



**COLLEGE OF SCIENCE AND TECHNOLOGY**

**AFRICAN CENTER OF EXCELLENCE IN INTERNET OF THINGS**

**P.O.BOX: 3900 Kigali, Rwanda**

**MASTERS THESIS**

**“Design and Implementation of a Face Mask Detecting Device to curb Covid-19  
Transmission”**

**Case study: College of Science and Technology (CST).**

*A dissertation submitted in partial fulfillment of the requirements for the award of*

**MASTER’S DEGREE IN INTERNET OF THINGS- WIRELESS INTELLIGENT  
SENSOR NETWORKS.**

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30<sup>th</sup> December 2021



**Thesis title:**

**“Design and Implementation of a Face Mask Detecting Device to curb Covid-19  
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A dissertation submitted in partial fulfillment of the requirements for the degree of Masters of Science in Internet of Things in the option of Wireless Intelligent Sensor Networks in the College of Science and Technology.

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## **DEDICATION**

I, Vincent NTAMBARA, hereby announce that the content of this theory file is my unique effort, organized towards the contentment of the necessities for a Master's degree in Internet of Things (IoT), Wireless Intelligent Sensor Networking option.

I hereby assure that, this is my authentic work that has in no way been offered or submitted for any educational award, in complete or in part, at any university or organization.

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**CERTIFICATE**

I am hereby endorsing that the plan work titled “**Design and Implementation of a Face Mask Detecting Device to curb Covid-19 Transmission**” is a file of genuine work done by Vincent NTAMBARA with the recording number 220004734 in part of contentment of the precondition for the reward of a master’s of science in internet of things at College of Science and Technology, University of Rwanda in the course of the educational year 2019-2021.

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## **ABSTRACT**

COVID-19 is a deadly contagious sickness, which broke out in China by December 2019 in Wuhan city of Hubei Province. From that point, it has blowout to more than 210 countries and territories. Outstanding to the Severe Acute Respiratory Syndrome Coronavirus2 (SARS-CoV-2) virus, this one is far a viral sickness. The signs and symptoms of flu with dehydrated cough, painful throat, extraordinary fever, and respiration issues symbolize the sufferers. It is pronounced that over 262,593,580 million human beings were inflamed and greater than five,228,488 million deaths globally at the same time as in Rwanda there are a hundred thousand case and 1,342 death. The maximum affected country with the highest wide variety of instances about 49,301,070 million and 801,326 death being the USA. Apart from tons of effort to fight against the disorder, no treatment to date has been determined even though prevention and control measures are the nice options. Implementing energetic plans and timely decisions have helped countries to limit big unfold of covid-19 amongst their populations. As different nations worldwide, the government of Rwanda enforced preventive measures amongst others were carrying facemasks, well-timed hand washing with clean aquatic and soap or use hand disinfectant, and social distancing, flight suspension, ultimate educational establishments, lockdown and curfew in city and rural areas. In addition, patients were supplied with free-of-charge healthcare in isolation facilities. These measures were strange to citizens thus it was hard for citizens to willingly follow them. Therefore, to enforce these measures, the government used “Youth Volunteer groups’ country wide to follow up on people and keep on alerting or reminding those people who forgot to properly wear their masks and sometimes could be punished by paying some fine. As humans, the youth volunteers sometimes get tired thus not closely monitor how people respect these measures. With these people behaviors, an automated COVID-19 transmission preventive measures enforcing system is needed in order to consistently monitor and control the pandemic transmission. In this research, a monitoring device to enforce facemask wearing among people is proposed. This device controls covid-19 transmission by alerting anyone who might in any case violate the measure of facemask wearing in particular, is expected to bring down the pandemic disease spread thus a free of covid-19 pandemic disease community. The results of this research show that the proposed device can control the mask wearing by providing sound alert to people. This research was carried out at the college of Science and Technology, University of Rwanda.

**Key Words:** *IoT, Facemask, Machine learning, COVID-19, Covid-19 Transmission, Covid-19 Preventive Measures.*

## LIST OF ACRONYMS

ACEIOT:	African Center of Excellency in Internet of Things
ARM CORTEX-A53:	Advanced RISC Machines originally Acorn RISC Machine
ATMS:	Automated Teller Machine
CNN:	Convolutional Neural Network
CO-SUPERVISOR:	Co-operate Supervisor
COVID-19:	Coronavirus Disease of 2019
CST:	College of Science and Technology
DGS:	DiGeorge syndrome
DMA:	Direct Memory Access
DR:	Doctor
GFLOPS:	Giga Floating-point Operations per second
GND:	Ground
GPIO:	General-purpose Input Output
HDMI:	High-definition Multimedia Interface
IOT:	Internet of Things
LAN:	Local Area Network
LPDDR2:	Low power double-data-rate 2
MERS-COV:	Middle East Respiratory Syndrome Coronavirus
MICRO SD:	Micro Secure Digital Card
NTSC:	National Television Standards Committee
OPEN CV:	Open Source Computer Vision Library
P.O.BOX:	Post Office Box
REG. NO.:	Registration Number
RNA:	Ribonucleic Acid
SARS-COV-2:	Severe Acute Respiratory Syndrome Coronavirus 2
SDIO:	Secure Digital Input Output
TV:	Television
USB:	Universal Serial Bus
WHO:	World Health Organization
WI-FI:	Wireless Fidelity

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## CHAPTER 1: OVERALL INTRODUCTION

### 1.1 Introduction

As it is well recognized all over the world that during early December 2019 in China, there broke up a pandemic disease by Corona Virus and spread worldwide [1]. The break out of this pandemic disease caused most human social daily activities like business, games, entertainment, education and others come to halt because of measures to combat the spread of this disease [2].

Among measures that have been put in place to combat the pandemic disease transmission, is the face mask wearing to stop or control the spreading of the disease through salivary particles from one's mouth to another as they talk, physical distancing of one to two meters away from one person to another to avoid contamination, hand washing, timely curfews and lockdown all to contain the Covid-19 spread [3].

Normally, most of the daily human activities are done in groups of co-working people like in meetings, shopping, studying, sports, family and so many activities that bring together people and when they are together, they sometimes do not consider or remember the rule to properly put on the face mask to avoid the disease transmission. Like other worldwide countries and in particular a developing country, Rwanda also suffered the pandemic Covid-19 that caused most of such activities to halt. It was on 14/3/2020 when the first case was reported in Rwanda [4]. Since the first case up to 15 March 2021, the 20,186 Coronavirus cases, 280 deaths and 18,566 recovered cases have been registered [5]. Among the enforced measures to curb covid-19 transmission, was also lockdown, face mask, hand wash, closing of schools [6].

After some three or four weeks then the authorities could announce the re-opening of activities and educational institutions, it's from this good but full of questions to many events like how will students behave at schools? Will they really respond positively to the measures of physical distancing, face masking wearing? Won't they stubbornly violate these measures? With all these questions, an idea came in for developing an IoT based device to monitor and alert students to properly put on their facemask avoiding spread of the disease among themselves.

Therefore, the main reason of the study is to design an IoT based monitoring device with the use of different IoT components and technologies that will help identifying whether among the group of people and an individual, there is any or some people who have their face masks not properly put on. If the facemask is not properly put on, the monitoring device will signalize by sound alerting that someone in the crowd or all of them have not put on their facemasks properly and if all have their face masks put on properly, no reaction apart from sending an event log identity, date and time of the event to the repository directory or database that the situation is normal or measures against covid-19 spreading are respected. It is in this same manner

that whenever an event happens, after alerting the student, the device will also send the data to the storage or a repository system to be stored there and be analyzed later for further actions or decision making. The system or the device will communicate through Wi-Fi as a medium; it will use sensors like face recognition sensor mounted on the microcontroller (Raspberry pi B). The device will be powered by connecting it to the power outlet near where the device is mounted. Presently, even though the students go to school with their facemasks but the challenge is that do they always keep them on face or sometimes they remove them. Do students continuously keep the required distance between them? The main concern goes to the face mask where the campus management select some students, deploy them to specific public places to monitor whoever goes without the face mask or not properly put on and advises him/her to put on his/her face mask properly or go back and come with it for those who don't have face masks. Like the substitution, this monitoring device will be placed at public pathways and often-gathering point like meeting rooms and the place where students gather together for any purpose like watching the TV, group assignments, or any kind of meetings so that the system keeps on monitoring if the facemask measure is respected among them.

The advantage of the proposed system is that no any other third party to follow up to students whether they have kept this preventive measure in their mind or stubbornly violate it. In addition, the report will be generated and sent to the server, which will be reviewed later, and further decisions will be taken accordingly. This research aims at introducing an IoT based innovation technology and machine learning to introduce a monitoring device to keep on alerting students whenever they do not properly put on their facemasks in public. This monitoring device will have the face recognition sensor (camera) that recognizes faces in the distance of its monitoring capacity and compares them with the saved ones for the real reply by the sound signal reminding students to properly put on their facemasks. A powerful and financial approach to the use of AI in a production setting to build comfortable environment. Using a facemask detection dataset, we will use Open CV to carry out real-time face detection from a live movement from the digital camera. Using Keras, Python, Tensor flow and Open CV, and, we will build a COVID-19 facemask detector with computer vision and prescient. Using computer vision and CNN, with the purpose to decide whether the picture character within the photograph or video streaming is wearing a mask or not.

## 1.2 Background of the study

In December 2019, a new fresh coronavirus became recognized in China imposing excessive breathing disorder with pneumonia. It twisted into firstly named Novel Coronavirus and The World Health Organization (WHO) recommended the subsequent language related to the virus. The virus producing the contamination has been baptized - extreme acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [7]. The sickness initiated because of infection is known as - coronavirus sickness (COVID-19). COVID-19 has been characterized as an airborne High Consequence Infections Disease [8]. SARS-CoV-2 is scattering among human beings worldwide and may be visible on the WHO condition reports dashboard that is updated day by day.

This respiratory-related sickness can blowout and cause contamination from patients to different humans effortlessly. This disease regarded with signs and symptoms including fever, fatigue, a loss or exchange to feel of scent or flavor and dehydrated cough is likely in the primary level of sickness; though, a few patients will not develop to greater intense infection [9]. Dyspnea is said to be commonplace in hospitalized patients, whilst essential signs and symptoms are described to be usually solid at the time of admission [10]. Adult sufferers with an underlying fitness disorder are more likely to progress to intense contamination, a spread of irregularities can be predicted on chest x Rays, however two-sided lung penetrates look like commonplace, and just like what is observable with other forms of viral pneumonia [11].

Therefore, worldwide governments put and announced measures to control this kind of covid-19 transmission rate that is even not easily controlled because there is no treatment for it and even the vaccine itself do not guarantee protection [12]. Among measures put in place, was also the facemask wearing to control the saliva spreading from someone's mouth to another.

The main reason for the facemask is that it can support in avoiding or diminish the danger of scattering respiratory viruses from person to person [13]. This study shows the development of the monitoring and alerting system to the people for wearing the masks by using the ESP32-CAM and raspberry pi. The Haar as feature and cascade organize training methods are used to sense the human faces and the masks in this system. A total of 2000 sample images were trained for modeling the mask detection on human faces. The system developed can sense and categorize somebody who is wearing the facemask for shielding the breathing infection at the maximum level.

### 1.3 Problem statement

The outbreak of covid-19 during December 2019, caused most human social daily activities like business, games, entertainment, education and other useful activities come to halt as result of measures laid down to combat the spread of this disease [14].

Among the measures put in place to combat the pandemic disease transmission, is facemask put on, physical distancing of one and a half to two meters away from one person to another and to avoid contamination through salivary particles from their mouths as they talk and body temperature test as one of the signs of covid-19 infected person [15].

Normally, most of the daily human activities are done in groups of co-working people like in meetings, shopping, studying, sports, family and so many activities that bring people together and when they are together, they do not even consider or remember to obey the facemask on while in crowd to avoid the disease transmission.

Masks need to be used as portion of a complete technique of procedures to overpower spread and save lives [16]; using masks alone is not always enough to offer a good enough level of protection in fighting COVID-19 transmission [17].

If COVID-19 is scattering on your public, live harmless via winning some humble protections, together with physical distancing, sporting a mask, preserving housings nicely aired, escaping masses, cleansing hands regularly, and coughing into a curved elbow or tissue. Check native reference wherein you live and work. Do all of it. Make carrying a masks an ordinary part of being around different human beings.

This monitoring device will have the camera that will always monitor bypassing students or anybody in its proximity, capture the image that is compared to the trained model to predict whether the person has the facemask properly put on or not. With the facemask properly put on, no sound signal alert is given unlike when the person has no facemask or the facemask not properly put on, the system gives an audible alert to the people.

### 1.4 Objectives of the study

#### 1.4.1 Aim

The aim of this research is to design a COVID-19 monitoring IoT based device that will enforce facemask wearing especially when student or staff come together to eradicate COVID-19 transmission in the public places. The device will alert students whenever they violate the rule of facemask or have not properly put on



their facemasks, which is the important one among others. The event reporting will be every after the complete event happening, whenever someone comes after an alerting signal and immediately send the data to the repository for further use in decision making.

#### 1.4.2 General objectives

Generally, the principle objective of the thesis is to layout a monitoring device so that it will scale back the spread of the lethal ailment covid-19 amongst college students and staff at the campus and community at massive.

#### 1.4.3 Specific objectives

- To assessment the present works on the transmission of covid-19
- To design a monitoring device that helps control the transmission of covid-19 by alerting students who do not have facemasks or don't put on their facemasks properly.
- To collect covid-19 monitored data for further decisions and insights.

### 1.5 Hypothesis

IoT-based facemask detection system is upcoming to control covid-19 transmission or spreading as a result salivary droplet from someone's mouth to another person's body parts like nose, eyes and mouth thus being contaminated. The system will provide real time alert to the students and CST community who will be seen not properly put on his/her facemask. The system will play the exact role as youth volunteers (selected students) so they get time to concentrate on their studies.

### 1.6 Scope of the study

This system is going to focus on monitoring whoever comes in its focus whether he/she has properly put on the facemask and alerts who ever (students and the community at large) by pass within in the device perimeters with his/her facemask not properly put on. The audible signal will be heard to alert whoever is found his/her facemask is not properly put on.

### 1.7 Significance of the research

As previously defined, this system is IoT-based monitoring device to enforce proper facemask wearing. It will be aimed at preventing covid-19 transmission at CST campus premises. This will control covid-19

transmission among students and staff at the campus thus a covid-19 free community fearlessly and confidently carrying out their studies, academic and administrative duties because everyone assures proper facemask wearing. Therefore, this system will help to monitor people who do not respect the regulation to keep wearing facemask when talking to others for it is the easiest way of transmitting covid-19 through salivary droplets from mouth to air and reach the partner through the nose. Every event captured will be save to the server so that it can be reviewed later for further decisions. In addition, this system will simplify this tiresome work by some students voluntarily moving around talking to those who do not have their facemasks properly put on instead the device will always notify who ever does not respect that rule.

