# JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

**School of Computing and Information Technology**

**(SCIT)**

**Department of Computing**

**Third Year, Semester Two Project Documentation**

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|---|---|
| Student Name | Ian Mike Kaibi |
| Registration Number | SCT212-0107/2016 |
| Course | Computer Technology |
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| Student Signature | |
| Lecturer | Dr. Isaac Mulang’ |
| Lecturer Signature | |
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ABSTRACT

The coronavirus COVID-19 is a respiratory disease that is transmitted through contact with infected persons or objects and was declared a pandemic by the World Health Organization (WHO) on March 11th 2020. The first steps to mitigate mass spreading were quarantine and self isolation as tests were being carried out to learn the nature of the virus. Lockdowns were introduced but this did not last since people needed to continue with their livelihoods. Eventually, wearing masks was introduced to help them continue with their day to day activities and to also reduce the chances of spreading the virus and the results were impressive.

However, flaunters of that measure rose and enforcing of the policy became a priority. How could the government ensure that people adhered to this policy? A quick solution is the need for a system that would identify individuals who had violated the policy and appropriate authorities would take action.

This system is built on the knowledge of Computer Vision and Object detection using **Haar-cascade Classifier** and written in Python. The resulting system is able to detect when a person is wearing a face mask or not through the use of a computer webcam and can be integrated to work with external cameras.

**Acknowledgment**

I take this opportunity to express my profound gratitude to my lecturer, Mr. Isaiah Mulang' for his  guidance and monitoring throughout the course of this project. Without his new ideas, this system would not breathe to life.

I also thank God for the gift of a sound mind and good health to which this assignment would not be possible.

## OUTLINE

# 1 INTRODUCTION

## 1.1 BACKGROUND INFORMATION

Coronaviruses are zoonotic, meaning they first develop in animals before developing in humans. For the virus to pass from animal to humans, a person has to come into close contact with an animal that carries the infection. Once the virus develops in people, coronaviruses can be spread from person to person through respiratory droplets when people cough or sneeze.

The rapid spread of Coronavirus (COVID-19) resulted in a global pandemic and necessitated measures to curb it, among them being avoiding mass gatherings, staying at home, washing hands and cleaning surfaces regularly, avoiding touching one's nose and eyes and not limited to wearing face masks. Correct facemask wearing is valuable for infectious disease control, but the effectiveness of facemasks has been diminished, mostly due to improper wearing.

## 1.2 PROBLEM STATEMENT

Correct facemask wearing is valuable for infectious disease control, but the effectiveness of facemasks has been diminished, mostly due to improper wearing. We have witnessed people wearing them below their chins, on their foreheads and on their wrists while  others do not wear them at all. How do we ensure that the general public adheres to the face mask policy?

At the onset of the pandemic, little was known about COVID-19 and people were bombarded with large amounts of information that we could not easily distinguish the authentic from the misleading. Such a case was in this publication that was retracted citing that masks were ineffective against preventing the spread of COVID-19.[6].

## 1.3 SOLUTION and JUSTIFICATION

According to the World Health Organization (WHO) [4], masks are a key measure to reduce transmission of COVID-19 and save lives. Wearing well-fitted masks should be used as part of a comprehensive **'Do it all!'** approach including maintaining physical distancing, avoiding crowded, closed and close-contact settings, ensuring good ventilation of indoor spaces, cleaning hands regularly, and covering sneezes and coughs with a tissue of bent elbow. Masks can be used:

I. For protection of healthy persons.

II. In preventing onward transmission to the uninfected.

III. As a last resort given that there are fewer alternatives because in the absence of a vaccine to treat people who are sick with COVID-19, the preventive measures of handwashing, physical distancing and mask wearing are the available measures.

An airborne transmission simulation conducted by Hiroshi Ueki, Yuri Furusawa, Kiyoko Iwatsuki-Horimoto, Masaki Imai, Hiroki Kabata, Hidekazu Nishimura, and Yoshihiro Kawaoka [5] from the National Centre of Biotechnology Information (NCBI) on Severe Acute Respiratory Syndrome Coronavirus 2(SARS-CoV-2), the strain of coronavirus that causes COVID-19, containing droplets produced by human respiration and coughs and assessed the transmissibility of the droplets and the ability of various types of face masks to block the transmission found that cotton masks, surgical masks, and N95 masks all have a protective effect with respect to the transmission of infective droplets of SARS-CoV-2 and that the protective efficiency was higher when masks were worn by a virus spreader. The N95 mask had the highest protective efficacy (approximately 80% to 90% reduction) of the various masks examined.Several systematic reviews of randomized controlled trials have evaluated the effect of face masks in preventing the spread of influenza and other respiratory viruses, all of which were performed prior to the COVID-19 pandemic [2], although it was unknown to what extent the conclusions from these studies apply to COVID-19. In another study that examined the rate of secondary transmissions of influenza in Beijing homes that had at least one confirmed COVID-19 patient, evidence that suggests mask-wearing helps mitigate community transmission of COVID-19 [3].

The system I am developing will ensure that people wear masks in public and possibly maintain the above efficacy.

## 1.4 OBJECTIVES

### 1.4.1 Main Objective.

The main objective of carrying out this study is to develop a computer system that is able to detect whether a person in a given organization or location has their mask on or not in real time and conclusively issue an alert depending on a given situation.

### 1.4.2 Other Objectives.

1. To investigate the available literature facial recognition systems.
2. To develop a model that predicts whether a person is wearing a face mask or not.
3. To evaluate the accuracy of the resulting model and its suitability as a prediction model.
4. To develop a real time system that is able to detect face masks.
5. To attain a bigger dataset to achieve higher accuracy

## 1.5 RESEARCH QUESTIONS

1. What kind of technology is going to be used in developing the system?
2. How does distance affect the overall accuracy of the system? How far can the system reach?
3. What amount of time does the system consume in between processing input and giving meaningful output?
4. What is the source and method of gathering system requirements?
5. Will the system produce accurate results?

6. What algorithm will be used to train and give a working model?

## 1.6 RESEARCH METHODS AND DESIGN

The development methodology I will incorporate is Object Oriented System Analysis and Design methodology that entails inception, elaboration, construction and transition and I have exhaustively described it in the system analysis and design section.

