connect with other sources. For the file transferring and connecting with the appliances can be used. These ports are also needful to gain the connectivity easily with the devices.

Raspberry Pi contains two rows of GPIO which works like switches those switches can connect with the device as well as the real world. The solution module needs to demonstrate turning on/off a LED light and can be data from a sensor as well can send a signal to another device. This is a good way to interact with the real world as well as controlling the devices.

3.2.2 Raspberry Camera

The Raspberry pi camera module is a five-megapixel mode which is used in this solution. It is useful because it can relate to the CSI connector on the Raspberry pi. So, it can connect directly into the raspberry pi device. For this research needed to process real-time video processing with good quality in real time. Per the requirement it is important processing real-time video, this device provides 1080p HD video recording at 30fps. Cost of the device is also lower than another camera module. Using this camera module, it can be fulfilled the research requirement in a better way.

3.2.3 OpenCV

OpenCV is an open source library written in C++ language. It is needed to make partial support to the program writing process when it is needed to write algorithms as well as codes.

Since it is supporting with the Raspberry Pi device it is the better way for good and quality coding as well as it can bind with python. OpenCV includes hundreds of

computer algorithms which can be reused while coding. It will be helpful to make a stronger and quality solution [8].

3.2.4 Python

In this solution needs to address the devices so need to write strong algorithms as well then need to use high-level language with more understandability, OpenCV provides easier when it uses python.

Python is a powerful language so can achieve by few numbers of lines of codes. As well as there are some available libraries for python as well as for C++. When implementing the solution had to use those libraries because it helped to increase the reliability and accuracy of the code.

Because of the simplicity of the Python language it is easier to use python when doing programming. It is useful when need to use OpenCV and Dlib because for the face detection part these libraries are strongly needed because of its good general computer vision.

3.2.4 Dlib

Identifying a person in aid of lifestreaming video is responsible with Dlib. Using the code which is implementing for the solution needs to detect the object then the Dlib will able to recognize the face.

Facebook, Google as well as Amazon use this library for the face detection part. For this solution has been used OpenCV with python to detect faces from captured frames.

3.3 Hosting and Deployment Technologies

3.3.1 Microsoft data science server

The Microsoft Data Science Virtual Machine is an Azure virtual machine (VM) image pre-configured with several popular tools, including Machine Learning Server on the

Linux VM and both Machine Learning Server and SQL Server Machine Learning Services on the Windows.

Machine Learning Server (Developer Edition) includes the complete R distribution from CRAN and a Python interpreter, python distribution from Anaconda, plus additional data-analysis functions with big-data capabilities, and the operationalization framework for integrating R and Python into applications as web services.

The developer edition is identical to the Enterprise Machine Learning Server edition but licensed for development/test use[12].

Chapter 4

4. A new approach to Home Automation

4.1 Introduction

The previous chapter briefed about the technologies which adapt to build the proposed solution and this chapter will be discussing the approach used to implement the solution.

4.2 Requirement Gathering

To build this proposed solution spent time studying previous solutions, reading research papers, articles done by other researches and searched about hardware parts. As well as people who have faced this issue in real-time provided some practical scenarios related to their experiences.

4.3 User of the system

As mentioned in the previous chapters this research is all about domestic security specially focus to protect children and women from crime and rape incidents. Then this solution is developing any type of users.

Users can be a range of technical users to non-technical users. Everyone can get benefits from using the proposed system. This solution will send an alert to the mobile phone as well as email. To minimize the complexity doesn't create a mobile application then only provides a message to the user.

If the message contains an arrival of a known person user can take the action according to the user's preferences and If the user gets an alert of unknown person record, then the user can immediacy dial police or can be taken the necessary actions.

Mostly non-technical users are the users of this system so focused to build a user-friendly solution with high accuracy. As well as within this system provides a simple action to make the environment better after notifying the new appearance to the frame. As an example, If the camera set in front of the gate when a person appears to the camera while detecting the person as an action lighting up the bulb will occur. So, the user can get an advantage of it to feel this system more reliable.

4.4 Input to the system

Simply live video stream will capture by the Raspberry camera is the input of the system. Those data will send to Raspberry device It will capture the images which will be used to compare with stored data.

4.5 Outputs of the system

According to this solution as the main output user can identify the person who faces the camera whether a known person or unknown person. It will send notify the result in many ways. Sending a message to the mobile phone is the most reliable way to educate the user. Because nowadays Sri Lankan has the highest literacy as like as developed countries so their use of mobile usability is considerably higher, then this method will be the successful method to convey the message to the user other than other ways. Instead of the sending alerts to the mobile phones, it can be done by sending emails also, for the persons with a bit of literate with the new technologies or with computer literacy can be able to use this way. However, for this introduced solution both methods are implemented for the demonstration purposes.

When person appeared in front of the camera it is necessary to perform an action while the recognition details are being sent to the user, such as light up/off a LED, actions can be done by remotely to improve security or executions related to power/energy savings. For this demonstration lighting up the LED is performed.

As mention, the above explanations user can be able to perform the actions after getting the application results. This solution will be more reliable when it performs as mentioned here.