### 1.8 Limitations of the study

This research deals with only alerting every one found with his/her facemask not well put on or completely not put on the face. The most challenging limitation will be lack of all or some required or suitable tools to implement the project.

### 1.9 Organization of the study

This segment introduces all chapters that make up this thesis, underneath are the chapters described.

Chapter 1, it offers an introduction of the studies which includes the historical past of the have a look at, observe targets, hypothesis of the study, the limitation of the study, module, platform, software, and hardware.

Chapter 2 discusses associated researches done earlier than, its gaps and how this studies is going to improve the existing gadget.

Chapter 3 the study's methodology. It gives an outline of the research strategies a good way to be used in this research. It also affords the necessities wanted for the work to be executed.

Chapter 4 talks approximately the records of covid-19, the IoT based Monitoring tool to put in force facemask wearing amongst people to control covid-19 spreading, the device algorithm used, and steps thru which the gadget meets its goal.

Chapter 5 concludes the thesis and provides recommendations and future work.

## CHAPTER 2: LITERATURE REVIEW

### 2.1 Introduction

This chapter will review the literature done by various researchers and what they have discovered concerning facemask detection systems. It will depend on how much research has been done previously in the area of this study. It will also discover a comparatively new area of the works alike to this part of study or studies that lead up to the current research.

It will also comprise a description of terms section that are matchless to this study so that they are elaborated to be understood by the general readers. It is under this chapter that the researcher will identify, relate and evaluate the resources consulted for this research study.

### 2.2 Theories Studied

As it is well known all over the world that during early December 2019 in China, there broke up a pandemic disease by Corona Virus and spread worldwide [18]. The break out of this pandemic disease caused most human social daily activities like business, games, entertainment, education and others come to halt because of measures to combat the spread of this disease [19].

Among measures put in place to combat the pandemic disease transmission, is facemask wearing to avoid contamination through salivary particles from one's mouth as they talk, hand washing, timely curfews and lockdown all to contain the Covid-19 spread [20]. The emphasis is mostly put on the measure of wearing the facemask properly and always when in the crowd discovering what researchers say about the use of the facemask.

Maqbool A, et al. Provide an explanation for, COVID-19 is a lethal epidemic sickness that originated from the new coronavirus circle of relatives known as extreme acute breathing syndrome coronavirus 2 (SARS-CoV-2). Up to now, there are neither injections nor clear drugs around to therapy COVID-19 disease, so the social measures and public healthcare are beneficial in controlling the number of contaminations and shop lives. Having this in mind, a try is being made to the present study to come up with a tool to shrink the covid-19 transmission. Up to date this pandemic sickness has neither the vaccine nor explicit drugs available for its treatment.

There is not any possible proper clinical medicine for covid-19, but suitable options for stopping covid-19 transmission like facemask carrying, case isolation, touch tracing, quarantine, social distancing and foreign journey measures, hand washing, floor cleaning [21].

Ashkan Mohammad Sadeghi et al. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has broadly speaking pretentious humans running in health care centers global, so it is very important for the global intervention and produce a system to use in health care system. Stopping the transmission of this disease in the process of medical services and dental processes that produce airborne droplets and particles can be assumed the main achievement in monitoring the blowout of covid-19 in health care centers. We very well know that no solution has been proved for this issue; therefore, the main idea in this matter is to introduce a monitoring device that will always monitor and alert where violation occurs along with the same measures and sanitary practices. For we are not sure of the period we should stay with this globally issue, applying antecedent pharmacotherapies to minimize breathing emissions to curb the virus would play a task in this matter for there is no clear cure for covid-19, so we assume that taking medicine solutions to minimize saliva and droplet manufacture might be useful in containing covid-19 transmission by the time of aerosol and respiratory droplet production procedures. [22].

According to Hussain R. et al., the system called drive-thru pharmacy is the one of the measures that could increase security and care for both the pharmacy staffs and patients. In this service, a patient receives pre-ordered medicine that is checked before, labelled, filled before from a drive-thru window without having to exit the vehicle, and in this whole process, there is no human interaction [23].

Rutayisire E. et al. debate that the covid-19 epidemic showed a countless threat to numerous African countries from towns to rural areas, formed a solid request on already rare incomes, and need strong mobilization of extra resources to start measures. Closing down the boundaries and activities of people limitations within the nation state as procedures to avoid the transmission of covid-19, lead to the sector being poorly pretentious by the loss of revenue [24].

Cooper J. Et al. Declare that numerous transmissible illnesses may additionally have contact, airborne, and or droplets broadcast. Following the COVID-19 epidemic, Taiwan government applied the use of facemasks, and hand sanitizer and other anticipation moves, like social distancing, sanction on social occasions, operating from homebased, etc. Were amongst approaches being accompanied to slash the blowout of the covid-19 [25].

According to Yogi, Tri Prasetyo et al. Coronavirus is a very infectious disorder that threatens humans globally; it is taken to be the 3<sup>rd</sup> epidemic in twenty first century. After the coming of Middle East, breathing syndrome coronavirus (MERS-CoV) in Saudi Arabia and simple acute respiratory syndrome coronavirus (SARS-CoV), in China a brand new SARS-like coronavirus has been revealed closing December 2019 [26].

Siukan Lawa et al. The present international pandemic COVID-19 initiated with the aid of the intense acute respiratory syndrome coronavirus 2 (SARS-CoV-2), and its possible unfold over wastewater is rising concerns amongst technology network [27].

While research on the ways over which human beings can contract the virus are nevertheless growing, the presently acknowledged methods are breath of drops of saliva, sputum, and person-to-man or woman frame interactions [28]. Current research show that the SARS-CoV-2 virus is shed from inflamed sufferers with plain indicators of asymptomatic grade and treated sufferers without a similarly signal of the signs and symptoms stated the occurrence of the SARSCoV-2 viral RNA inside the urine trials of diseased sufferers, clinic sewage, and network wastewater [29]. However, the capability of the SARS-CoV-2 to preserve inside the aquatic medium, in addition to wastewater stays doubtful, the invention of the SARS-CoV-2 RNA in each unprocessed and treated wastewater and the separation of the communicable SARS-CoV-2 from stool examples boom the fear of the threat of the possible unfold over this medium [30]. Nevertheless, up to now, no study can approve the unfold of SARSCoV-2 over virus-infected water. In addition, a few studies testified that SARS-CoV-2 loses its infection in no time in wastewater. The up to date state of hygienic system in low-earnings nations, specifically in Africa, is risky [31].

Jimenez T. Et al. Wrote that, on 11 March 2020, the World Health Organization categorized COVID-19, generally said as coronavirus, as an international epidemic [32]. From the time whilst it became first pronounced in December 2019, coronavirus has blowout to over one hundred eighty international locations, prevailing thousands of lives [33]. In the US, daily lifestyles has been disturbed to an extraordinary point because of defensive tactics assumed the sizeable nature of coronavirus spread: organizations and schools have shut, works have been long past, humans have started carrying on their duties from home, network congregations have been negated, journey has been controlled, and a few zones have qualified foodstuff and skincare product scarcities [34]. Presently, the acknowledged fundamental spread mode for coronavirus is over the change of respiration watery, regularly over sprays thru coughs and sneezes but also on shared surfaces [35]. Its unfold can be reduced by means of pre-emptive practices together with social distancing (i.e., purposely cumulate the bodily space among people and escaping community meetings) and hand washing [36]. Definitely, the Grand College COVID-19 respond Team schemes that such plays, in performance with justification guidelines which includes quarantining fantastic cases, could diminish deaths by way of half [37].

According to Siukan Lawa et al., the origins spread, symptoms and shielding strategies of SARS and COVID-19 were revised; but analysis and control stays for in addition observe [38]. Polymerase chain response to

approve for collaboration of SARS or COVID-19 occasionally may demonstrate an incorrect poor. No unique motion system only has an extensive variety of antiviral tablets for COVID-19 sufferers and no injection for stoppage at gift-day [39]. Currently, personal sanitization, sporting the facemask, washing fingers in addition to decreasing social interaction plus dodging multitudes, hired at domestic are the maximum giant preventing ways for the transmission of COVID-19 [40].

Vijay Kumara et al., COVID-19 epidemic came into presence by the end of December 2019 at Wuhan, China [41]. W.H.O introduced it as a virus. The basis of this take a look at is to make available the statistics regarding anticipation, environment difficulty, social economic results, and medicines for COVID-19 [41]. Communal separation, selection, stay home, face covering then use disinfectant or soap at normal period in-between for excellence expectation against COVID-19. The “oral feces” broadcast of COVID-19 is a danger to surroundings [42]. Inappropriate discarding of clinical/biomedical and humanoid leftover can damage the entire surroundings. Nitrifying-enriched prompted mud i.e. NAS fashion does an essential position to easy surroundings sections similar to mud and leftover [43]. COVID-19 revealed influence on social and financial lifestyles, nevertheless, no other alternative until medication finding. In drug or remedy of COVID-19 opinion, a blended method concerning new plus old-fashion drug gadget might also affirm an early prevention of greater viral transmission [44].

According to Precioso J, et al., COVID-19 identify of the WHO while contagious illness produced using fresh coronavirus that could reason plain breathing contagion, along with pneumonia [45]. The center methods of spreading COVID-19 are:

- 1) Near interplay with human beings diseased through virus or
- 2) Interaction with infected exteriors or things.

Spread occurs over drops, which can be barred whilst someone with COVID-19 coughs, sneezes or communicates, or over touch by unclean arms and bit eyes, nose or mouth of a person (arms without difficulty dirty through interaction with things or exteriors in which salivary drops from an ill individual propertied). Meaningful that nearby friends can donate cumulative the blowout of contamination, violation of those spread chains is vital. Portuguese Directorate-General of Health (DGS) offering approaches on the general public fitness strategies to be general by public carrier setting up to stop the blowout of the virus. For a short time, paramount does suggested means of DGS incorporate the subsequent: promise till pawns preserve bodily coldness of 1.5m; submit signage at the ground to support clients retain with proper social distancing; make physical fences among personnel and clients, with a view to keep away from “excessive estimate among individuals”. By means of tactics of cleansing plus disinfecting, DGS commends sanitizing complete

stock place at the least as soon as a day; and regularly cleansing (in any respect hours) the excessive-contact faces, inclusive of price tag distributor machines or ATMs. Furthermore, alcohol-based consequences must be if in planned places [46].

The main and common challenge found in all reviewed papers is that all preventive measures for coronavirus (covid-19) transmission in place by many country governments worldwide and the World Health Organization, would work effectively if could be set together with the use of IoT and AI technologies-based devices and be deployed to carry out all duties on the field without human interaction (man power).

## CHAPTER 3 RESEARCH METHODOLOGY

### 3.1 Introduction

This section offers a summary of the study strategies, which might be going for use at some stage in the work. It highlights the strategies and processes used and suggests how the analyzed results may be supplied for the duration of the complete work. Mainly clinical techniques for undertaking studies are used but; each qualitative and quantitative techniques are hardly ever used, as facts analysis is the part of this research. This study methodology lies in scientific research methods and it shows that technical kind of study methods is just used for clarification.

### 3.2 Tools used

In order to have the facemask-detecting device to control covid-19 transmission, a variety of tools have been used though classified in three categories. These three categories are Hardware tools, Software tools and the Dataset. The software, hardware and the dataset, the required tools to build up the system are elaborated here below. Each group of tools play important dependent roles towards effective results.

### 3.3 Hardware required tools

#### 3.3.1 Introduction

Hardware is the physical part or element of the device sometimes called the machinery or equipment that makes up any device. To my project, I used different hardware tools to build up this device.

#### 3.3.2 Raspberry Pi 4 b

This microcontroller (Raspberry Pi 4) suggests groundbreaking will increase performance speediness, software presentation, reminiscence, plus connectivity as related to the prior-era forums, whilst maintaining in reverse compatibility and comparable power intake. The Raspberry Pi 4 offers laptop overall presentation corresponding to entry-level x86 PC systems. The Raspberry Pi 4 is available in three on-board RAM alternatives for even more overall presentation advantages: 2GB, 4GB and 8GB. This product's key functions encompass an excessive-performance 64bit quad-core processor, twin show production via Micro HDMI ports, up to 4K decision, hardware video interpreting at up to 4Kp60, up to 4GB of RAM, dual-band 2.4/5.0 GHz Wi-Fi LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.Zero, and PoE ability. Because of greater power needs, the Raspberry Pi 4 wants a 3.0A USB-C strength deliver (offered one by one). If you have a present



electricity deliver that is rated at 3.0A, you can make use of a micro USB to USB-C adapter to make use of your current Micro USB strength source to electricity the Raspberry Pi 4. The preferred HDMI port that have been a part of former technology Raspberry Pi group forums is swapped on the Raspberry Pi 4 by using Micro HDMI ports to provide twin screen assist. A 4K60P Micro HDMI to HDMI rope is needed (or two connectors for twin reveal process). The overview of the raspberry pi 4 model B shows different parts that make it up, describing their use or purpose on the board, specifications as they physically appear or look like. Figure 3.1 bellow shows Raspberry pi 4 model overview