The research methodology will encapsulate data collection, data processing, data training and evaluation of results from the model obtained from training and referencing several other existing works and internet sources.

## 1.7 SCOPE OF THE WORK

Since COVID-19 is a global pandemic, it follows that the system should be accessible and in operation in the whole country. However, the implementation of the system shall begin at lower organizational levels especially in the health, education and transportation sectors with further expansion to cover the whole country.

## 1.8 LIMITATIONS OF THE WORK

The following are the limitations of this system:

- Type of user interface used.

The system is built in the Python programming language. A user is only able to interact with the system through a command line interface and has to issue commands in order to run it. This becomes challenging especially if the user does not know how to run scripts written in Python.

- Absence of data retrieval features.

  The developed system can detect the live video streams but does not store records of the processed data because I have not integrated it with  a database. Therefore, it is impossible to rewind, play, pause or retrieve already occurred events as is the case with Closed Circuit Television (CCTV) cameras.  With addition of more complex functions, a snippet of a person's face can also be captured and stored as proof and for future reference.

- Social impact.

  In a questionnaire that I had issued to collect their thoughts about the system, a number of responses cited discomfort against development of the system due to fears of breach of privacy or data being collected without their knowledge and auctioned to the highest bidders, and the thought that they are constantly being watched.

- High end equipment

  The libraries that I used to build this system require at least a computer with an i3 processor, at least 4 Gigabytes of Random Access Memory and sufficient local storage. It also requires a camera with good resolution so as to detect faces efficiently.

- The system faces difficulty in classifying faces covered by hands and it cannot detect faces that are not in close proximity of less than a meter away.

## 1.9 Schedule

Below is the schedule of how I intend to develop the system and it spans across nine weeks.

| Schedule Table | | | |
|---|---|---|---|
| Step ID | Task Name | Task span | Result |
| 1 | Project idea | Week 1 | Vision document |
| 2 | Project proposal | Week 2 | Proposal report |
| 3 | Read related works | Week 2 to 3 | Literature review report |
| 4 | System design | Week 4 to 5 | Design prototype |
| 5 | System implementation and deployment | Week 6 to 8 | Complete working project |
| 6 | Project documentation | Week 9 | Project documentation report |

## 2.0 Budget allocation

| Resource | Description and use | Cost (in KSH) |
|---|---|---|
| Internet | Provided by an ISP | 2800 |
| Compact disk | For storing my project | 50 |
| Office stationery | For printing and binding the documentation | 150 |
| Time | To learn and implement concepts | —- |
| Total cost | | 3000 |

# 2 LITERATURE REVIEW

## 2.1 Introduction

The coronavirus pandemic has wreaked havoc across the globe especially in the early stages of its discovery, very little was known about it , a vaccine had not been discovered yet and it was a rush against time while people were succumbing to it. Quick measures like self isolation and quarantine after contraction, social distancing, banning of international travel, lockdowns, banning of gatherings exceeding a certain threshold and mask wearing were introduced. With further studies and experiments on the virus, it was determined that masks played a major role in reducing [5] the spread of COVID-19 and lockdowns were lifted in some countries cautiously. At the same time, developers were looking into ways of reducing the spread of COVID-19 through the use of technology which led to development of face mask detection systems as a way of ensuring people abide by the face mask policy

A face mask detection system is a system that has been trained to detect if a person is wearing a mask or not through algorithms and Machine Learning. The system is able to accurately detect objects in a camera's field of view, classify the object as a human or not and determine whether the person is not wearing a face mask. These systems are built with the knowledge of facial recognition systems that are used in the fields of security, law enforcement and biometrics. In 2001, The Viola-Jones framework was developed by Paul Viola and Michael Jones it is based on training a model to understand what is and is not a face. Once trained, the model extracts specific features, which are then stored in a file so that features from new images can be compared with the previously stored features at various stages. If the image under study passes through each stage of the feature comparison, then a face has been detected and operations can proceed. However, this framework had limitations since it could not detect a face if it was covered with a mask or not properly oriented. To eliminate these drawbacks, other algorithms like the region-based Convolutional Neural Network (R-CNN) have been developed to improve the process.

A CNN is a neural network used in image recognition specifically designed to process pixel data and primarily used in the field of pattern recognition within images.

## 2.2 Project Overview

In 2001, Paul Viola and Michael Jones in the paper "Rapid Object Detection using a Boosted Cascade of Simple Features" proposed object detection using Haar feature-based cascade classifiers. It is a machine learning based approach in which a cascade function is trained from a lot of positive and negative images and then used to detect objects in other images. My project imports an already pre-trained classifier from OpenCV (OpenSource Computer Vision) for the face in XML format.

The following are the building blocks of this system:

a) Image processing

In the processing step, the images from the dataset are not transformed into grayscale images because Multi-task Convolutional Neural Network (MTCNN) works well with RGB color images although RGB color images contain redundant information that is not necessary for face mask detection. The input images are all reshaped to 120 * 120 * 3 to maintain uniformity.

b) Learning Method

The architecture of the learning technique relies on CNN. It involves:

- ➔ Dataset collection: The dataset I used for training and testing a model is available at [7]. It contains 5000 training images of people with and without face masks, 483 test images for people with masks and 509 test images of people without masks.
- ➔ Architecture development: The learning model is based on CNN and the network comprises an input layer, several hidden layers and an output layer. The hidden layers consist of multiple convolution layers that learn suitable filters for important

feature extraction from the given samples. The features extracted by CNN are used by multiple dense neural networks for classification purposes

## Related Works

### **2.3.1: An Automated System to Limit COVID-19 Using Facial Mask Detection in Smart City Network**

**Authors: Mohammad Marufur Rahman (Khulna University of Engineering and Technology), Md. Motaleb Hossen Manik (Khulna University of Engineering and Technology), Md. Milon Islam (University of Waterloo), Saifuddin Mahmud (Kent State University) and Jong-Hoon Kim (Kent State University)**

The authors of this paper proposed a system that restricts the growth of COVID-19 by finding out people who are not wearing any facial mask in a smart city network where all the public places are monitored with Closed-Circuit Television (CCTV) cameras. While a person without a mask is detected, the corresponding authority is informed through the city network. They incorporated the use of a deep learning architecture to train on a dataset that consists of images of people with and without masks collected from various sources.