4.6 Summary

This chapter explained the approach that allowed to propose a solution that could fill the research gap. This made it possible by considering hypothesis which will be taken to support the development more realistic and practically accurate. Inputs and outputs of the solution are explained in detail which will be used to demonstrate the research idea.

Chapter 5

5. Analysis and Design

5.1 Introduction

The previous chapter has been discussed about the overall approach to the proposed Smart Home Appliance Control Over Wi-Fi system. In this chapter, we will be going to discuss how the planning was done when developing this tool and which mythology suited most when developing this proposed tool. Apart from those going to discuss the top-level architecture of the systems, modules, and submodules inside of each component of the architecture.

5.2 Research Planning

Before starting the development, it was important to go through the research planning and scheduling in below table have listed the time taken for the process. Spend some time studying previous solutions provided by others as well find solutions for the limitation on the previous development according to information collected in the literature survey. Based on the details already found and hypothesis can be taken by previous details summaries directed below sketch of the execution plan.

Task	Q1				Q2				Q3				Q4		
	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Identify the problem															
Review the litrature															
Clarify the problem															
System design															
Implmentation															
Testing and debugging															

Table 5-1: Execution plan

5.2.1 Development Methodology

The evolutionary prototyping methodology is used to develop the system, according to the research components involved through the research. A considerable number of rounds were circulated to ensure the quality of the solution so, necessity number of fine-tuning rounds were fulfilled to get the best possible as well as most reliable prototype generated.

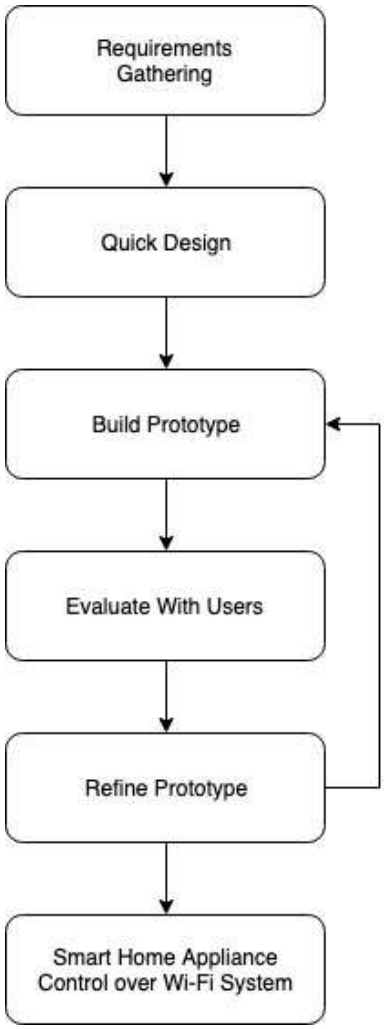

Figure 5-1: Development Methodology

5.3 Analysis of the Current Development Workflow

As discussed in the approach chapter, before the initialization of this research great measure of time spent on looking at the past research papers. In industry experience, we have confronted issues when creating web applications and portable applications developing the solution explained in this thesis. Ideas and suggestions were gathered from some exports in Raspberry pie filed and who are engaged in similar work activities.

5.4 Requirement Analysis

Proposed tool Home Appliance Controller Application functionalities can be described as mentioned here. A tool capable of identifying the correct user through image processing patterns and trigger relevant action based on that like turn on the light when entering the room by identifying the user or identifying dangerous activities by underage children's and trigger alarm for that.

5.4.1 Functional Requirement of the Proposed Tool

The main goal of this tool is to provide better security and low-cost home appliance controller through Wi-Fi for users. Most of the functionalities are going to be auto triggered based on user activities. The system is also able to trigger notifications to the user as well. Notifications will send a short message to the provided mobile number.

5.4.2 Non-functional Requirement of the Proposed Tool.

This tool helps the user to improve security and lower energy consumption with this automated process. Because of the low-cost average customers also able to experience features provided by this tool.

5.5 Top level Design Architecture

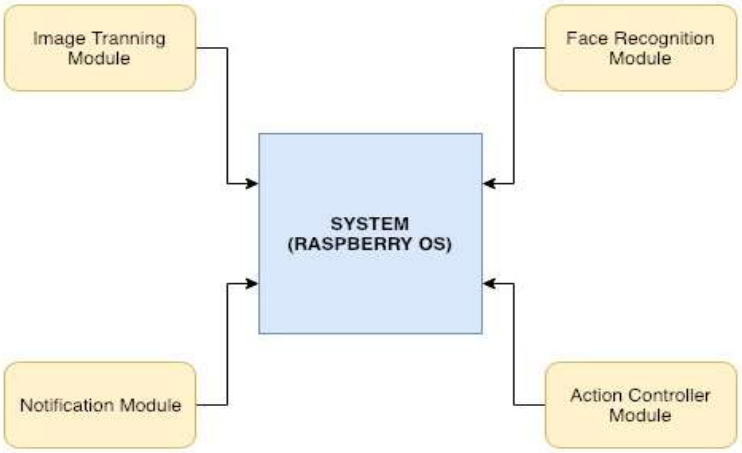

Figure 5-2: Top level design

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5.6 Module Architecture

As display in top-level architecture main model consists of four submodules.