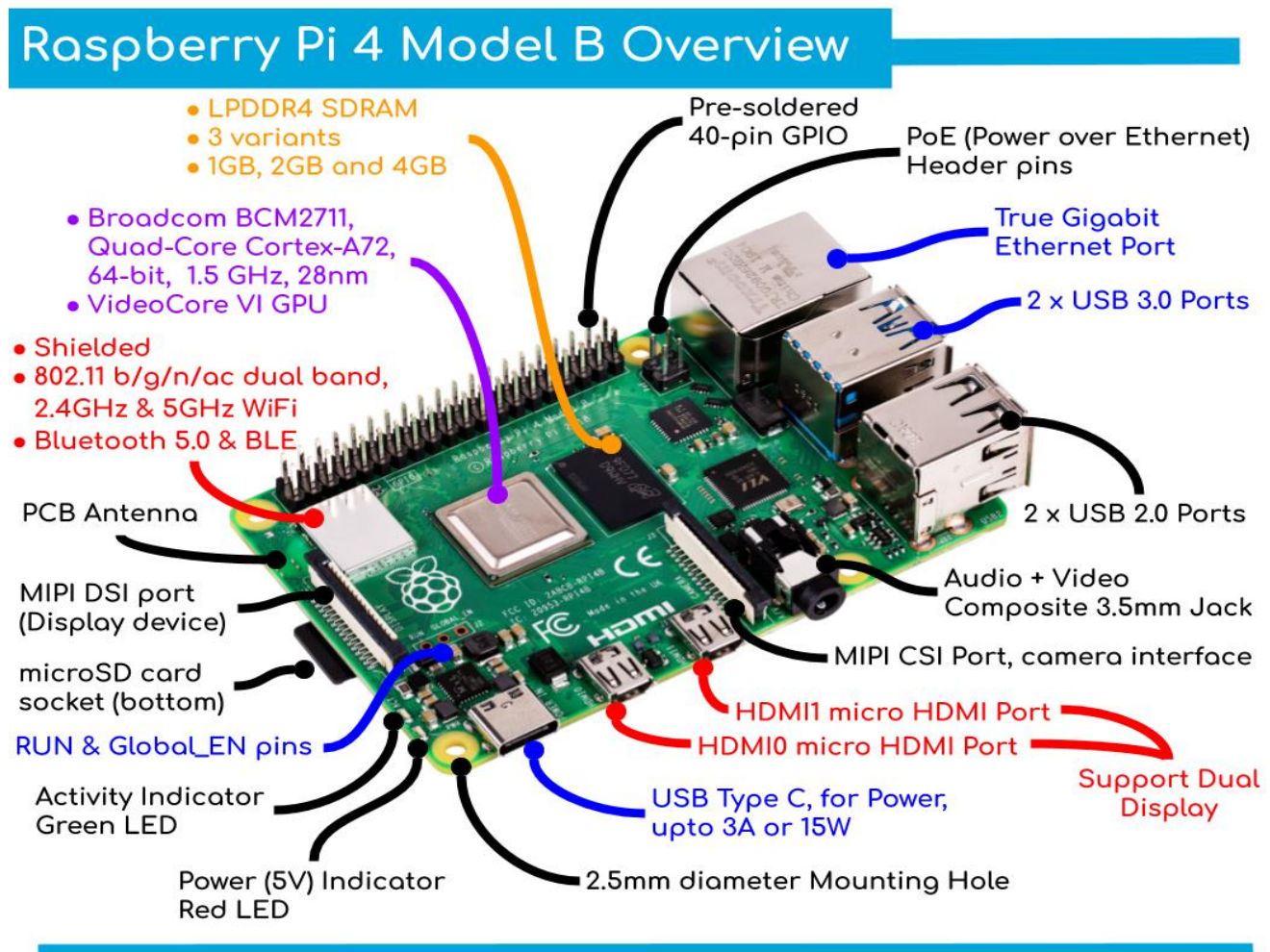


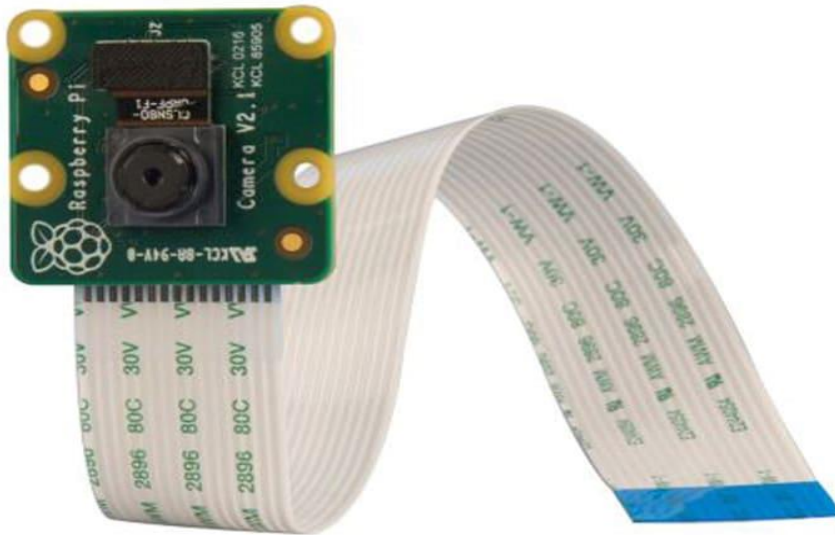
Figure 3.1 Raspberry Pi 4 Model B Overview (source: smartbitbn.com, 2021)

### 3.3.3 Raspberry Pi Camera

This Raspberry Pi Camera is an excessive nice 8 megapixel Sony IMX219 photo sensor customized add on board for Raspberry Pi, providing a static attention lens. It is able to capture 3280 x 2464 pixel static photographs, helps 1080p30, 720p60 and 640x480p60 ninety video. It connects to the Pi by means of way of one of the minor outlets on panel higher surface and makes use of the devoted CSI connector, intended specifically for interfacing the camera. The panel is as tiny as 25mm x 23mm x 9mm. Again, it has over 3g, creating it ideal for cellular or additional uses, as size and weight are critical. It joins to the Raspberry Pi by quick ribbon connector. The terrific Sony photograph sensor itself owns a local resolve 8 mega pixel, and has a hard and fast cognizance lens on the project. In phrases of static snap shots, the camera is able to capture 3280 x 2464-pixel still pictures, and supports 1080p30, 720p60 and 640x480p90 video.

The camera on the system is to capture either streaming video or stand still image for comparison leading to the prediction decision whether a person has put on his/her facemask or not.

Figure 3.2 bellow shows a typical view of the camera.



*Figure 3.2 Raspberry Pi Camera Module* (source: uk.rs-online.com, 2021)

#### **Features:**

The camera has the capacity of eight-megapixel, able to take pictures of 3280 x 2464 pixels, Capture video at 1080p30, 720p60 and 640x480p90 steadfastness. It is sustained with the aid of cutting-edge model of Raspbian Operating System. It may be programed as a CCTV for security camera, movement detection, and time lapse photography about 1.12  $\mu\text{m}$  X 1.12  $\mu\text{m}$  pixel with Omni BSI knowhow for excessive overall

presentation (extraordinary sensitivity, little crosstalk, low noise), Optical length of 1/4", it's a next Generation Raspberry Pi Camera Unit with Static Emphasis Lens, a Sony Exmore IMX219 Sensor Capable of 4K30 1080P60 720P180 8MP Static, 3280 (H) x 2464 (V) Dynamic Pixel Amount, Maximum of 1080P30 and 8MP Stills in Raspberry Pi Board, a Power Supply Highly Suggested. This camera can work with every Models of Raspberry Pi 1, 2 & 3 being connected to the raspberry Pi Camera Panel by a Ribbon connector.

### 3.3.4 Raspberry Pi SD Card

This card, is a brief for Secure Digital card, it is a detachable storage used to store and install massive amounts of records in huge sort of mobile electronics, cameras, smart devices, and extra. Raspberry Pi do now not have any internal reminiscence so this indicates it do now not include pre-set up working machine. Without an OS, you cannot perform center operations. So, to make raspberry pi work, you going to need a micro SD card on which you may deploy Pi OS to make it practical.

This card is a very important part of the Raspberry Pi; it has the primary space for the OS and documents. Storage may be prolonged via many sorts of USB related peripherals.

When the Raspberry Pi is 'switched on', i.e. Related to a power deliver, a special piece of code referred to as the bootloader is finished, which reads greater unique code from the SD card this is used to begin up the Raspberry Pi. If there may be no SD card inserted, it is going to no longer begin. Do NOT push in or pull out an SD card even as the Raspberry Pi is attached to the strength, as this is in all likelihood to deprave the SD card facts (you may break out with it, but it is best now not to). The card is set up, or printed on, in an extraordinary style, which means the Raspberry Pi can examine the records it wishes to begin nicely. One gain of the use of an SD card like that is that you can have several SD playing cards, each with a distinct running gadget, or a special purpose. Simply power off, switch cards, and reconnect the electricity. Please undergo in attention that the supreme amount of the cardboard reader of the Raspberry Pi is 25 MB/s and that maximum probably study then compose rapidity will not surpass 22 MB/s. The pi SD card is of great importance on the system in a way that it is the main storage where even the operating system is installed and primary required application like python with its essential libraries are installed and running to have a fully functioning system. Figure 3.3 bellow, is the secure digital card (SD Card).

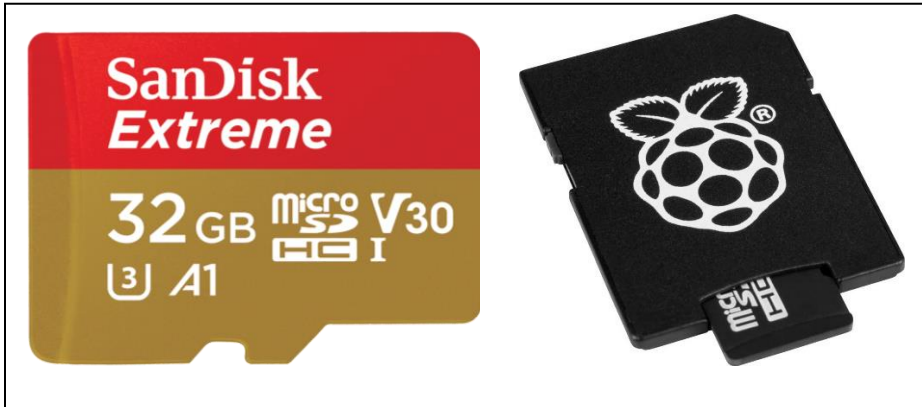


Figure 3.3 Raspberry Pi SD Card (source: amazon.com, 2021)

### 3.3.5 The Cana Kit Raspberry Pi 3 Power Supply

The Cana Kit Raspberry Pi power deliver, differs starting with normal popular 5V USB energy substances on market so that it takes a complete 2.5A and static production of energy properly in USB minimal energy specifications. This connector has been included as a noise clear out aimed at maximum steadiness and dependable process.

The strength source still has approximately 0.5A of output strength to spare, so even on the most modern supported with the aid of the Raspberry Pi 4; the electricity deliver is not at its absolute maximum. It is also best to be used by using every person over-clocking the Raspberry Pi, which causes better power necessities that a lower power adapter might not be capable of deliver. With this energy supply, you can energy the Raspberry Pi 3 at complete load as well as up to 1.2A throughout the 4 USB ports.

2.5A is now a demand for the Raspberry Pi 4. The Cana Kit 2.5A Raspberry Pi electricity supply / adapter has been specially designed and tested for the new Raspberry Pi 3 and carries an inline noise filter out for maximum stability and dependable operation.

This strength supply differs from traditional general 5V USB strength supplies inside the market in that it may supply a complete 2.5A and nonetheless output a voltage nicely in the USB minimal voltage specs. Standard 5V USB energy components inside the market have a high voltage drop while the entire modern-day is drawn from them, which may additionally reason the Raspberry Pi to reboot all at once.

With this electricity supply, you could energy the Raspberry Pi three at complete load in addition to up to one.2A throughout the four USB ports. The electricity supply nonetheless has about 0.5A of output energy to spare, so even at the most current supported by means of the Raspberry Pi 3; the power supply is not at its absolute most.

It is likewise perfect for use with the aid of all people over-clocking the Raspberry Pi, which causes higher power necessities that a decrease energy adaptor might not be able to deliver. For the power adaptor of the Raspberry pi, refer to figure 3.4 bellow.



*Figure 3.4 Raspberry pi 4 power adaptor* (source: joom.com, 2021)

The power adaptor is the power supply to rest of the components of the system. It is capable of passing or outputting the minimum required current or power to the system so that it may properly meet the intended objective.

### 3.3.6 Display connecting cables

To get started with Raspberry Pi, I had to store Raspbian OS on SD card; this was done by installing the OS on SD card, and connected to the Raspberry Pi Board. Initially to use raspberry Pi we need a computer monitor or Digital Display that can be directly connected to the Raspberry Pi board using HDMI cable.



*Figure 3.5 HDMI Cable* (source: brightonline.co.ke, 2021).

For the reason being that the raspberry has an hdmi interface, it is the hdmi cable that is used to connect to the screen during operating system installation and setting up the device. It connects to the screen with hdmi interface. The HDMI cable overview is in figure 3.5 above.



*Figure 3.6 HDMI to VGA Converter* (source: made-in-china.com)

The hdmi to vga converter comes in scenarios where there is only hdmi and vga interfaces on both ends thus a converter from one end to another is needed for communication or display purpose. Figure 3.6 above, shows the HDMI to VGA converter.



*Figure 3.7 VGA cable (source: kameha.com, 2021)*

The vga cable is also needed to work together with the converter to make it to another side of raspberry pi that uses the hdmi interface. After connecting the Raspberry Pi to the Display/monitor and Power-On Raspberry Pi. Then a Black command window asking for Login and Password credentials which are raspberry pi Login: pi and Password: raspberry appear as shown below. Figure 3.7 above, is the VGA cable.

### 3.3.7 The speaker

The speaker is for sound alert message amplification when played so that everybody around hears it and if he/she is the one concerned, immediately put on right the facemask.

### 3.3.8 Computer Input/Output devices

Namely, these are monitor, keyboard and mouse, used to do configurations on the raspberry pi that are essential for it to run correctly. Configurations like date and time. These are required just because once the device is shutdown; it requires re-configuration on the next reboot.

```

[ OK ] Reached target Sockets.
[ OK ] Reached target Timers.
Starting Restore Sound Card State...
[ OK ] Reached target Basic System.
Starting Avahi mDNS/DNS-SD Stack...
Starting Configure Bluetooth Modems connected by UART...
Starting dhcpcd on all interfaces...
Starting System Logging Service...
Starting Regular background program processing daemon...
[ OK ] Started Regular background program processing daemon.
Starting D-Bus System Message Bus...
[ OK ] Started D-Bus System Message Bus.
[ OK ] Started Avahi mDNS/DNS-SD Stack.
Starting Login Service...
Starting LSB: triggerhappy hotkey daemon...
Starting LSB: Autogenerate and use a swap file...
[ OK ] Started System Logging Service.
[ OK ] Started Restore Sound Card State.
[ OK ] Started dhcpcd on all interfaces.
[ OK ] Reached target Network.
Starting UVC Server in Service Mode daemon...
[ OK ] Started UVC Server in Service Mode daemon.
Starting OpenBSD Secure Shell server...
[ OK ] Started OpenBSD Secure Shell server.
Starting /etc/rc.local Compatibility...
Starting Permit User Sessions...
[ OK ] Reached target Network is Online.
Starting LSB: Apache2 web server...
Starting LSB: Start NTP daemon...
[ OK ] Started LSB: triggerhappy hotkey daemon.
[ OK ] Started Permit User Sessions.
[ OK ] Started Login Service.
[ OK ] Started /etc/rc.local Compatibility.
Starting Terminate Plymouth Boot Screen...
Starting Hold until boot process finishes up...
[ OK ] Started LSB: Autogenerate and use a swap file.

Raspbian GNU/Linux 8 raspberrypi tty1
raspberrypi login: pi
Password:
Last login: Tue Jul 25 11:18:53 UTC 2017 on tty2
Linux raspberrypi 4.9.35-v7+ #1014 SMP Fri Jun 30 14:47:43 BST 2017 armv7l

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.

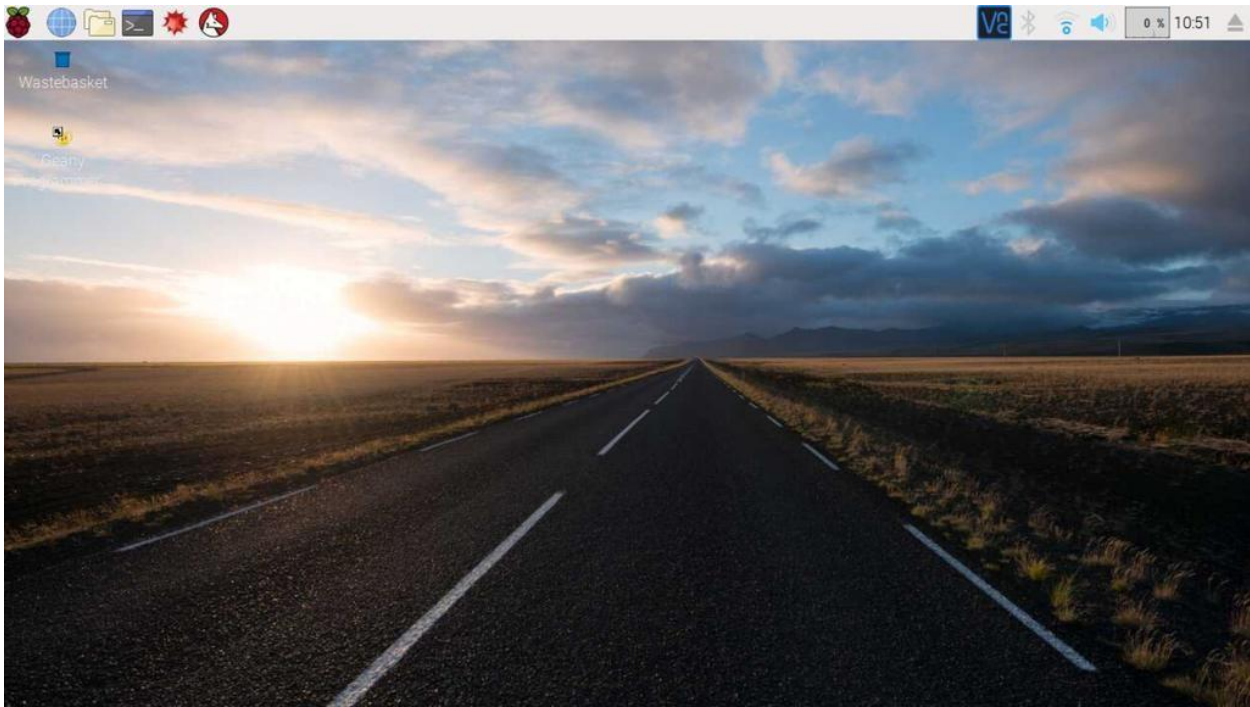
SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.

pi@raspberrypi:~ $
```