In their methodology, the authors proceed with an automated framework for identifying people without masks. CCTV cameras are used to capture images from public places and these images are fed into their system. The images captured by their system required preprocessing by converting the images to grayscale images and reshaping them to uniform size.

From a dataset of 1539 samples, their trained model was able to achieve an accuracy of 98.7%. The model was trained for 100 epochs whereas in my model I've only used 5. There is a noticeable difference between their graphs of accuracy and loss against epochs from my graphs because of the low number of epochs. Their system also faced a similar challenge of difficulty in classifying faces covered by hands

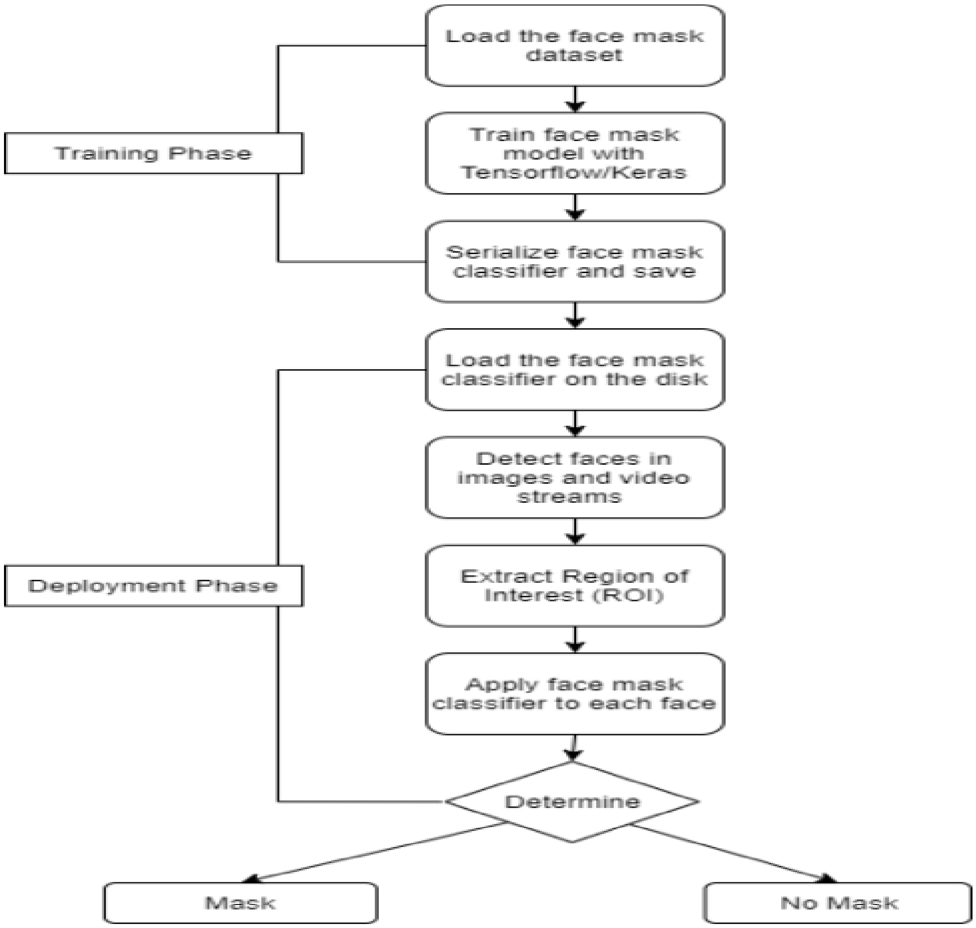
### 2.3.2 Face Mask Detection using Machine Learning and Deep Learning by Saiyam Jain, Mayank Goyal, Deepak Singh, Abhishek Aswal and Upasna Joshi

This paper describes the requirements that need to be met when developing this kind of a system. The authors propose a Face Mask Detection project that consists of training and deployment phases. The training phase detects human faces while the deployment phase uses deep learning to identify the Region of Interest, the face, and to classify the faces detected in training as ‘With Mask’ or ‘Without Mask’. The authors further discuss the various libraries they incorporated in developing the system.

In this paper, they discuss Machine Learning, Deep Learning, Tensorflow, Keras, Scikit-Learn, OpenCV library and MobileNet V2. In both projects, we used Tensorflow and Keras to train our classifier to automatically identify if a person is wearing a face mask. Similarly, the dataset is first loaded in the training phase.

By using a dataset of 3847 images, an initial learning rate of 0.0001, batch size as 32, 20 epochs and resizing the images to 224 x 224 x 3, the authors system was able to attain an accuracy of approximately 98%

Below is a flowchart showing how they achieved training and deployment.




**2.3.3 Literature Review : Implementation of Facial Recognition in Society by M I Zarkasyi, M R Hidayatullah and E M Zamzami**

In this paper, the authors discuss facial recognition technology and its impact on society. Various fields take advantage of facial recognition especially in security and the most popular implementation is user authentication on smartphones. The authors further proceed to highlight that use of excessive facial recognition technology has been widely considered as a privacy intrusion. There are fears that nations may transform into full surveillance states where the privacy of citizens is not the priority of the government.

From an earlier administered questionnaire, I was also able to gather that a number of responses cited concerns about their privacy and they did not support the development of this system to enforce the face mask policy. According to the authors, facial recognition has the following impacts:

Positive Impact

- Enhancement of security.
- It has been used to identify criminals in law enforcement by the police.
- Facial recognition has been used to distinguish identical twin faces in the medical world. This is due to The 2002 Facial Recognition Vendor Test (FRVT).
- Facial recognition has been used in lie detection by observation of a subject's facial expressions while being interrogated.

Negative Impact

- Privacy intrusion.
- It has threatened the freedom of life and activities because of the thought of being constantly watched.
- It brought about racism when Google’s facial recognition was more focused and accurate on white faces and less accurate on black faces.