5.6.1 Image Training Module

For the image training, we are using OpenCV library which founded in 1999 We are using C++ interface running on windows. In OpenCV Haar like features are digital image features used in object recognition so that can be used for train this module. Haar Cascades[13] are trained classifiers used for detecting features like face, eyes, upper body. Here wanting to actualize face location.

The calculation needs a great deal of pictures to prepare the classifier. At that point we must remove highlights from it. For this, Haar highlights appeared in the beneath picture are utilized.

For this, we apply each element on all the preparation pictures. For each element, it finds the best limit which will group the appearances to positive and negative. Be that as it may, clearly, there will be blunders or misclassifications. We select the highlights with a base mistake rate, which implies they are the highlights that best arranges the face and non-face pictures.

5.6.2 Face recognition module

In image training module we are using dlib[14] service for better face detection. dlib is a toolkit for making real-world machine learning and data analysis applications in C++. While the library is originally written in C++, this library is known as a high accuracy library for frontal face detection.

5.6.3 Notification module

Using this module, it will be able to notify the end user to relevant information. If image processing detects warning situation it will use notification module to send SMS to end user with a warning message. For SMS triggering we are using an SMS gateway to send messages.

5.6.4 Action controller module

This is where all the action will be managed if the face detection module identified the user as a valid user. It informs the action controller to trigger the predefined action. Example: it programs to detect the valid user and turn on the bulb. This is where it controls.

5.7 Testing

It is required to be done testing for this solution to measure the accuracy of the system. To verify the solution results with expected outputs it is driven for the manual testing sessions under various parameters.

5.8 Summary

In this chapter, a detailed description of the system design has been discussed. Usage of different technologies and libraries were also mentioned in this chapter. In the next chapter, we will be discussing the implementation of the proposed system according to the designs which we have discussed.

Chapter 6

6. Implementation

6.1 Introduction

The previous chapter explained the top-level design of the system as well it has been included the major modules separately which will be given an idea of the and system architecture of the proposed solution. In this chapter, it will be going to discuss the implementation details with more clarifications and with more deeply so below paragraphs were described in detail each module of the proposed solution.

6.2 Overall solution

The overall solution has developed to improve the non-technical user-friendly application and give alerts over the wi-fi. It is meant that the user can identify people who stored in the database and other people are displayed as unknown by the raspberry camera.

Here for this implantation as mentioned in the previous chapters has been used the raspberry pi device as well as a raspberry camera because of the simplicity of the usage so, integrated solution can be identified persons who appear in front of the camera and give alerts to the house owner. As well the system can be getting some important action without get delaying. Face recognition part is the most turning pointed technology which is connected in the wide area of the technical world.

Although this face detection module is common and familiar to the industry this solution has been introduced more new features while implementing the solution such as scaling, and lighting conditions were the major challenge when identifying human faces. But this

project is addressed by some of these limitations successfully as a specialty of these projects when this carrying more unique features like real-time, simple, useable as well.

6.3 Implementation of the Solution

The outcome of this proposed solution is identifying the person who faces to the camera and provides an action according to it so, this solution can be introduced as an IoT product because it will work under the definition of IoT concepts.

The details about the appeared person will send to house members and They can decide what should be done based on the result they get. Because of this solution house owners can keep on eye to their family as well as to properties while they are not around in the same premises. This solution will support different lightning and scaling situations.

6.3.1 Programming

To complete the coding part used python language mostly, also python is used on the OpenCV library. In this solution what has been implemented firstly is processing images in aid of data science server according to the algorithms we wrote as well as some libraries also we used.

Then we create a module of them and send it to the Raspberry. Images training part can be done inside Raspberry pi, but the memory issues will be raised so, better to use a server which will support for training image data of that.

Then we compare captured images with model results. We used to capture images a Raspberry camera when live video stream So those a comparingly try to identify.

According to the algorithm, we have written it is taking a percentage as a comparison result. Then it can recognize whether he/she is a known person or not.

After that, we have set an action to be done. At the same time, the house owner will receive a notification if someone appears in front of the camera. It is very easy to get an action according to the result. Because the notification will send to the mobile application. Raspberry is connecting to the server via WI-FI. As well as lighting a bulb when person arrival can be performed as well.