Figure 3.8 Raspbian Login command window

This is the default user name and password that can be changed after the first login. The above command window can be used to operate Raspberry Pi but it is possible to change or get to the GUI environment on Raspberry Pi by using a command starts. Figure 3.8 above, is the Raspberry pi login command line window.





*Figure 3.9 GUI Home Screen of Raspberry Pi as shown after login*

In figure 3.9 above, the system is up and running. To have the system fully operable and function, the input and output computer peripherals such as screen, mouse, and keyboard are required to facilitate IO operations. Refer to figure 3.9 above for the graphical user interface of the Raspberry pi.

### 3.4 Software tools

#### 3.4.1 Introduction

Software, commands that tell a computer what to do. Software incorporates the whole set of programs, methods, and exercises related to the operation of a computer device. A set of commands that directs a pc's hardware to carry out a project is known as a program, or software program. The software can be used to build or construct other instructions for a certain target.

On this project, I used Python to build the facemask detector to execute in collaboration with the hardware towards a target.

### 3.4.2 Data set

The dataset is the collection of images both masked and unmasked in two different folders name according to the images. Masked images totaling to 2044 images in a with-mask folder and a without-mask folder containing 2060 images. All these images are used to train the system for the model to be used.

### 3.4.3 Xampp

XAMPP, an abbreviation for Cross-platform, Apache, MySQL, PHP and Perl, is a simple database management system to help store frames captured and be analyzed later. It is the database working on the system.

### 3.4.5 PHP

It is the general purpose scripting language geared towards web page development. In the system, it is used along with Java script and cascading style sheet for the dashboard page development, appearance, and functionality.

### 3.4.6 Python

Python is an interpreted, object-orientated, high-level programming language with dynamic semantics. Python is easy, smooth to learn syntax emphasizes readability and consequently reduces the price of application renovation. Python supports modules and packages, which encourages software modularity and code reuse. It is a general-reason programming language, so it can be used for web improvement, AI, gadget studying, operating systems, cellular application development, and video games.

Python has many libraries for exclusive software writing and execution but especially for my challenge, there are eight essential libraries used for the facemask detection tool.

Executing ML and AI algorithms need a nicely based & properly examined setting to permit builders to come up with the maximum reliable high-quality coding solutions. To limit development time, there are numerous Python libraries for gadget learning.

### 3.4.7 Proposed system Platform

The IoT based monitoring device to control covid-19 transmission system has an interface, which is a web-based platform. This platform provides an interface to the system information. With this platform essential information like the number of cases captured today, the previous number of cases captured the unmasked cases and masked cases captured both outdoor and indoor operating device where people gather for different activities like meetings, classes, pathways, and offices. It monitors whether among these or all of them respect the rule of wearing the facemask properly.

### 3.4.8 Modules

**Log in module:** This module will authenticate any entry to the system for security purposes. It will require valid information (username and password) for an entry interaction towards any activity. After providing authentic information to the system, then you come to the dashboard that holds most of the information needed.

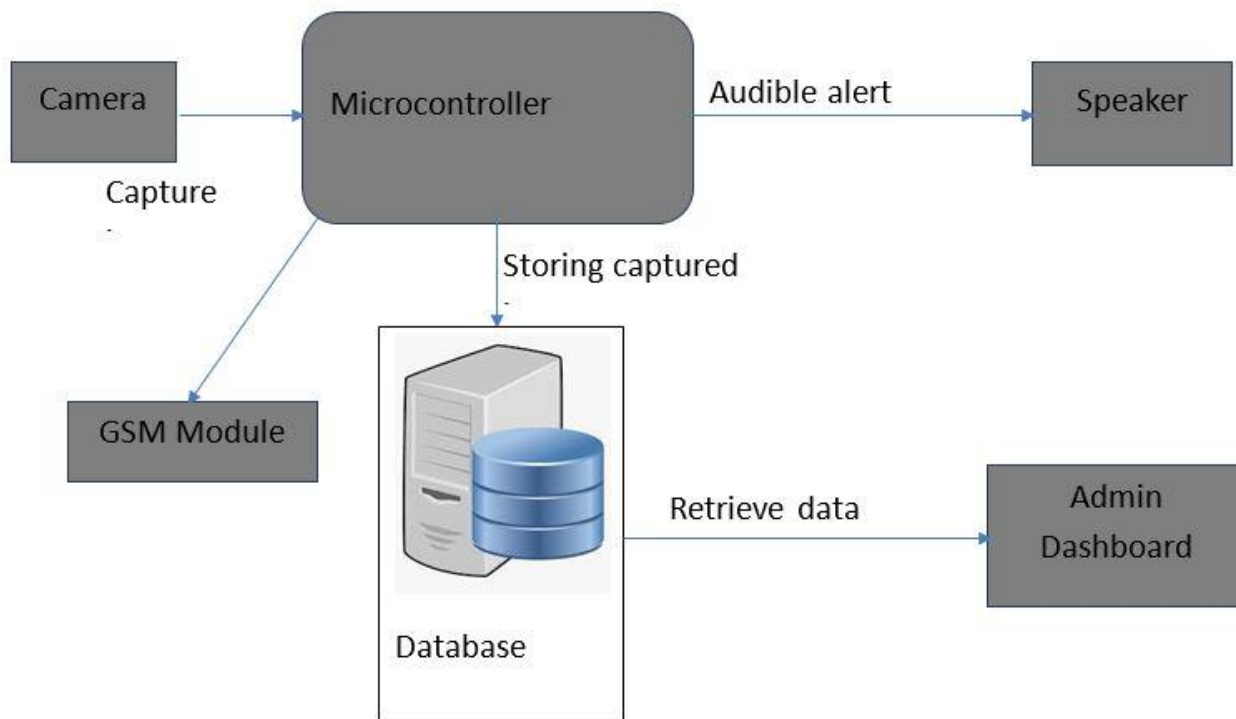
**Dashboard:** The dashboard is there to show all captured information in a summery manner. This information includes today's masked and unmasked cases captured in number, the unmasked cases captured in number, the unmasked cases captured in number, the previous cases captured in number and the all cases ever since captured in number. The dashboard displays the list of all cases captured by the system. It has a link to the covid-19 live update site for easy update of the covid-19 situation.

**Reporting:** The dashboard also has the reporting part whereby all cases captured can be reported one by one or all of them at ago. Apart from the summary statistics viewed on the dashboard, a report link directs to facemask detection report generator that generate reports such as detailed number of all captured cases recorded today, detailed number of unmasked cases captured today, and detailed number of masked cases captured today. There is also previous reports for yesterday, current week, last seven days, previous week, current month, last thirty days, previous month, and all cases ever capture.

## 3.5 System architecture

A device assembly is the theoretical ideal that explains the structure, conduct, as well as extra viewpoints of a device. A construction explanation is a proper report and illustration of a system, set in a way that helps mental approximately the systems and performances of the system. The system architecture of the system elaborates the logical structure of the system. It logically shows the data flows from section to another section

as they are interconnected to each other for a given purpose. Figure 3.10 bellow shows the architecture of the system.



*Figure 3.10 System Architecture*

### 3.6 Description of the System

**The Camera:** The function of the camera on the system is to stream the video and capture the image whenever required. A Ribbon Cable attaches it to the Raspberry pi. After streaming and capturing, it sends the data to the Microcontroller to be processed.

**Microcontroller or Raspberry Pi:** This is a central processing part of the system. With Raspbian operating system, running python codes, and the trained model on it, it processes and compare the captured image with the ones trained in the model to determine whether the image is masked or not and give the decision. If the compared image is found not masked, it is saved in the database and an audible alert message is given through the speaker. Again, if the compared image found masked, then no action is done.

**The Speaker:** It is there to amplify the audible alerting message loudly so that any one in a crowd can hear it.

**The Database or Storage:** The main purpose of the database is to store the unmasked captured images so that they will be revisited and analyzed later for further decisions.

**Admin Dashboard:** The Admin dashboard provides the login authentication facilities for the security of the system. After logging in, you view the summary of the information in the system like today's cases captured, masked and unmasked cases, previous case and total cases (masked and unmasked) ever captured. Again, here you can find detailed printable reports for all these cases.

## **CHAPTER 4: FACEMASK MONITORING DEVICE TO CURB COVID-19 SPREAD**

### **4.1 Introduction**

After SARS-CoV and MERS-CoV got here Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), officially called as the unconventional Coronavirus-2019 (nCoV-2019), and then taken into consideration noticeably pathogenic and a massive outburst via using the WHO. This one is said to have initiated in Hubei province, China at some stage in late December 2019. Meanwhile, the COVID-19 outburst has ended up a community well-being problematic around the world.

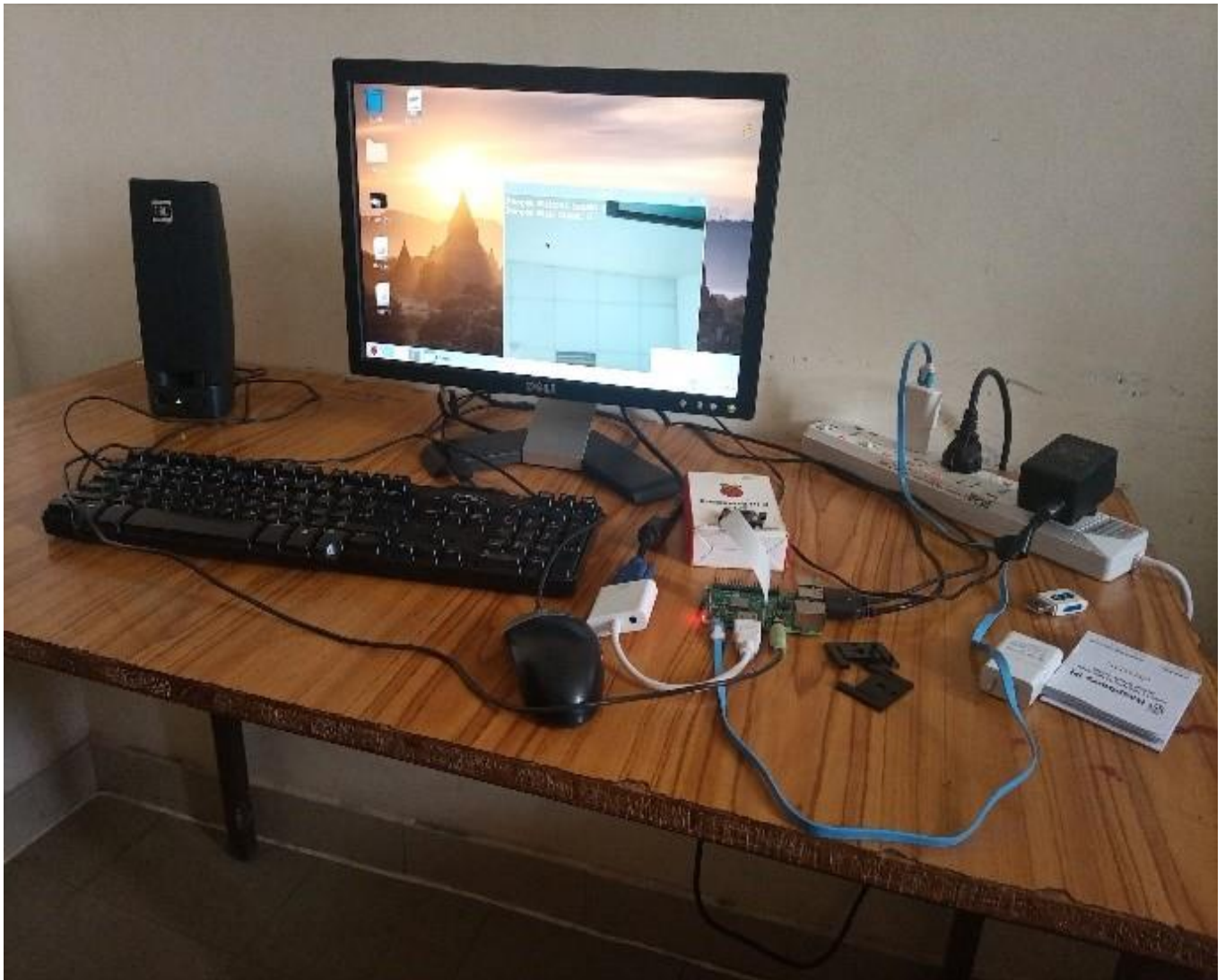
Signs of COVID-19 remain fever, dry cough, respiratory complications, pain, pneumonia, and myalgia or tiredness. In addition, excessive instances also can result in cardiac damage, respiration failure, and acute respiratory distress syndrome and in the end passing. At the start, COVID-19 became spread from innate to humanoid, and then human-to-human broadcast began via respiration dewes and frame associates. It changed into additionally determined out that the disease transmission is thru speaking, mainly with louder speech. This may be condensed via protective methods, which include face pack sporting, hand cleaning, dodging of public touch, situation finding, touch sketching, and isolations. The COVID-19 be able to have an effect on all age organizations, however the danger of demise since the virus has been related through adult a while and continual sicknesses.