The authors conclude by stating that, “next-generation face recognition systems are going to have a widespread application in smart environments where computers and machines are more like helpful assistants and the way to achieve this goal is by developing systems that reliably identify people in a manner that fit within the pattern of normal human activities. This implies that future smart environments should use the same modalities as humans, and have approximately the same limitations”.

### **2.3.4 Face Mask Detection using Deep Learning by Thumati Masilamani and Dr. D. Vivekananda Reddy**

The authors cite their concerns on the spread of COVID-19 and state that surgical face masks could reduce the spread of the virus. This necessitated the development of Face Mask Detection systems to help the global society. They further state there is a need for an automated system that is able to check if people are wearing masks instead of manually having to ensure that everyone wears a mask.

In this paper, the authors used CNN for the implementation of the model which is used during the training phase of the model. They incorporated the following steps in their development method:

a) Dataset preparation

   This dataset consisted of 3835 images of people wearing and not wearing face masks. The dataset is used to train the model. They also used a separate dataset of 25 images to test the model

b) Model creation

   Similar to my project, a sequential model was used because the architecture of the model is built layer by layer, convolution layer, maxpool layer, flatten layer, drop out and dense layer. The model is developed by:

   A. Converting RGB images to grayscale images.
   B. Resizing the images to 48 x 48 pixels
   C. Using 'relu' activation function on the convolution layer with images as input.
   D. Generating a Maxpooling layer and stride of size 2 x 2 each.
   E. Normalization with the Batch normalization layer.
   F. Using dropout to overcome overfitting of the model.
   G. Implementing the flatten layer.
   H. Creation of a dense layer after the flatten.
   I. Creation of the drop layer to reduce the number of output from layer to layer.
   J. Creating Batch normalization.
   K. The last layer is a dense layer created with two neurons with the activation function 'Softmax'. This layer gives the output of whether a person is with a mask or without a mask.

c) Model training

Then the model is trained with the dataset gathered in a specified number of epochs according to the batch size specified.

d) Evaluation

After training the model, the authors evaluate the system with the test dataset. The model is then stored for further prediction in the future.

“The user gives an image or live webcam feed as the input to the model that is created, trained and saved and the model identifies the face of the humans in the image and predicts whether that particular person wears a mask or not”.

## **2.4 References**

In reference to the above, literature materials that are relevant to this study are listed below.

They include and are not limited to books and excerpts from research works that are in existence.


1. Hussain, Shabir, Yang Yu, Muhammad Ayoub, Akmal Khan, Rukhshanda Rehman, Junaid A. Wahid, and Weiyan Hou. 2021. "IoT and Deep Learning Based Approach for Rapid Screening and Face Mask Detection for Infection Spread Control of COVID-19" *Applied Sciences* 11, no. 8: 3495. https://doi.org/10.3390/app11083495

2. N.C. Brienen, A. Timen, J. Wallinga, J.E. van Steenbergen, P.F. Teunis

   The effect of mask use on the spread of influenza during a pandemic

   Risk Anal, 30 (2010), pp. 1210-1218

3. Y. Wang, H. Tian, L. Zhang, M. Zhang, D. Guo, W. Wu, et al.

   Reduction of secondary transmission of SARS-CoV-2 in households by face mask use, disinfection and social distancing: a cohort study in Beijing

   China BMJ Glob Health, 5 (2020), Article e002794

4. https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-covid-19-masks
5. Effectiveness of Face Masks in Preventing Airborne Transmission of SARS-CoV-2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7580955/
6. https://doi.org/10.1016/j.mehy.2020.110411
7. Dataset link:

   https://www.kaggle.com/ashishjangra27/face-mask-12k-images-dataset

8. An Automated System to Limit COVID-19 Using Facial Mask Detection in Smart City Network

   Authors: Mohammad Marufur Rahman , Md. Motaleb Hossen Manik, Md. Milon Islam, Saifuddin Mahmud and Jong-Hoon Kim.

# 3 SYSTEM ANALYSIS AND DESIGN

## 3.1 Overview

System analysis and design comprises System Analysis and System Design processes. System analysis is concerned with defining a system in terms of its requirements, functionality and its users. It attempts to decompose the system into modules for easier development and understanding.  System design is concerned with determining the architecture of the system by defining its hardware and software dependencies.

## 3.2 System Analysis

System analysis is coupled with a feasibility study; an assessment of the practicality of a proposed project or system. Feasibility study evaluates a system technically, operationally and economically and from this study, an entity is able to view the advantages and limitations that development of the system may come across

### 3.2.1 Technical Feasibility

Technical feasibility answers the question: “Can I build this system?”. It examines my capability as a developer to create a fully functional system as well as determining the hardware and software requirements needed to build the system. It also evaluates a system based on:

- The familiarity with the technology - Defines my ability as a developer and the users of the system to interact with the system.
- The familiarity with the resulting system - Defines the level of understanding of the system that the users have after training.
- project size -  Defines the complexity of the system in relation to the allocated time. Large projects require more time and skills and offer great risk to an organization.The project size is fair and achievable within the given scope.

The system is built using Python programming language and bundled with consequent libraries and runs on a command line interface which is fairly easy to use by running one command. The system is technically feasible.

### 3.2.2 Operational Feasibility

Operational feasibility answers the question: “If the system is built, will it be used?”. It determines if the system meets its intended purpose and what relevance does it add to an organization. The system, when equipped with reporting services, will be able to identify offenders of the face mask policy and will bring about stricter adherence to wearing masks and thus reducing the chances of mass spreading the virus significantly.

### 3.2.3 Economical Feasibility

Economical Feasibility evaluates the value a system brings forth to an organization, if any. Face mask wearing will reduce the chances of spreading the virus and will in turn reduce the heavy load that is being witnessed on our health sector to an extent that hospitals are fully occupied and lack room to admit more patients. With fewer people admitted in hospitals, patients who might have different ailments other than COVID-19 will also have access to better and reliable health care.