6.4 Encoding images

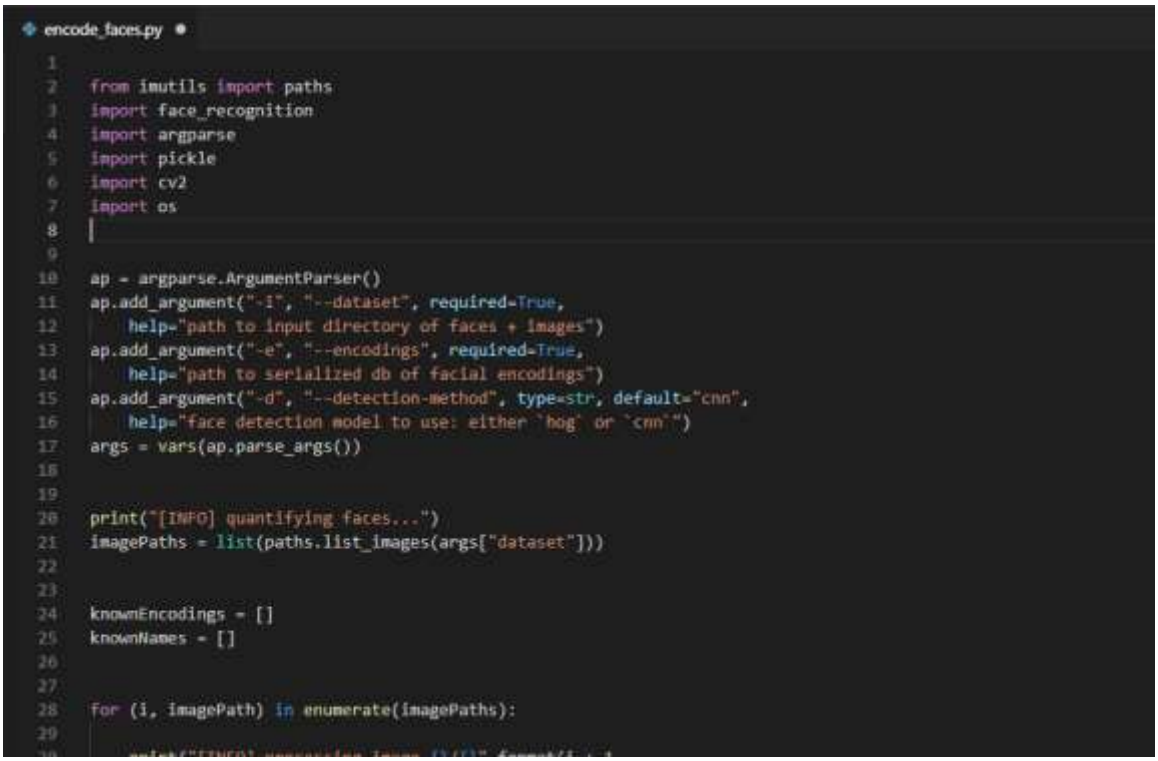
Encoding part is can be done in the PC/Laptop, Raspberry pi device as well as data science servers. All these methods have been tried in this solution. If we need to train a greater number of images it is faster using a data science server more than other devices, except that for a smaller number of images can be trained by above devices without any issue.

This training module is done as a separate module aiming to create a pickle file. For this code python, face recognition library has been used only for the identify the head part as a face of the human body.

First, it is coded the construct the argument parser and construe the result to the arguments. Next, it gets the paths of the input images from the data set. Then it is needed to have a way of naming the images, after image comparison it is needed to give the name of a known person. This name is taken by the folder name, which is named the folder. Here we create folders for every person’s and named the folder by that person’s name.

Then this folder name is used to pass the person's name when doing the encoding. Through the path name, it can access the image and convert the RGB to Dlib ordering RGB. As per the X and Y arranges distinguish the jumping the crates and relate to each face in the information picture. At that point process the facial inserting for the face and consolidate the encoding and name the picked by the picture found envelope and make the document with those encodings.

From this way, pickle file is generated, and it has put in the main program which will respond to the face detection. To fulfill the major targets of this research inside of this image folder around 15 to 20 images were stored, as well as those images were captured by under the different lighting conditions and different scale conditions. When they encoding those were encoded to enhance the results.



```
45
46      for encoding in encodings:
47
48          knownEncodings.append(encoding)
49          knownNames.append(name)
50
51
52  print("[INFO] serializing encodings...")
53  data = {"encodings": knownEncodings, "names": knownNames}
54  f = open(args["encodings"], "wb")
55  f.write(pickle.dumps(data))
56  f.close()
```

Figure 6-1: Encoding Algorithm

6.5 Face Recognition

In aid of the pickle file which has stored the data related to the known person image comparison part has been developed as well as for that Haar cascade library module also used. In the beginning, it constructs the arguments and parser and do passing them, then make them load the known faces and embeddings along with OpenCV's Haar cascade for face detection should be done to decode the encoded file.

In this program loop over the frames from the live video file stream and cut it to the frames and resize it. Then resize those into 500 px this will increase the speed the processing. Then these input frames were converted to the BGR to the grayscale for the face detection, as well as BGR to RGB, then detect the face. Here all images were reordered according to top, right, bottom, left order then only can be able to compute the facial embeddings for each bounding box then attempt to match each face in the input image with the known encodings.

If the match is available, it will return the person name if not it returns the word “Unknown”. This comparison is implemented to find the indexes of all matched faces via a dictionary to count the total number of times each face going to match for that it maintains a matched index count of the recognized face by looping. According to this