As around is presently no treatment and serums, the sickness will proceeds a long time to move out, with a view to save you these various affects, it is important to emphasis on hindrance methods. Practice of facemasks is one of the crucial events to stop the broadcast of COVID-19 though not usually reputable by using humans also students inclusive.

Due to this, stubbornly conduct among college students, a concept of developing this device came in our minds so that after lock down and college re-commencing, it allows reminding them to correctly put on their mask on faces.

## 4.2 System Prototype

The proposed facemask wearing detecting system has been built using different components and devices among which are; Raspberry pi 4 model B, the pi camera, keyboard, mouse, screen, hdmi to vga adaptor, power adaptor, sd card, and speaker. Having all components interconnected and the system switched on, a visualized frame pops up with statistics for persons who have their facemasks well put on and those whose facemasks are not properly on. Refer to figure 4.1 below for further review.



*Figure 4.1 System components interconnected and powered on*

Now with the use of a pi camera, the system captures faces of people who come in its coverage, send them to the Raspberry pi for processing and predicted that two people are found without facemasks. Immediately an audible sound signal is heard, faces without facemasks are identified with a red color rectangle with having certain percentage on which this person is putting on the facemask. Again, the frame show the number of people without facemask (for this case 2) and those with facemasks (for this case 0), the image is captured and stored in the database for further analysis. For more clarifications, refer to figure 4.2 bellow.



Figure 4.2 The system predicted two people without facemasks on their faces



When a group of people crossing the camera coverage area captured, their image processed, compared and the outcome is that they have their facemasks well put on or not, the statistics are shown (number of people with and without facemasks found), a green color rectangle with the percentage is put on their faces but no audible signal is heard because the measure is respected and the image will be saved. Refer to figure 4.3 bellow for further understanding.

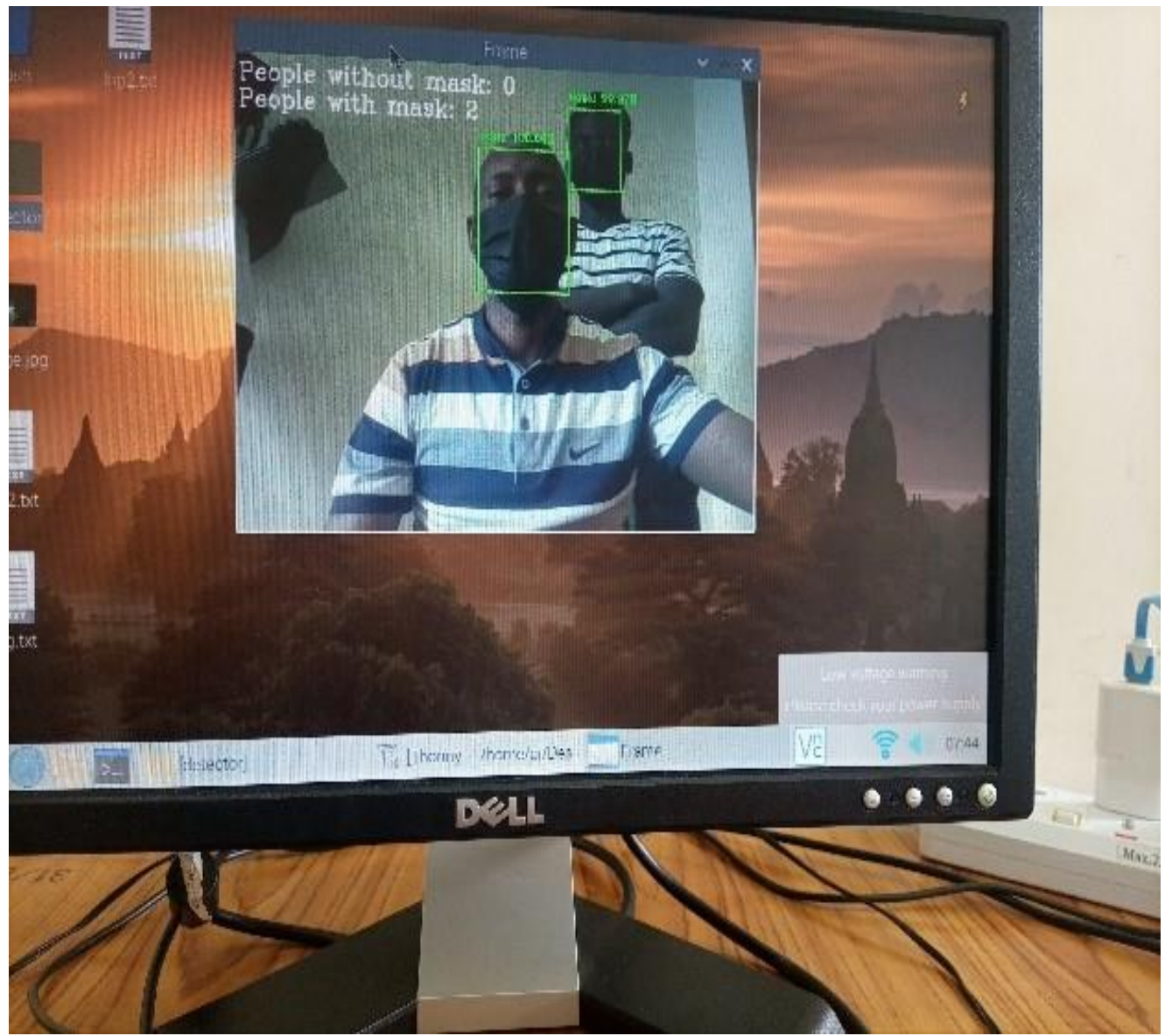
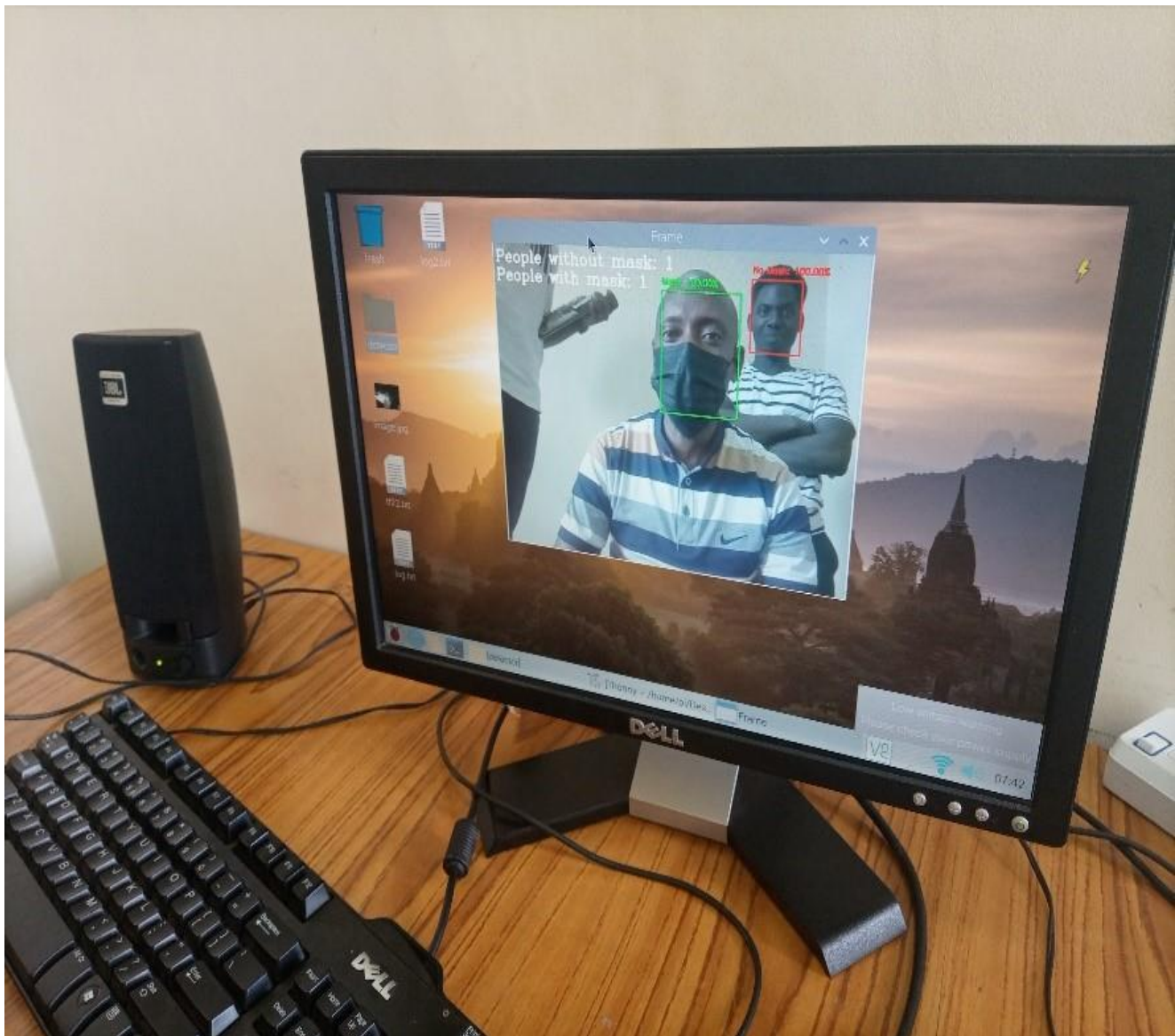


Figure 4.3 Two people with facemasks are shown

Within a group of people, the system can identify each one's behavior (whether his/her face is covered with the facemask well or not), if at least one is found, as it is in figure 4.x below, the audible signal alert is heard, the red color rectangle with the percentage is put on that very person's face. The green color rectangle with percentage is put on the face that is properly covered with the facemask and the whole frame is saved for further analysis. Statistics are shown according to how many people are putting on or not their facemasks (for this case one is putting on and one is not). Figure 4.4 below elaborates more.



*Figure 4.4 Someone without a facemask is automatically detected.*

#### 4.2 The final prototype ready for implementation

The final prototype has been set, configured and mounted in a metal box, fixed on a stand with the power cable ready to be placed at any desired public place like house entrance, meeting room, restaurants and pathways to monitor and alert people in case there happens to be one without facemask or not properly put on. Figure 4.5 bellow, shows the final prototype.



*Figure 4.5 The final prototype ready to be deployed.*

### 4.3 Image capturing and processing

Face Recognition is a technique that matches stored models of each human face in a group of people to identify a person based on certain features of that person's face. Face recognition is a natural method of recognizing and authenticating people. Face recognition is an important portion of people's daily contact and exists. The security and authentication of an individual is critical in every industry or institution. As a result, there is a great deal of interest in automated face recognition using computers or devices for identity verification around the clock and even remotely in today's world. Face recognition has emerged as one of the most difficult and intriguing problems in pattern recognition and image processing. With the aid of such a technology, one can easily detect a person's face by using a dataset of identical matching appearance. The most effective approach for detecting a person's face is to use Python and a Convolutional Neural Network in deep learning. This method is useful in a variety of fields, including the military, defense, schools, colleges, and universities, airlines, banks, online web apps, gaming, and so on. Facemasks are now widely used as part of standard virus- prevention measures, especially during the Covid-19 virus outbreak. Many individuals or organizations must be able to distinguish whether or not people are wearing facemasks in a given location or time. This data's requirements should be very real-time and automated. The interesting concern, which can be revealed in face exposure, is in-built mixture in faces such as figure, smoothness, color, got beard\moustache and/or glasses and even masks. From the experiments, it is clear that the proposed CNN and Python algorithm is very efficient and accurate in determining the facial recognition and detection of individuals. With the facemask detection system, to come up with the result, there are several stages it has to go through as follows.

### 4.4 The Input Image from camera

Real-time input pictures are recycled in this future system. Face of individual in enter images should be completely or partly protected as they have masks on it. The machine requires an affordable amount of pixels and an appropriate quantity of clarity for dealing out. Established on trial proof, it is meant to execute well interior as well as exterior i.e. Passport workplaces, clinics, resorts, police posts plus many others.

#### 4.5 The Pre-processing Stage

Input image dataset must be loaded as Python data structures for pre-processing to overturn the noise disturbances, enhance some relevant features, and for further analysis of the trained model. Entered images need to be pre-processed earlier face discovery and identical methods are realistic. Thus, pre-processing includes sound elimination, eye and mask detection, and dump filling techniques. Noise elimination and whole satisfying help remove incorrect discovery of face/ faces. After the pre-processing, the face image is cropped and re-localized. Histogram Normalization is done to improve the quality of the pre- processed image.

#### 4.6 Face detection algorithm

The algorithm of the system starts at the initialization of the system. The moment the system is switched on or started, the operating system starts and the system starts streaming the camera, makes it ready for any object. When an object comes in its coverage area, it captures it and it is compared with the model to find whether it is a face. If it is found to be a face, again the prediction goes on to find out whether it is covered or not with the facemask as trained. When covered with the mask, the image is captured and saved but no sound signal is heard, the green color rectangle on the face but when it not covered, a red color rectangle appear on the face, the image is captured, and saved for further decisions. Figure 4.6 bellow elaborates more.