## 3.3 Development Methodology

Following the Object Oriented System Analysis and Design methodology and Rational Unified Process, the phases of development involved are:

### 3.3.1 Inception

In this phase, the scope of this project is determined and defined as well as getting to understand the user requirements of the system. It is also in this phase I conducted the feasibility study . The deliverable of this phase is a system development plan

### 3.3.2 Elaboration

In the phase, I did further defining and refining of user requirements and completed the system development plan. So as to derive the baseline architecture of the system, I came up with a use case diagram.

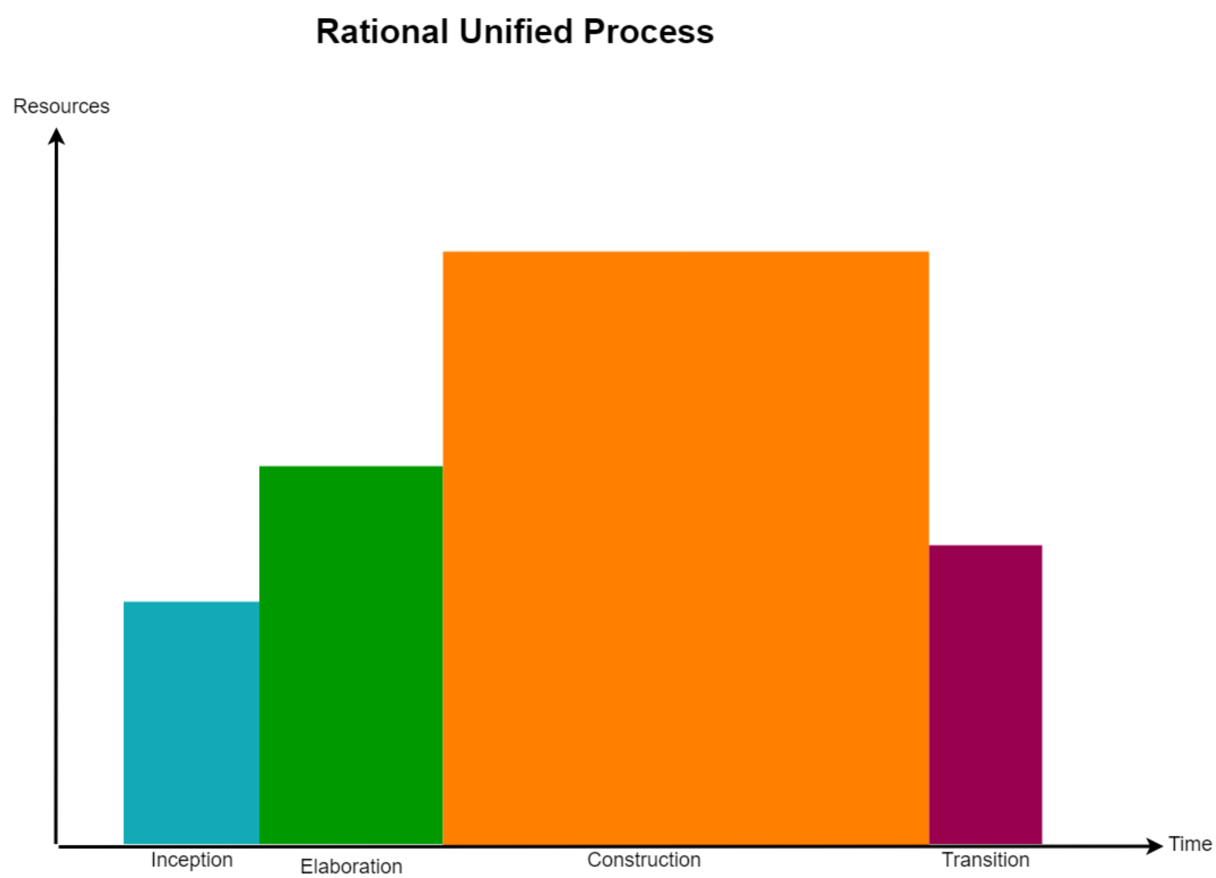
### 3.3.3 Construction

This is the longest and most resource intensive phase. It is at this phase that I did actual coding and testing inline with the user requirements. The deliverable is an implementation of the actual system.

### 3.3.4 Transition

At this phase, I did further testing and completed the system.

The figure below illustrates the Rational Unified Process methodology.



### 3.4 Functional and nonfunctional requirements

#### Functional Requirements

Functional Requirements describe what the system should be able to do. This system should be able to provide the following functions:

a) The system should be able to read a computer's webcam and deploy it to facilitate facial recognition.
b) The system should be able to accurately determine if the user is wearing a face mask or not.
c) The system should be able to accurately label a user as wearing a face mask or not wearing a face mask.

#### Non-functional Requirements

Non-functional Requirements describe the characteristics that my system should have and they include:

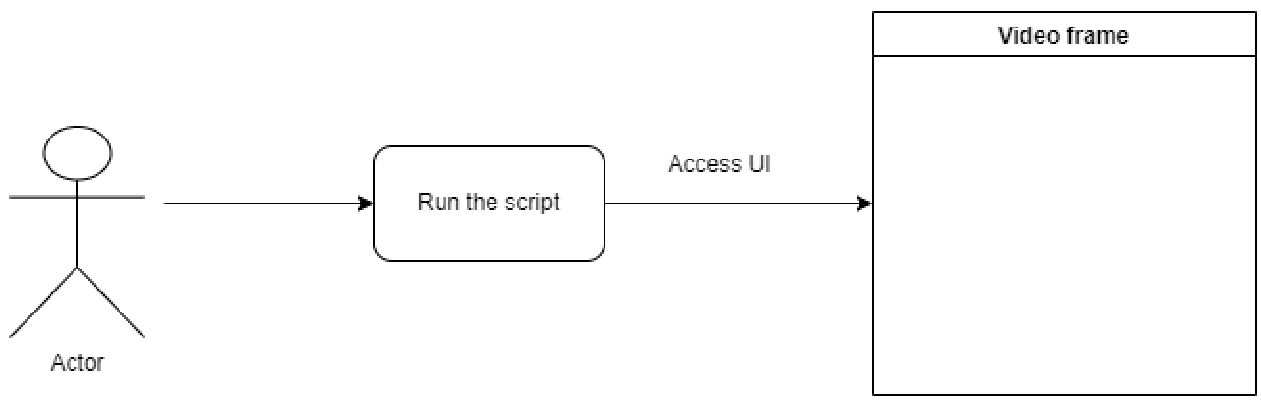
a) The system should be able to run on any operating system that has the required Python libraries installed, whether Linux, Windows or MacOS environments.
b) Performance - The system should be fast and provide quick responses. Time taken between image processing and image classification should be as minimal as possible
c) Usability - The system should be easy to use.
d) Portability - The system should give accurate results effectively in one environment compared to the other. For example, it should run as efficiently when changes in hardware are made.
e) Compatibility - The system should be easy to integrate with other systems like database engines and external hardware components.