algorithm, it gets a higher count of the recognized faces. Then append the name as an identified person

```
# USAGE
# python pi_face_recognition.py --cascade
haarcascade_frontalface_default.xml --encodings encodings.pickle

# import the necessary packages
from imutils.video import VideoStream
from imutils.video import FPS
import face_recognition
import argparse
import imutils
import pickle
import time
import cv2

# construct the argument parser and parse the arguments
ap = argparse.ArgumentParser()
ap.add_argument("-c", "--cascade", required=True,
    help = "path to where the face cascade resides")
ap.add_argument("-e", "--encodings", required=True,
    help="path to serialized db of facial encodings")
args = vars(ap.parse_args())

# load the known faces and embeddings along with OpenCV's Haar
# cascade for face detection
print("[INFO] loading encodings + face detector...")
data = pickle.loads(open(args["encodings"], "rb").read())
detector = cv2.CascadeClassifier(args["cascade"])

# initialize the video stream and allow the camera sensor to warm up
print("[INFO] starting video stream...")
vs = VideoStream(src=0).start()
# vs = VideoStream(usePiCamera=True).start()
time.sleep(2.0)

# start the FPS counter
fps = FPS().start()

# loop over frames from the video file stream
while True:
    # grab the frame from the threaded video stream and resize it
    # to 500px (to speedup processing)
    frame = vs.read()
    frame = imutils.resize(frame, width=500)

    # convert the input frame from (1) BGR to grayscale (for face
```

Figure 6-2: Face Recognition Code Snippet – 1

```
# detection) and (2) from BGR to RGB (for face recognition)
gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
rgb = cv2.cvtColor(frame, cv2.COLOR_BGR2RGB)

# detect faces in the grayscale frame
rects = detector.detectMultiScale(gray, scaleFactor=1.1,
    minNeighbors=5, minSize=(30, 30),
    flags=cv2.CASCADE_SCALE_IMAGE)

# OpenCV returns bounding box coordinates in (x, y, w, h) order
# but we need them in (top, right, bottom, left) order, so we
# need to do a bit of reordering
boxes = [(y, x + w, y + h, x) for (x, y, w, h) in rects]

# compute the facial embeddings for each face bounding box
encodings = face_recognition.face_encodings(rgb, boxes)
names = []

# loop over the facial embeddings
for encoding in encodings:
    # attempt to match each face in the input image to our known
    # encodings
    matches = face_recognition.compare_faces(data["encodings"],
        encoding)
    name = "Unknown"

    # check to see if we have found a match
    if True in matches:
        # find the indexes of all matched faces then initialize a
        # dictionary to count the total number of times each face
        # was matched
        matchedIdxs = [i for (i, b) in enumerate(matches) if b]
        counts = {}

        # loop over the matched indexes and maintain a count for
        # each recognized face face
        for i in matchedIdxs:
            name = data["names"][i]
            counts[name] = counts.get(name, 0) + 1

        # determine the recognized face with the largest number
        # of votes (note: in the event of an unlikely tie Python
        # will select first entry in the dictionary)
        name = max(counts, key=counts.get)
```

Figure 6-3: Face Recognition Code Snippet - 2

```
        # update the list of names
        names.append(name)

    # loop over the recognized faces
    for ((top, right, bottom, left), name) in zip(boxes, names):
        # draw the predicted face name on the image
        cv2.rectangle(frame, (left, top), (right, bottom),
            (0, 255, 0), 2)
        y = top - 15 if top - 15 > 15 else top + 15
        cv2.putText(frame, name, (left, y), cv2.FONT_HERSHEY_SIMPLEX,
            0.75, (0, 255, 0), 2)

    # display the image to our screen
    cv2.imshow("Frame", frame)
    key = cv2.waitKey(1) & 0xFF

    # if the `q` key was pressed, break from the loop
    if key == ord("q"):
        break

    # update the FPS counter
    fps.update()

# stop the timer and display FPS information
fps.stop()
print("[INFO] elasped time: {:.2f}".format(fps.elapsed()))
print("[INFO] approx. FPS: {:.2f}".format(fps.fps()))

# do a bit of cleanup
cv2.destroyAllWindows()
vs.stop()
```

Figure 6-4: Face Recognition Code Snippet - 3

6.6 Sending Notifications

If the person who comes in front of the camera known person to the system it sends the message to the owner's mobile with known person's name, if not it sends as unknown these messages are sent to mobile as well as it sends an email also.

6.7 Action controlling

As mentioned in the previous chapters when a person appears the system has configured with the ability of lightning up/off the light bulb.

6.8 Summary

In this chapter six discussed the main models and sub models deeply then all the modules were presented by with clear and descriptively. The algorithms are also described which are helpful to build the solution. Different technologies were mentioned in this chapter which is used for the implementation.

Chapter 7

7. Evaluation of the solution

7.1 Introduction

The previous chapter discussed the details of the implementation of all the modules mentioned in the proposed solution. This chapter justifies and evaluates the overall solution, also this chapter will collect feedbacks from end users to improve the functionality and provide a better tool this solution can be tested with respect to different aspects such as functionality, reliability, efficiency, maintainability, and simplicity.

Testing is the best process of evaluating a system as mentioned in the software engineering processes, here each component which intent to find whether it satisfies the given requirements. A major purpose of the testing is running a system in order to identify any gaps, errors, bugs or missing requirements in comparison to actual requirements.

7.2 Testing and Evaluation

This product is aimed to all kind of users which means technical as well as non-technical so testing was driven for both users to check the usability if the usability higher then can assume the solution is leading simplicity also. Here twenty people were chosen, by half of the sample as of presenting one category wise versa.

As well as for the testing trained thirty number of folders to which contain twenty images each folder, so six hundred images were trained individually to verify the results with expected results. When storing images people with different shapes of faces were included to get higher reliable results as a testing result.