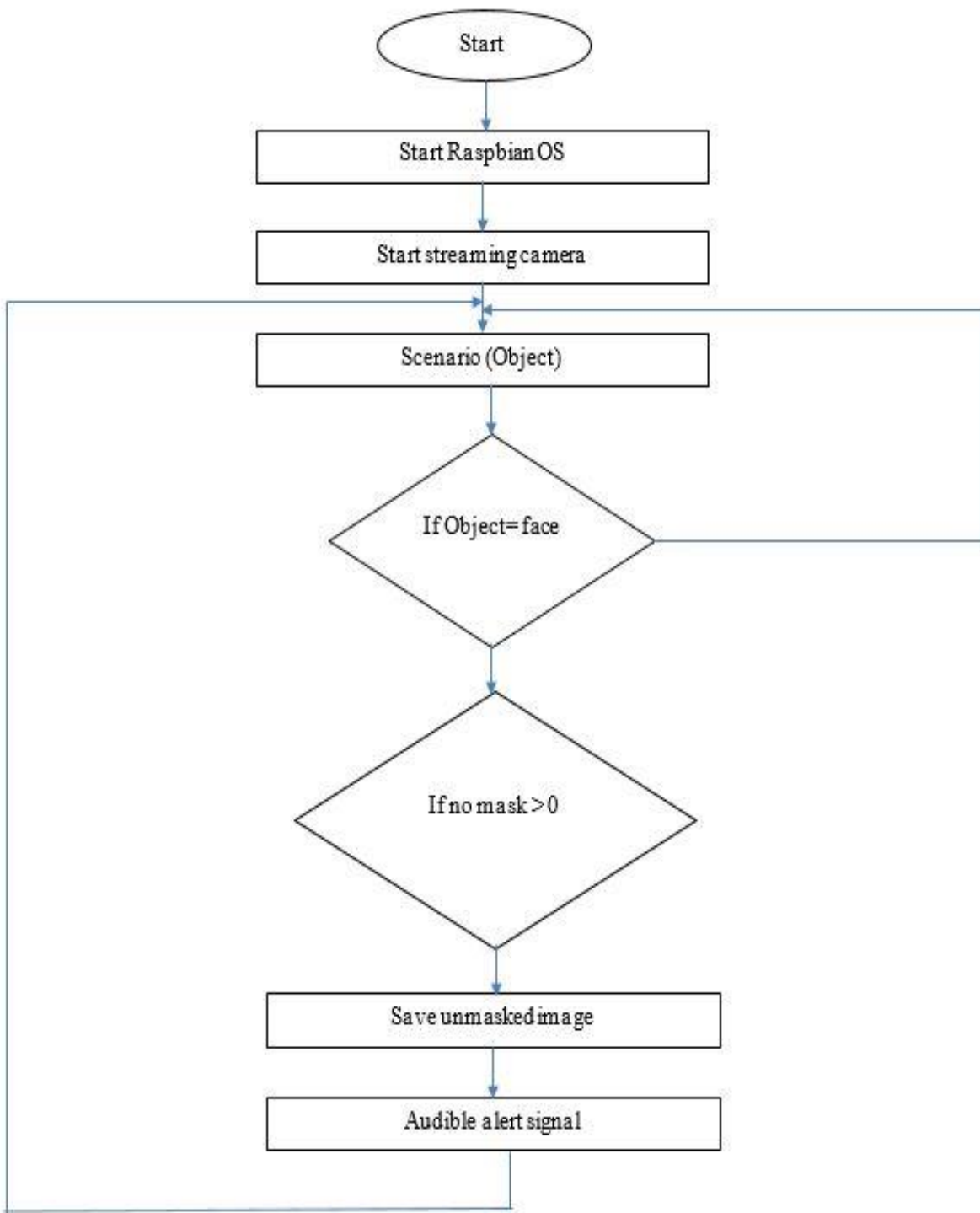


Figure 4.6 The face detection algorithm

#### 4.7 The Face Detection Stage

We carry out face detection the usage of HAAR Cascade algorithm. This machine consists of the cost of all black pixels in greyscale snap shots turned into collected. They then deducted from the full number of white containers. Finally, the outcome is matched to the given starting point, and if the criterion is seen, the feature reflects it a hit. In well known, for each calculation in Haar-function, every single pixel within the characteristic regions can need to be received, and this step may be prevented by way of the usage of fundamental image wherein the value of each pixel is the same to the variety of grey values above and left in the photograph.

Feature =  $\sum_{i=1}^N w_i \cdot \text{RecSum}(x, y, w, h)$ , in which  $\text{RecSum}(x, y, w, h)$  is the summation of depth in any known standing or circled frame surrounded in a discovery window and  $x, y, w, h$  is for match up, sizes, and spin of that rectangle, correspondingly. Haar Wavelets characterized as field classifier, which is recycled to excerpt face capabilities by means of the usage of vital image

#### 4.8 The Feature-Extraction Stage

Feature Extraction improves model accuracy by extracting features from pre-processed face images and translating them to a lower dimension without sacrificing image characteristics. This stage allows for the classification of human faces.

#### 4.9 Training Stage

The method is based on the notion that it learns from pre- processed face images and utilizes CNN model to construct a framework to classify images based on which group it belongs to. This qualified model is saved and used in the prediction section later. In CNN model, the stages of feature extraction are done by PCA and feature selection done by Sobel Edge Detector and thus it improves classification efficiency and accuracy of the training model.

CNN or the convolutional neural network (CNN) is a class of deep mastering neural networks. In brief, think about CNN as a mechanism getting to know set of rules that could soak up an enter photo, give standing (learnable masses and prejudices) to numerous components/gadgets in the image, and be able to distinguish one from the alternative. CNN mechanism with the aid of extracting capabilities since the photos. Any CNN includes the subsequent:

- The enter layer, that is a grayscale image
- The Output layer that is a binary or multi-elegance labels

□ Hidden layers, which includes convolution layers, ReLU (rectified linear unit) layers, the combining sheets, and a totally related Neural Network.

It could be actual essential to remember the fact that ANN or Artificial Neural Networks, made of a couple of neurons is not talented of removing functions from the picture. This is where an aggregate of convolution and pooling layers comes into the photo. Likewise, the convolution and combining sheets cannot transport out class subsequently we need a totally connected Neural Network.

Training the model is to teach the system for better recall and precision by which the system will use to accurately predict the decision. The more images used to train for the model, the more accuracy and able to recall the system is. Figure 4.7 bellow show values indicating how precision the system will be after training the model.

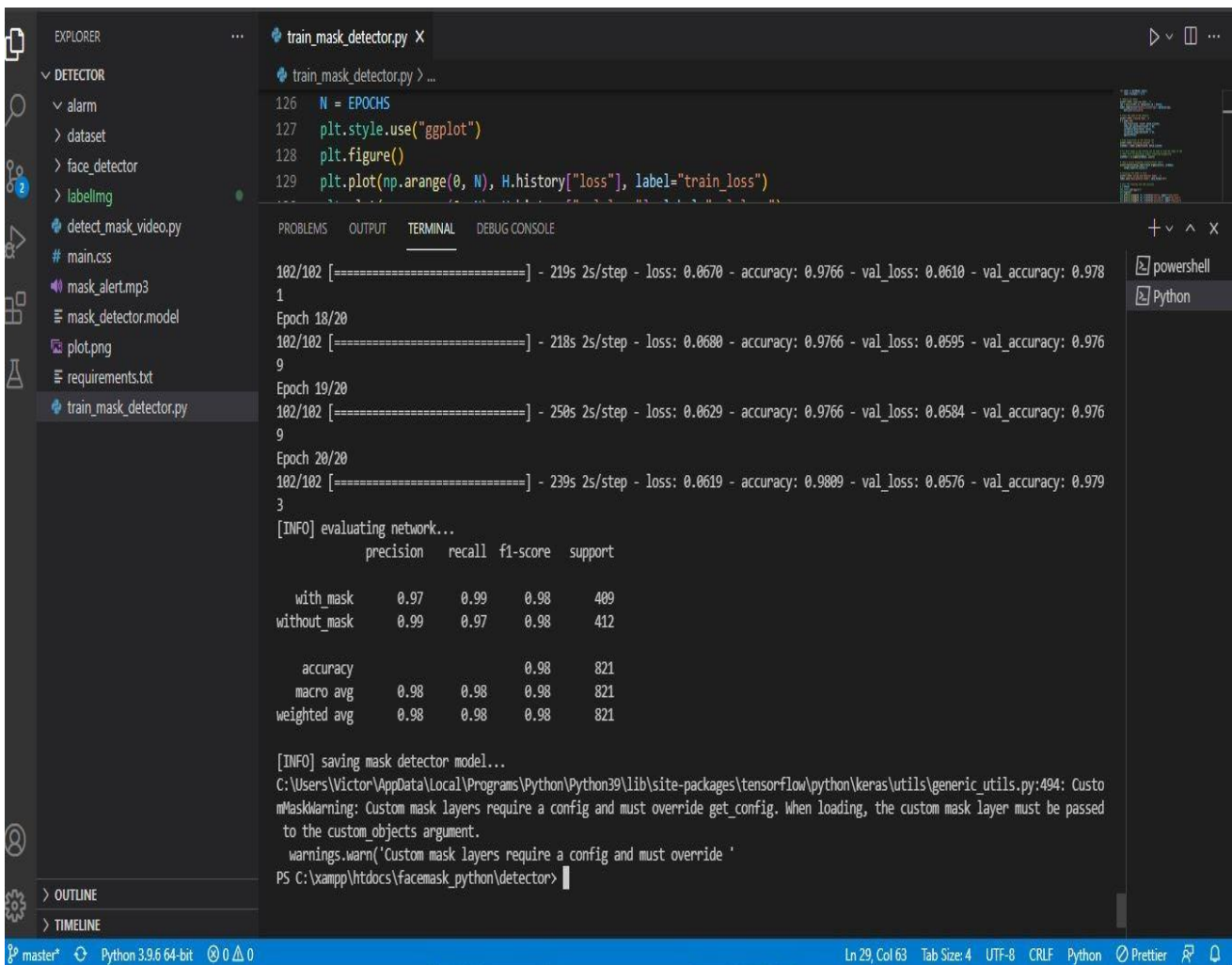


Figure 4.7 System training for the model



Trained for the model using 2044 masked images and 2060 unmasked images, graphically shows that the system will very accurate by being able to compare a variety of images with different styles of facemask wearing still predicts whether the facemask is properly put on or not. Training loss is very low for a big number of images was used and train accuracy is very high. Figure 4.8 bellow shows how accuracy and loss the system might be graphically.

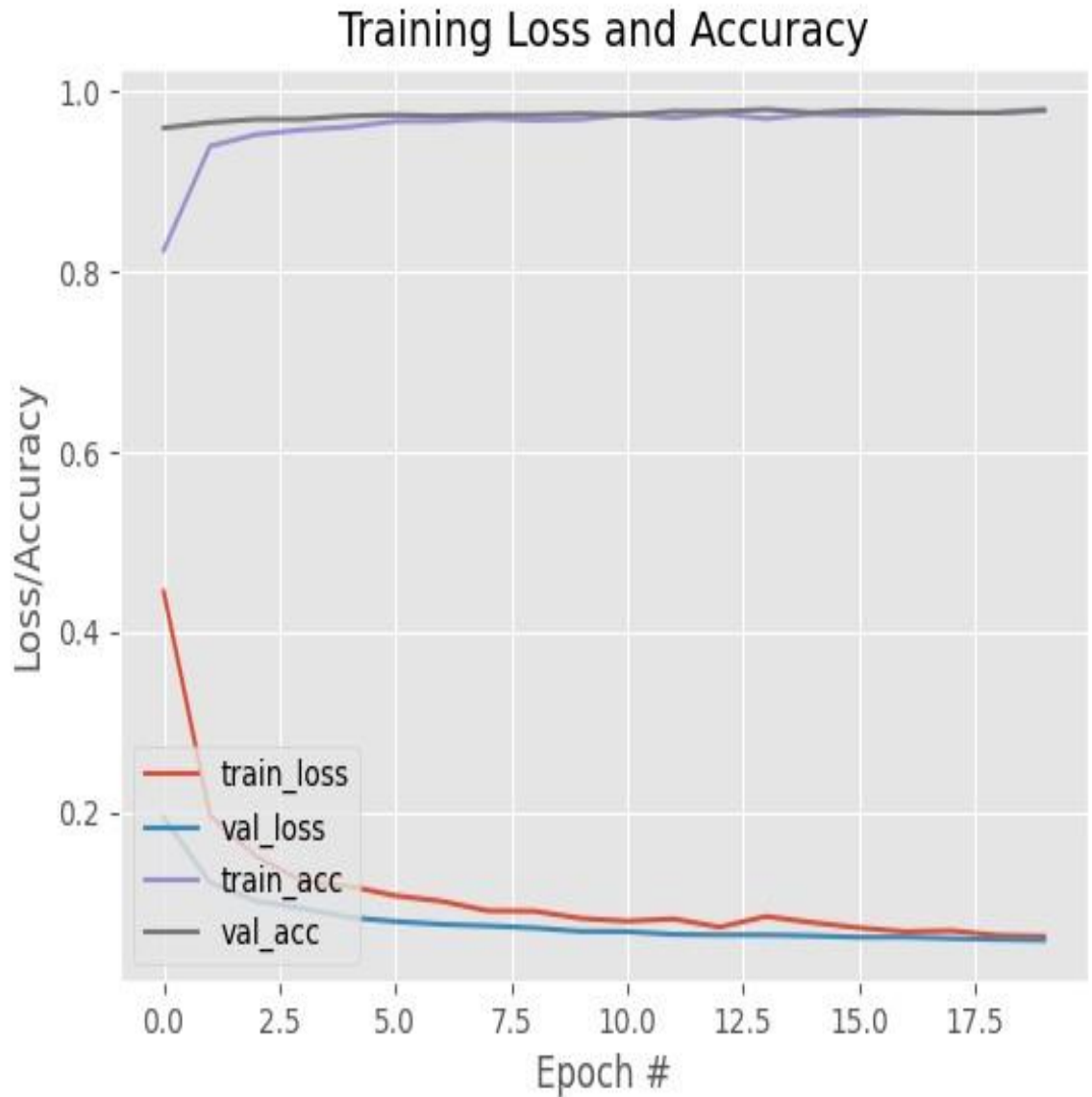


Figure 4.8 First plot with more images

With reduced images to 364 masked and 342 unmasked caused a change in graphs meaning the system accuracy and loss might not be reliable due to the training done with less or fewer images. Figure 4.9 indicates change in graphs due to less images used in training for the model.

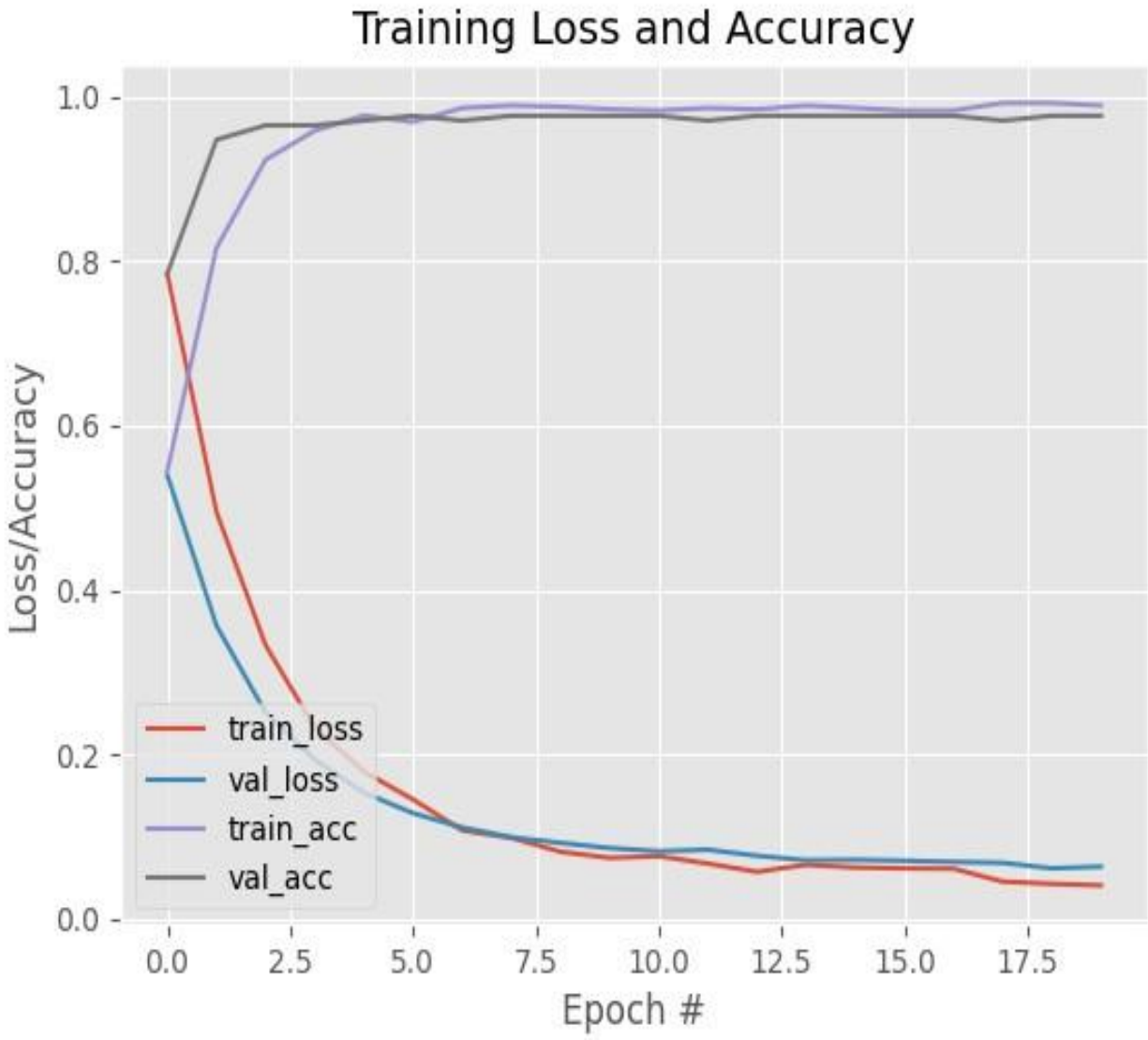


Figure 4.9 Plot of medium number of images trained

Again, training for the model with fewer images (100 masked and 100 unmasked images) trained and gave un-reliable predictions meaning the system awareness is low thus the prediction will not be perfect.