# 4 System Design

## 4.1 Overview

System design is the process of defining the components that make up a given system. It is concerned with determining the architecture of the system by defining its hardware and software requirements. This system uses a command line user interface to interact with the user.

## . 4.2 User interface

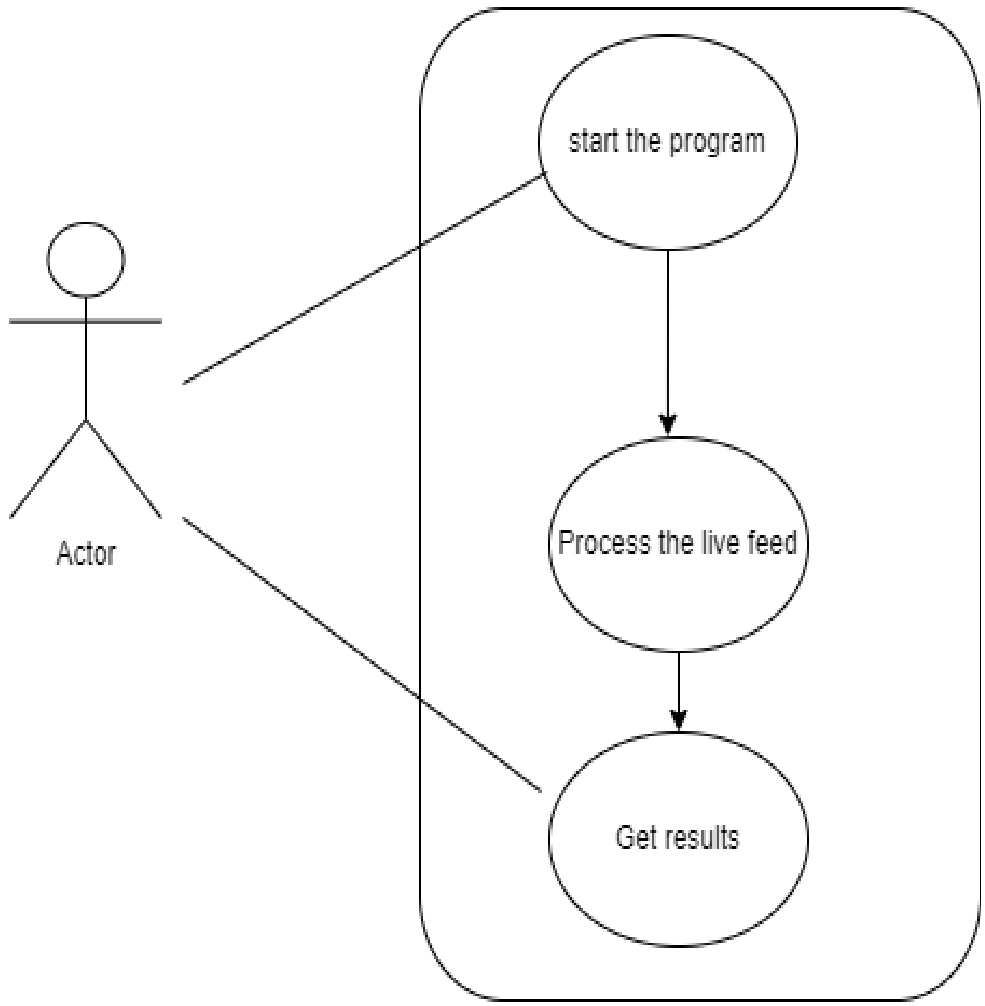


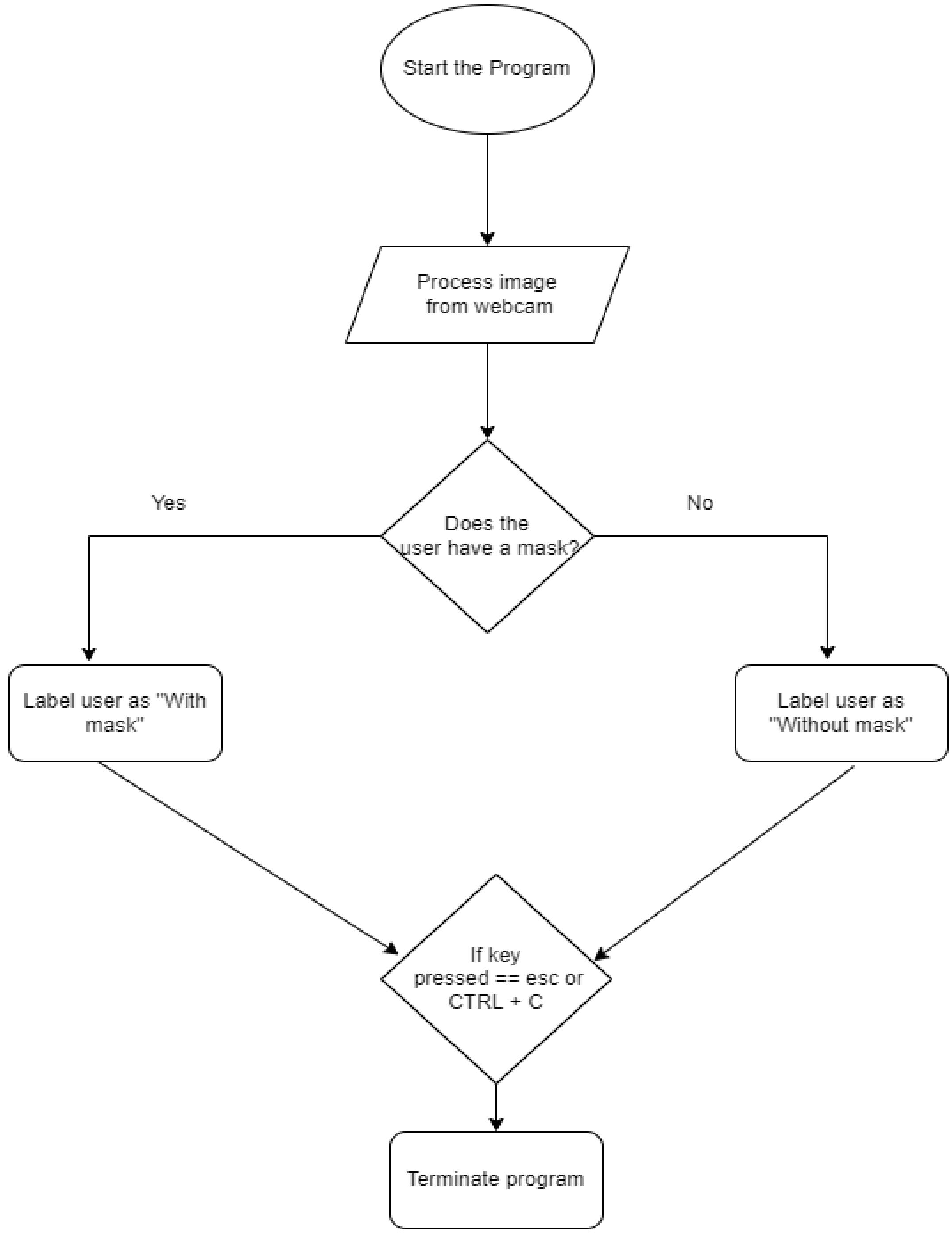

When in the directory that contains the python file, a user only has to run the command ‘python name_Of_File.py’ and the output will be a video frame from the computer’s webcam. From here, the system will automatically detect if they have a face mask on or not.

## 4.3 Use case diagram and Activity Diagram

The below use case diagram depicts how my system interacts with a user.

The diagram comprises a user(actor) and the system with three processes that occur before a user gets output from the system. A user has to run the system manually and the system once runny reads the live feed from the webcam, processes the input and gives an output by indicating if the user has worn a face mask or not.




Start the Program
Process image from webcam
Does the user have a mask?
Yes
No
Label user as "With mask"
Label user as "Without mask"
If key pressed == esc or CTRL + C
Terminate program

## 5 IMPLEMENTATION

Github Link: https://github.com/Trillhood/-3.2-Project-and-Documentation

### 5.1 Overview

This Face Mask Detection project is written purely in Python. In this project, there are two python files: Face Mask detector.ipynb and face_detector.py.