For the evaluation of the tested results took the mentioned sample results in the above paragraph.

	Tested people count – 20 people
Identify image within 10 seconds	Pass
Send alert to mobile within 10 seconds	Pass
Send email to within 10 seconds	Pass
Lightning the bulb within 10 seconds	Pass

Table 7-1: Efficiency Testing

Efficiency of the system is 100% according to the above results.

	Actual user count – Technical	Number of users abled to get target results.	Actual user count Non-Technical	Number of users abled to get target results
Able to receive and go through the mobile alert	10	10	10	10
Able to receive email and read it	10	10	10	8
Total	20	20	20	18

Table 7-2: Usability Testing

Usability results can be measured according to the above results as follows

Technical users 100%

Non-Technical users 90%

	Actual people count	Identified count	Percentage% of Accuracy
Face detection – Normal lightning and Normal scaling	30	30	100
Face detection – Dark lightning and Normal scaling	30	25	83
Face detection – Normal lightening and different scaling	30	23	77
Face detection – Dark lightening and different scaling	30	22	74

Table 7-3: Scaling, Lightning Based Test Results

7.3 Drawbacks and limitations

Although this system testing results returns are in high percentages still there are issues with lighting conditions and scaling conditions. For the above results as a dark light used candlelight as well as for the different scaling thirty degrees to forty degrees of scaling difference. Those were can be introduced as limitations of this solution.

7.4 Summary

This chapter is discussed about the evaluation and the testing aspects as well as the drawbacks and limitations of the system according to the aims and objectives defined in the previous chapters. According to the software engineering processes it is required to analyze the test results, and bugs were fixed to bring the system into an acceptable level. In the next chapter will be described the conclusion of this research project and further work that can be implemented.

Chapter 8

8. Conclusion and Future Work

8.1 Introduction

This chapter contains a brief discussion on the result obtained from the evaluation of this research and how many of the objectives were met through this proposed system. Under the future works can be done as of further improvements to be continued via this research for broader dimensions were considered for the discussion as well.

8.2 Conclusion

Developing the Smart Home Appliance Control Over Wi-Fi tool able to complete successfully. When going through the development process had to learn various new technologies and study number of libraries until finding the best match performance and functionality wise.

Because of the advanced face recognition, libraries use even wearing sunglass or cap will not be a disturbance to identify the correct user.

As a conclusion Smart Home Appliance Control Over Wi-Fi tool research successful and able to achieve its goals

8.3 Future Works

Even though the tool provides functionality which required to achieve the main goal and objectives, we can introduce some data processing part as well. When we allow this tool to record day to day activities like the period which build has been turned on, and the number of voltages spends on that build we can use that data set to make some prediction on usage patterns. By analyzing those data with a more suitable data mining method, we

can inform the user about how to reduce power consumption and what tips they should follow to have a good usage pattern.

As well as lightning effects and scaling changes related improvements also can be done in the future based on these research results.

8.4 Summary

This chapter described the results and future works on the developed tool. The solution provides a low-cost, high accurate, usable, simple and effective Smart Home Appliance Control Over Wi-Fi tool. It supports to send informative SMS alert to end user regarding the current dangerous situation as well as an email also can be performed. To make results more reliable it can be controlled devices as well. Even though through this research has been identified some new improvements which better to be added in future developments considering over rolled performances and test results this project can be suggested as the successful solution for this research problem.