Figure 4.10 bellow shows the training loss and accuracy of the system.

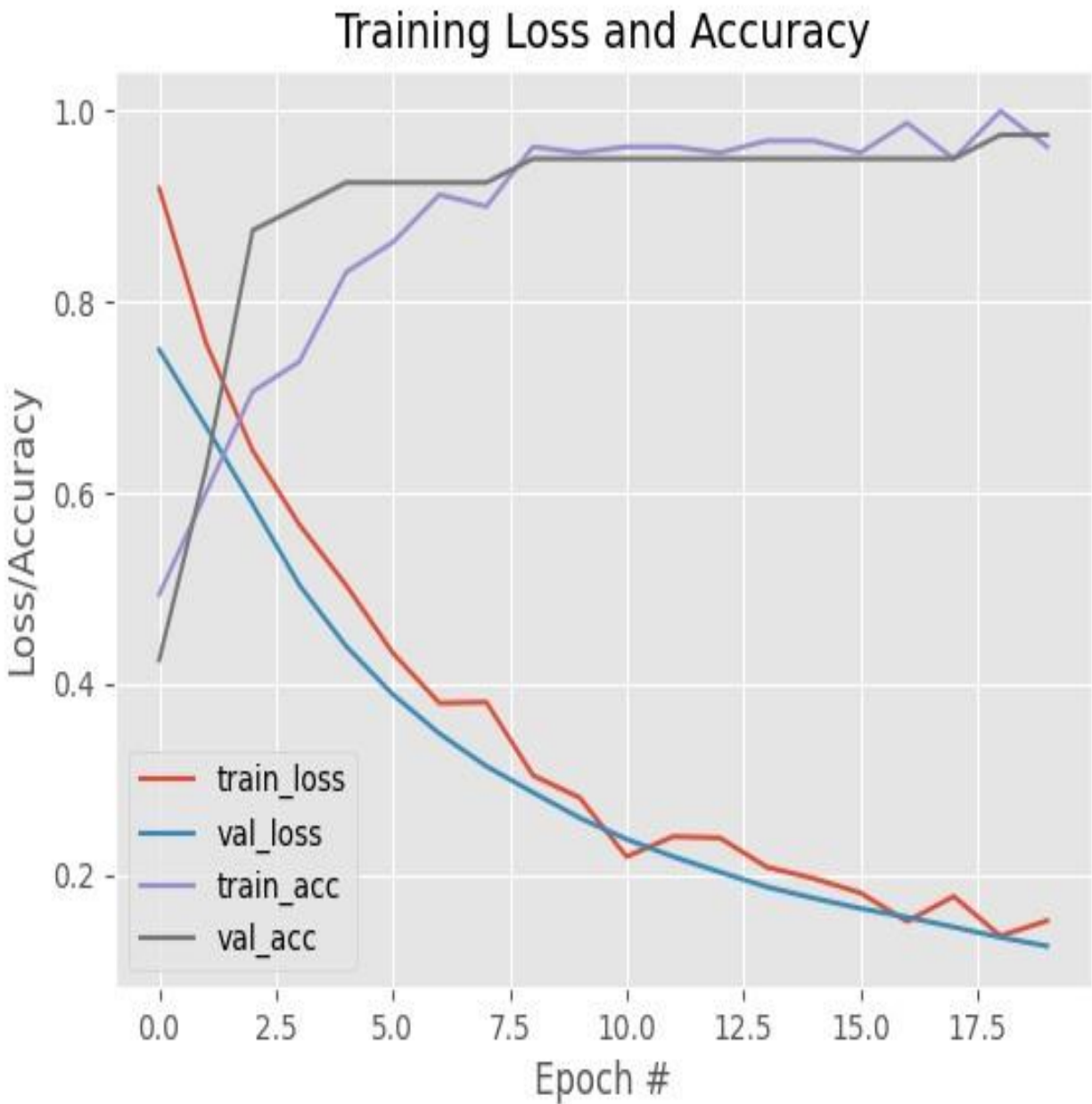


Figure 4.10 Plot of fewer images trained

#### 4.8 The Classification Stage

Principal Component Analysis (PCA) is used to classify faces after an image recognition model has been trained to identify face images. Identifying variations in human faces is not always apparent, but PCA appears and proves to be the ideal procedure for dealing with the problem of face recognition. PCA does not operate classifying face images based on geometrical attributes, but rather checks which all factors would influence the faces in an image. PCA was widely used in the field of pattern recognition for classification problems. PCA demonstrates its strength in terms of data reduction and perception.

#### 4.10 Prediction Stage

At this stage, saved model automatically detects the similarity of the facemask image captured by the camera. The saved model and the pre-processed images are loaded for predicting the person behind the mask. CNN offers high accuracy over face detection, classification and recognition produces precise and exact results. CNN model follows a sequential model along with Keras Library in Python for prediction of human faces.

#### 4.4 Data analysis

In this chapter, the performance of IoT-based facemask detector, how images are captured and stored in the database for further decision making with their description of not wearing the facemask and statistics when it is a crowd or group of people.

This chapter also shows the codes used to enable this system by providing solutions based on what is shown in this project. The system front end summarizes the information, as they are stored in the database for quite a period like days, week, and month defining masked and unmasked totals. It even clearly shows the image captured only without mask and stored as a proof for the work done showing the student and staff behavior towards this preventive measure.

The database with contents, which are the frames, captured, after processing, comparing and prediction, it is saved on its unique identification number, date and time on which it is captured. Figure 4.11 bellow shows this clearly.

acronym for DMA - Google Search | What does HAAR stand for? | Face Mask Detection | localhost / 127.0.0.1 / facedetect

localhost/phpmyadmin/sql.php?server=1&db=facedetectorlog&table=framelog&pos=0

phpMyAdmin

Server: 127.0.0.1 > Database: facedetectorlog > Table: framelog

Browse | Structure | SQL | Search | Insert | Export | Import | Privileges | Operations | Tracking | Triggers

Showing rows 0 - 24 (5368 total, Query took 0.0012 seconds.) [framelog\_id: 5457... - 5433...]

SELECT \* FROM 'framelog' ORDER BY 'framelog\_id' DESC

Profiling [Edit inline] [Edit] [Explain SQL] [Create PHP code] [Refresh]

1 > >> | Number of rows: 25 | Filter rows: Search this table | Sort by key: PRIMARY (DESC)

+ Options

	framelog_id	framelog_image	framelog_unmasked_count	framelog_masked_count	framelog_date	framelog_time
<input type="checkbox"/> Edit Copy Delete	5457	frame1637595513.jpg	1	0	2021-11-22	17:38:34
<input type="checkbox"/> Edit Copy Delete	5456	frame1637595511.jpg	1	0	2021-11-22	17:38:32
<input type="checkbox"/> Edit Copy Delete	5455	none	0	1	2021-11-22	17:38:25
<input type="checkbox"/> Edit Copy Delete	5454	none	0	1	2021-11-22	17:38:25
<input type="checkbox"/> Edit Copy Delete	5453	none	0	1	2021-11-22	17:38:24
<input type="checkbox"/> Edit Copy Delete	5452	none	0	1	2021-11-22	17:38:23
<input type="checkbox"/> Edit Copy Delete	5451	none	0	1	2021-11-22	17:38:23
<input type="checkbox"/> Edit Copy Delete	5450	none	0	1	2021-11-22	17:38:22
<input type="checkbox"/> Edit Copy Delete	5449	none	0	1	2021-11-22	17:38:20
<input type="checkbox"/> Edit Copy Delete	5448	none	0	1	2021-11-22	17:38:20
<input type="checkbox"/> Edit Copy Delete	5447	none	0	1	2021-11-22	17:38:20
<input type="checkbox"/> Edit Copy Delete	5446	none	0	1	2021-11-22	17:38:20
<input type="checkbox"/> Edit Copy Delete	5445	none	0	1	2021-11-22	17:38:20
<input type="checkbox"/> Edit Copy Delete	5444	none	0	1	2021-11-22	17:38:19
<input type="checkbox"/> Edit Copy Delete	5443	none	0	1	2021-11-22	17:38:19

Console

Figure 4.11 The database with captured images

The system dashboard is there to show the summary report of the captured and saved frames for today, both masked and unmasked cases in the frame, frames previously taken and total cases ever captured so that one can have a picture of the situation at that stage. This can be reviewed more in figure 4.12 bellow.