The Face Mask detector.ipynb deals with training and testing the accuracy of the model to be developed and the face_detector.py is the script that run the entire system to facilitate facial detection.

I opted for the OpenCV library. It is an open-source library for computer vision that facilitates recognition of objects.I also imported the Multi-Task Cascaded Convolutional Neural Network (MTCNN) library. MTCNN is a neural network which detects faces and facial landmarks on images with the following stages:

a) In the first stage the MTCNN creates multiple frames which scan through the entire image starting from the top left corner and eventually progressing towards the bottom right corner. The information retrieval process is called P-Net(Proposal Net) which is a shallow, fully connected CNN.
b) In the second stage all the information from P-Net is used as an input for the next layer of CNN which rejects a majority of the frames which do not contain faces or facial landmarks.
c) In the third and final stage, a more powerful and complex CNN outputs the facial landmark position detecting a face from the video stream.

**Face Mask detector.ipynb**

After training the model, I was able to visualize the training loss and training accuracy against the number of epochs used. The result is as below:

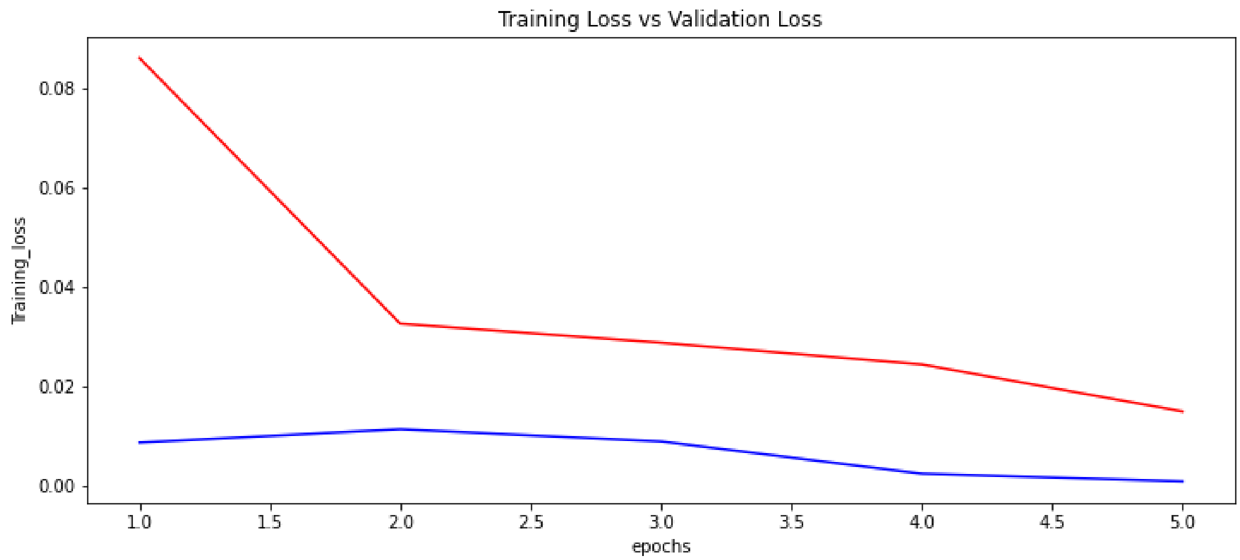



Figure 5.1 Training loss against validation loss

In the above graph, the blue curve represents validation loss and the red curve represents the training loss. As the number of epochs increases, the training loss decreases. This signifies that a model cannot be trained effectively from one epoch.