9. Reference

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Appendix A

Figure 9-1: Rasp Berry Pi Camera

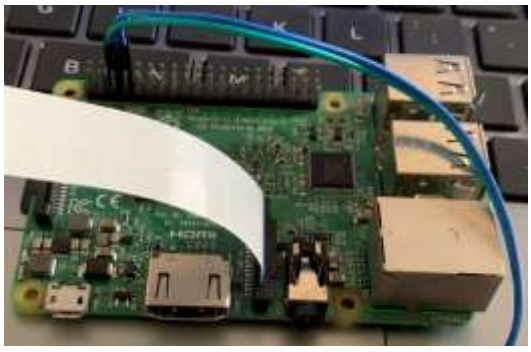

Figure 9-2: Rasp Berry Pi Device

Figure 9-3: Suggested device Structure

Appendix B

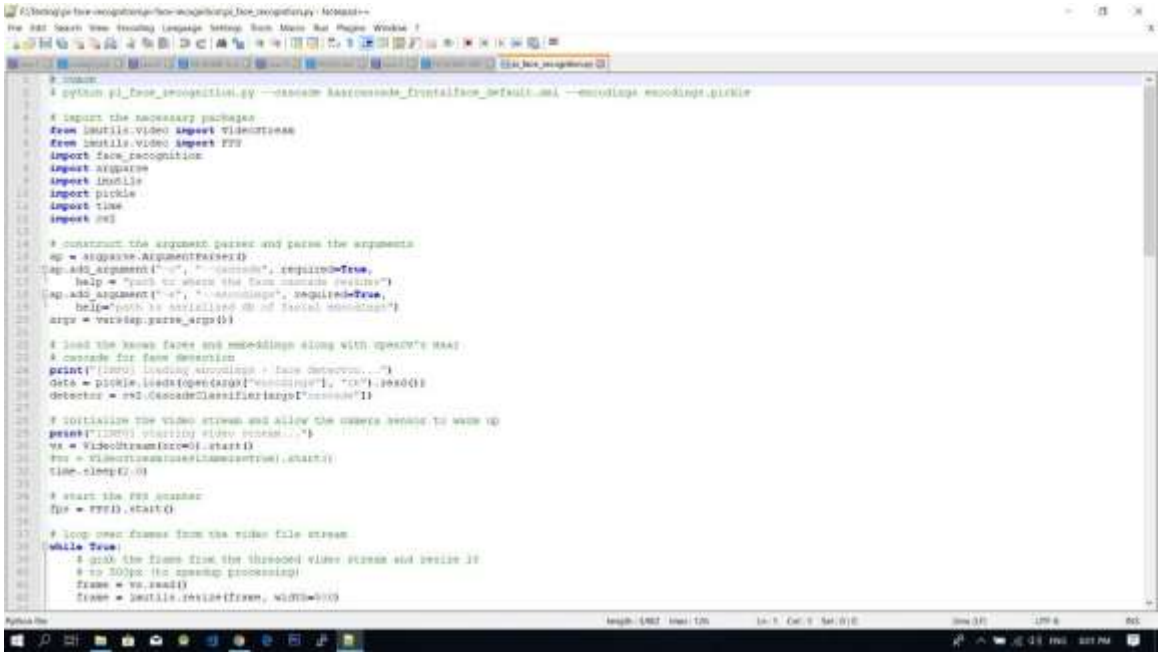

Figure 9-4: Face Training Code Snipper 1