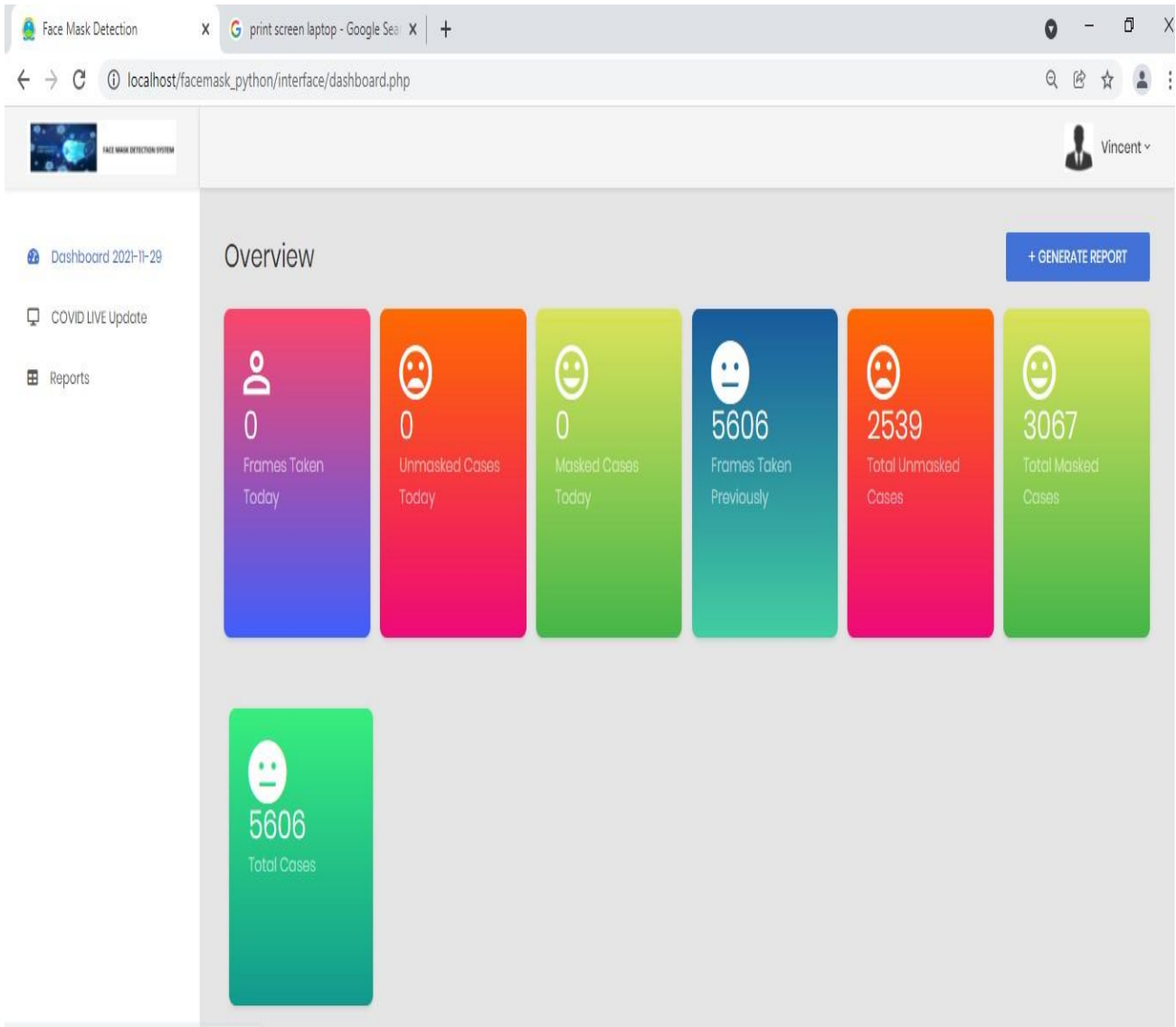


Figure 4.12 The dashboard with the summary of captured information

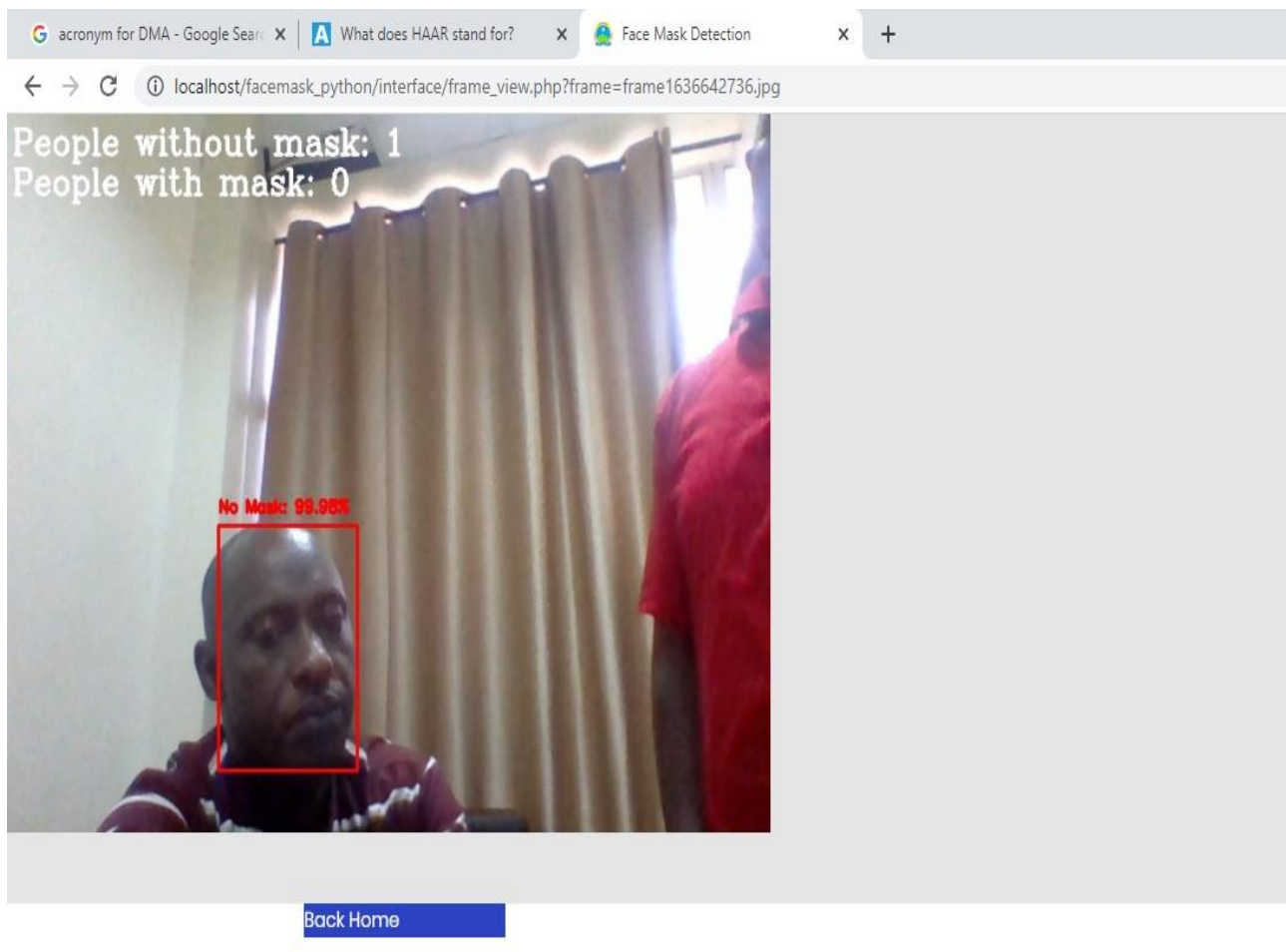
The saved frames can be reviewed through the dashboard by concerned authorities to further study how people behave towards the measure so that a decision can be taken. These frames are viewed, analyzed and decision taken accordingly. Figure 4.13 bellow shows frames to be viewed.

The screenshot shows a web browser window with the URL `localhost/facemask_python/interface/dashboard.php`. The dashboard header includes a logo for 'FACE MASK DETECTION SYSTEM' and a user profile for 'Vincent'. Below the header, there are navigation links for 'Dashboard', 'COVID LIVE Update', and 'Reports'. A table of captured frames is displayed, with a search bar and export options (Copy, CSV, Excel, PDF, Print, Column visibility) at the top. The table has the following data:

ID	Image	Unmasked Detections	Masked Detections	Date Taken	Time
5238	<a href="#">View Frame</a>	1	1	2021-10-16	23:37:36
5119	<a href="#">View Frame</a>	1	1	2021-10-16	23:30:02
5117	<a href="#">View Frame</a>	1	1	2021-10-16	23:29:59
5113	<a href="#">View Frame</a>	1	1	2021-10-16	23:29:14
5112	<a href="#">View Frame</a>	1	1	2021-10-16	23:29:12
5111	<a href="#">View Frame</a>	1	1	2021-10-16	23:29:10
5108	<a href="#">View Frame</a>	1	1	2021-10-16	23:29:04
5107	<a href="#">View Frame</a>	1	1	2021-10-16	23:29:02

Figure 4.13 Capture frames without masks are saved

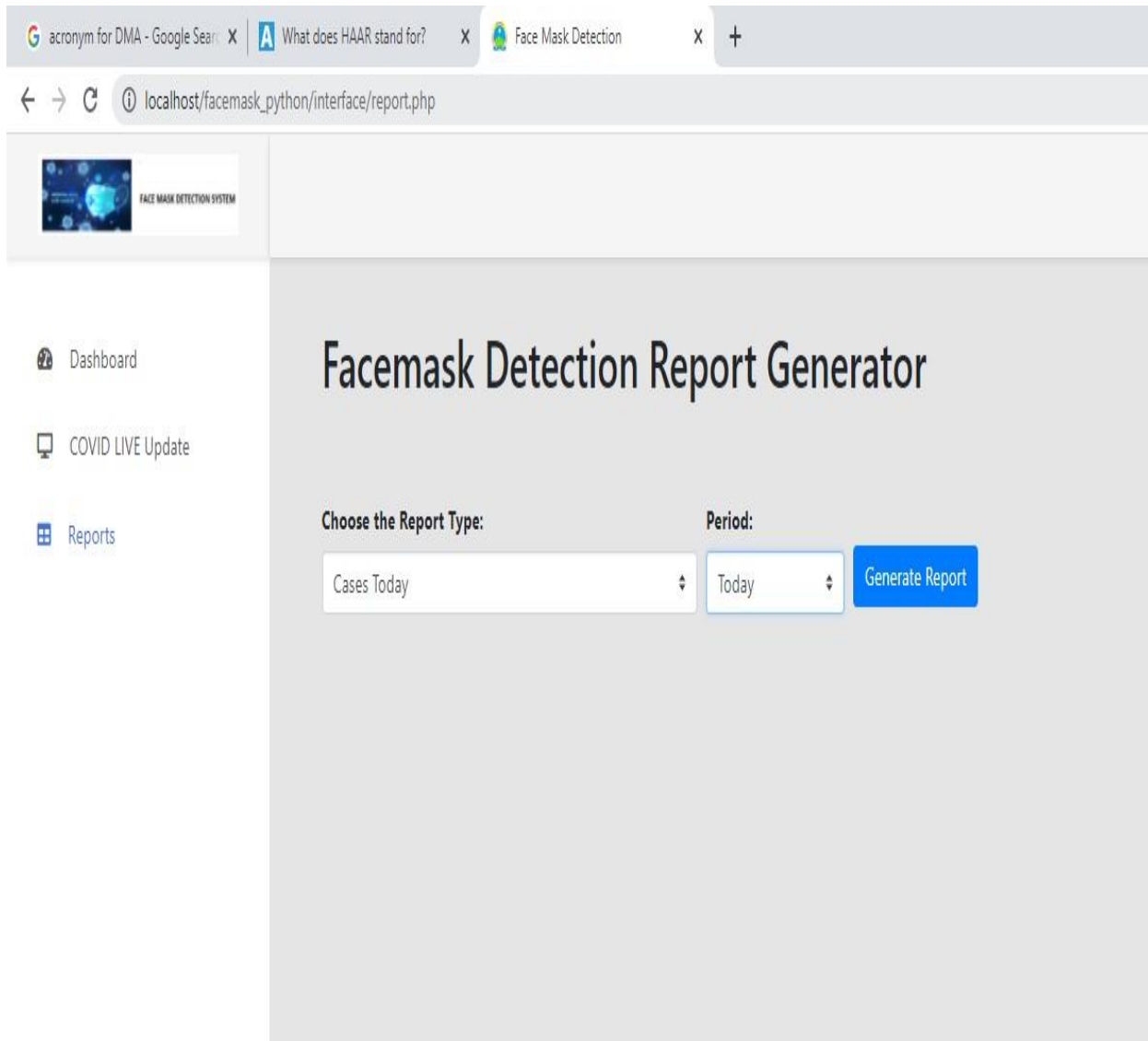
The viewed frame can surely confirm whether people do respect the preventive measure or not by viewing the saved frames in the database. With this, the concerned authorities can decide accordingly. One can view as many frames as possible with the “Back Home” button for other frames. Figure 4.14 bellow indicates a saved frame viewed.



*Figure 4.14 Frames capture without masks are saved for further reactions*



Using the report generator, various reports like cases captured today report, masked and unmasked captured reports, previous captured cases report like yesterday, last seven days, previous week, and last months and last thirty days are generated and can be printed for various use. For all these, refer to figure 4.15 bellow.



*Figure 4.15 Various reports are generated for review*

This generated report specifies or discloses all cases captured between 1<sup>st</sup> Nov. to 30<sup>th</sup> Nov. 2021. Unmasked cases being the most needed information, the identified case is labeled by 1. Refer to table 4.1 bellow.

*Table 4.1 The general report*

**FACE MASK DETECTOR REPORT**

**ALL CASES THAT OCCURED FROM 01-11-2021 TO 30-11-2021**

CASE No	NUMBER OF UNMASKED FACES DETECTED	NUMBER OF MASKED FACES DETECTED	DATE	TIME
1	1	0	2021-11-12	09:44:24
2	1	0	2021-11-12	09:44:26
3	1	0	2021-11-12	09:44:28
4	1	0	2021-11-12	09:44:29
5	1	0	2021-11-12	09:44:31
6	1	0	2021-11-12	09:44:33
7	1	0	2021-11-12	09:44:35
8	1	0	2021-11-12	13:00:05
9	1	0	2021-11-12	13:00:07
10	1	0	2021-11-12	13:00:09
11	1	0	2021-11-12	13:00:11
12	1	0	2021-11-12	13:00:13
13	1	0	2021-11-12	13:00:15

This is a printable report that shows all cases save between dates 31 Oct. to 30 Nov. 2021, it indicates date and time for which each case was captured. Table 4.2 explains more.

Table 4.2 The all cases captured report

**FACE MASK DETECTOR REPORT**

**ALL CASES THAT OCCURED FROM 31-10-2021 TO 30-11-2021**

CASE No	NUMBER OF UNMASKED FACES DETECTED	NUMBER OF MASKED FACES DETECTED	DATE	TIME
1	1	0	2021-11-12	09:44:24
2	1	0	2021-11-12	09:44:26
3	1	0	2021-11-12	09:44:28
4	1	0	2021-11-12	09:44:29
5	1	0	2021-11-12	09:44:31
6	1	0	2021-11-12	09:44:33
7	1	0	2021-11-12	09:44:35
8	1	0	2021-11-12	13:00:05
9	1	0	2021-11-12	13:00:07
10	1	0	2021-11-12	13:00:09
11	1	0	2021-11-12	13:00:11
12	1	0	2021-11-12	13:00:13
13	1	0	2021-11-12	13:00:15

This kind of report shows all cases captured since the system started working. The number value shows the number of people who acted corresponding to the column. The number value 1 under unmasked column means that in that frame capture, there is one person who is not masked and 0 value under the same column, means that there is no person who is masked. The same way in the masked column. Frames are saved along with time and dates on which they are captured. Refer to table 4.3 for further explanation.

Table 4.3 All cases ever captured

**ALL MASKED CASES THAT HAVE OCCURED**

CASE No	NUMBER OF UNMASKED FACES DETECTED	NUMBER OF MASKED FACES DETECTED	DATE	TIME
1	1	0	2021-11-22	17:37:58
2	1	0	2021-11-22	17:38:02
3	1	0	2021-11-22	17:38:03
4	1	0	2021-11-22	17:38:05
5	1	0	2021-11-22	17:38:07
6	0	1	2021-11-22	17:38:08
7	0	1	2021-11-22	17:38:08
8	0	1	2021-11-22	17:38:09
9	0	1	2021-11-22	17:38:09
10	0	1	2021-11-22	17:38:09
11	0	1	2021-11-22	17:38:09
12	0	1	2021-11-22	17:38:09
13	0	1	2021-11-22	17:38:10
14	0	1	2021-11-22	17:38:10
15	0	1	2021-11-22	17:38:10

Some sample of Python codes written to run the system as a whole. Figure 4.16 bellow show the sample of python codes.

```
File Edit Selection View Go Run Terminal Help detect_mask_video.py - detector - Visual Studio Code

EXPLORER
DETECTOR
  alarm
  dataset
  face_detector
  deploy.prototxt
  res10_300x300_ssd_iter_140000.c...
  labelling
  detect_mask_video.py
  # main.css
  mask_alert.mp3
  mask_detector.model
  plot.png
  requirements.txt
  train_mask_detector.py

OUTLINE
TIMELINE

detect_mask_video.py
1 # import the necessary packages
2 from tensorflow.keras.applications.mobilenet_v2 import preprocess_input
3 from tensorflow.keras.preprocessing.image import img_to_array
4 from tensorflow.keras.models import load_model
5 from imutils.video import VideoStream
6 import numpy as np
7 import mysql.connector
8 import imutils
9 import calendar
10 import time
11 import cv2
12 import os
13 from datetime import date, datetime
14
15 from playsound import playsound
16
17
18
19 def detect_and_predict_mask(frame, faceNet, maskNet):
20     # grab the dimensions of the frame and then construct a blob
21     # from it
22     (h, w) = frame.shape[:2]
23     blob = cv2.dnn.blobFromImage(frame, 1.0, (224, 224),
24     | | | | | | | | | | (104.0, 177.0, 123.0))
25
26     # pass the blob through the network and obtain the face detections
27     faceNet.setInput(blob)
28     detections = faceNet.forward()
29     print(detections.shape)
30
31     # initialize our list of faces, their corresponding locations,
32     # and the list of predictions from our face mask network
33     faces = []
```

Figure 4.16 Python codes to run the system

## **CHAPTER 5: CONCLUSION, RECOMMENDATION AND FUTURE WORK**

### **5.1 Conclusion**

A key purpose for developing a device or system is to monitor among students and staff at CST campus who by passes it with no facemask at all or not well put on, then it alerts them with an audible signal that encourages them to properly put on their facemasks. The device can do this to an individual or a group of people who come to its focus. All of this is done to advance the fitness of the persons in general but specially to stop the blowout of the covid-19 to freely allow circumstances caused by the pandemic disease. The proposed model shows how devices will be plugged in and work together to provide a sustainable solution. The proposed system will help students and staff always to respect the facemask wearing preventive measure and other covid-19 control related measures.

### **5.2 Recommendation and Future work**

Due to working effectiveness of this device, I recommend it to be widely used other than man power whereby sometimes get tired and maybe get unfocussed then people violate facemask wearing measure and go unmasked surely creating a loophole for the spread of the disease unlike this strict monitoring device.

These days technology is accelerating with much more innovations. This project will need to be expanded according to other challenges that will emerge, as it does not meet all the requirements for monitoring other body features. Due to the short duration and lack of some equipment, the project can be extended to other features monitoring like body temperature that can help to predict that this person who found not properly put on his/her facemask is more likely or not to be affected due body temperature.

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