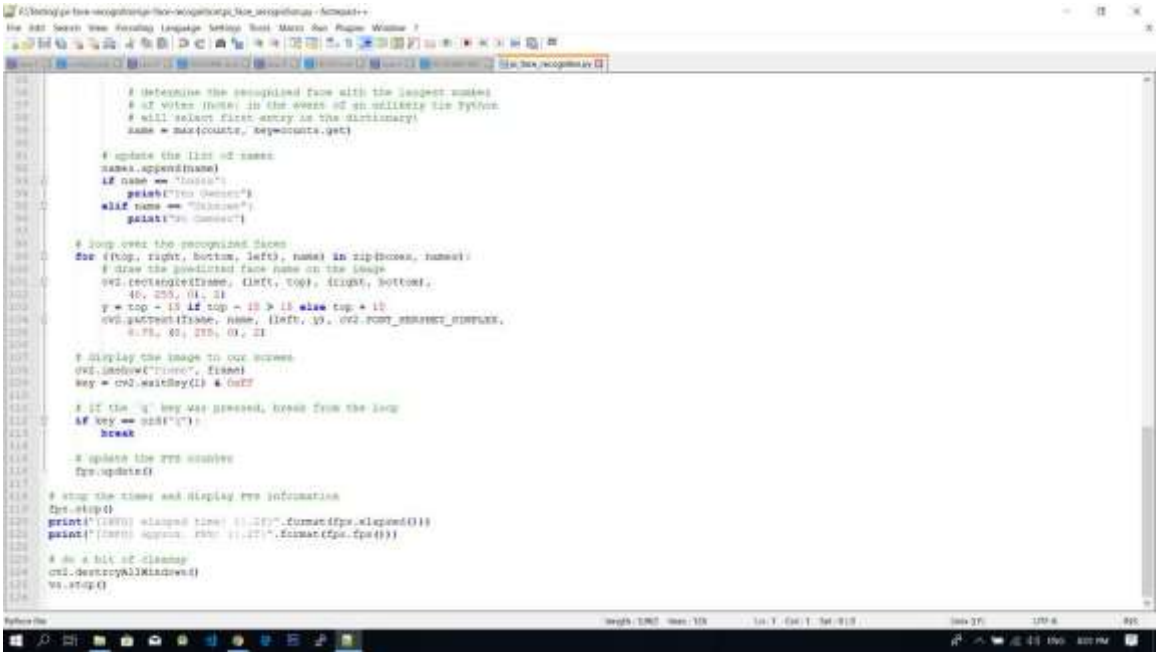

Figure 9-5: Face Training Code Snippet

Appendix C

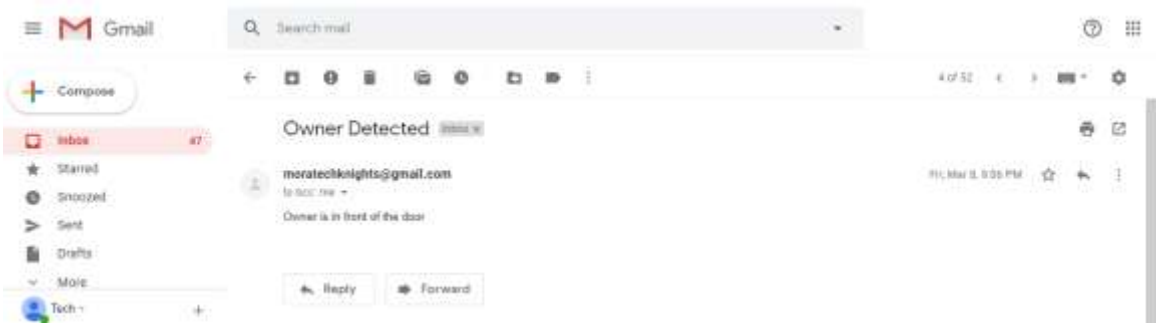

Figure 9-6: Email - Owner Detected

Figure 9-7: Email - Owner Unknown

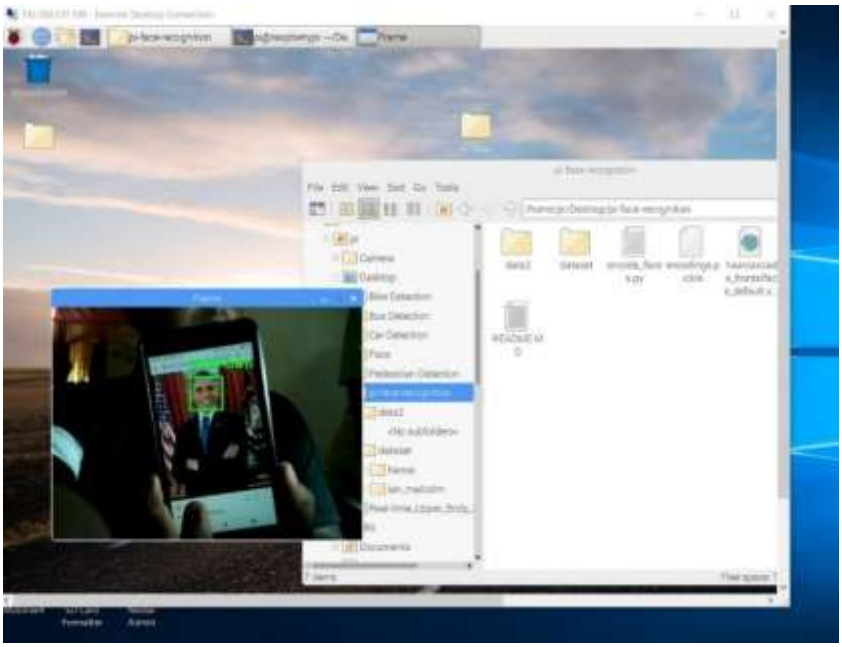

Figure 9-8: Face Identification UI

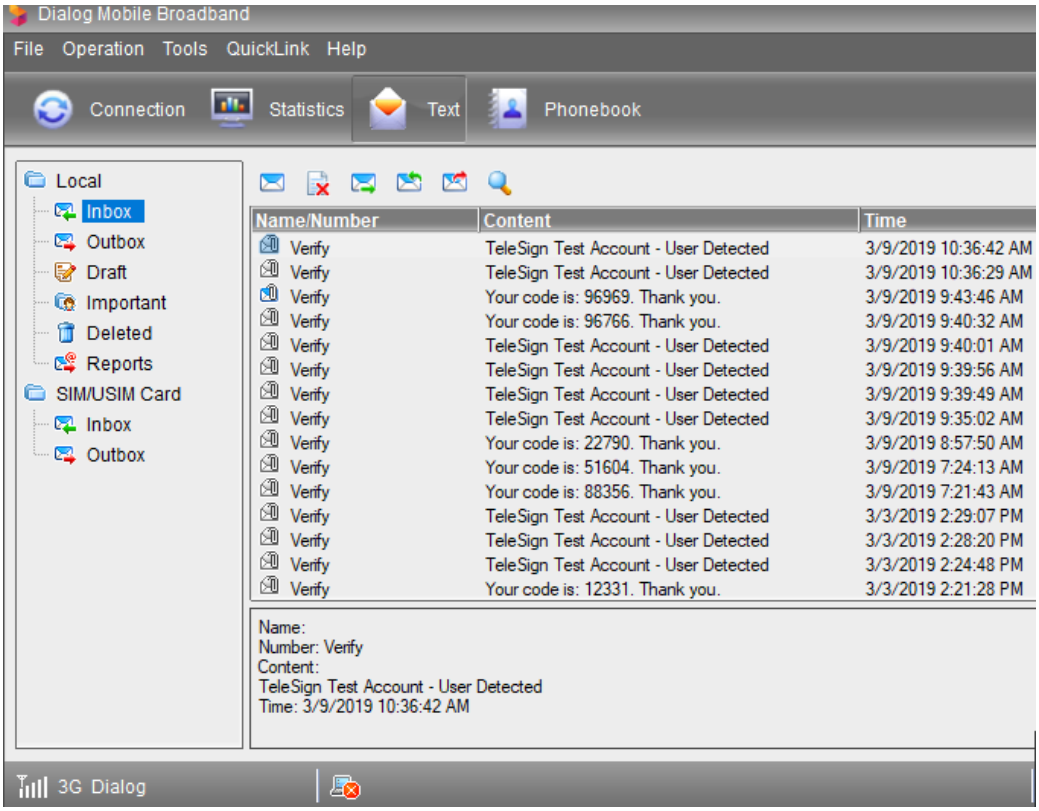

Figure 9-9: SMS-User Detected