In the figure below, the blue curve represents validation accuracy and the red curve represents the training accuracy.  As the number of epochs increases, the training accuracy increases. Increase in the number of epochs reduces the distance between the two curves and also increases the training accuracy up to a given threshold. A large number of epochs leads to overfitting of data.

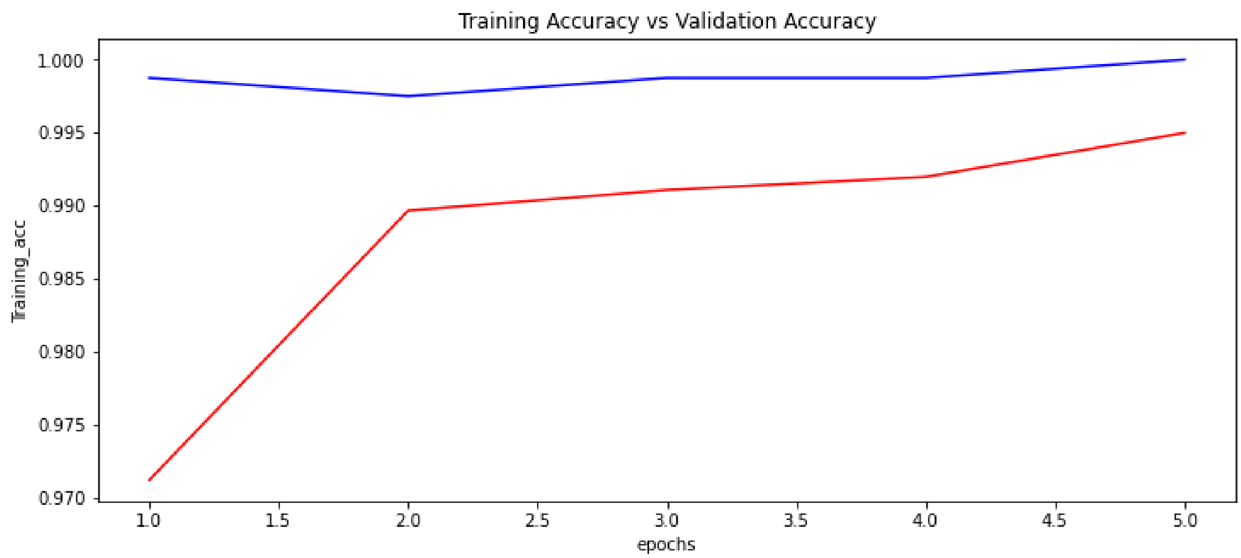



Figure 5.2 Training accuracy against validation accuracy

**face_detector.py**

In the face_detector.py, the program once executed opens up the computer’s webcam and begins scanning for faces in real time as demonstrated below:

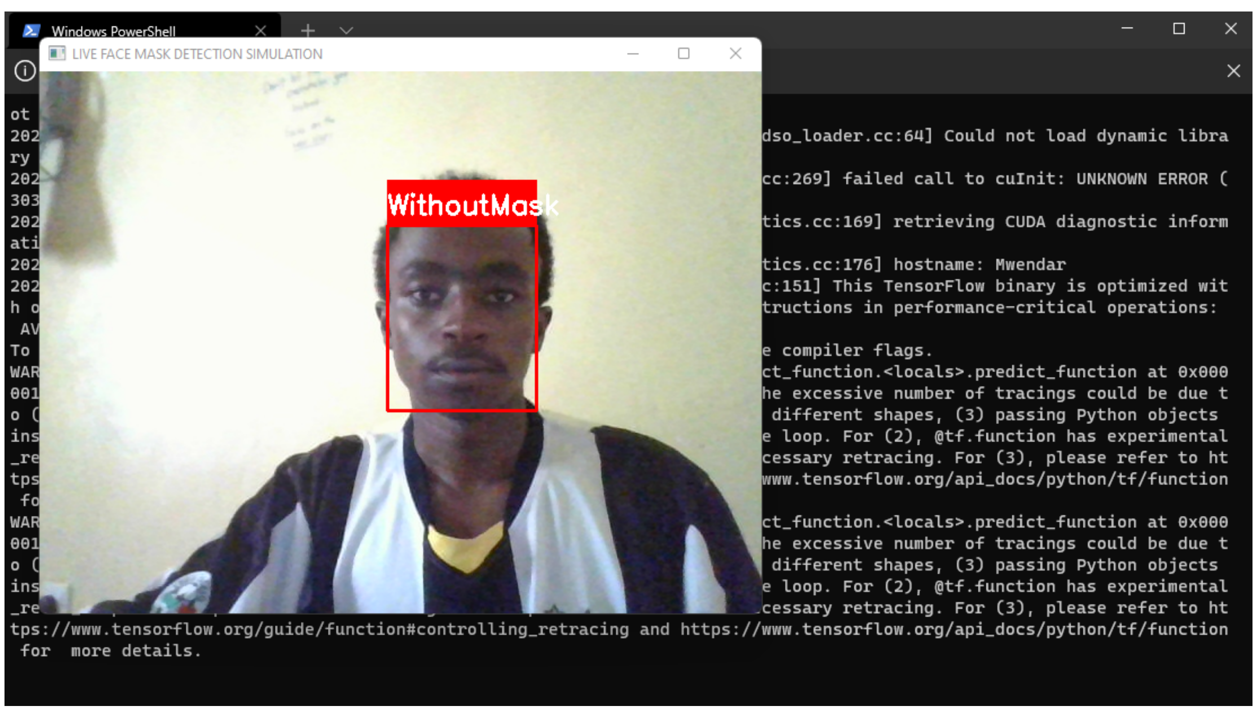



Figure 5.3: mewithoutmask.png

When wearing a mask, this is the output,

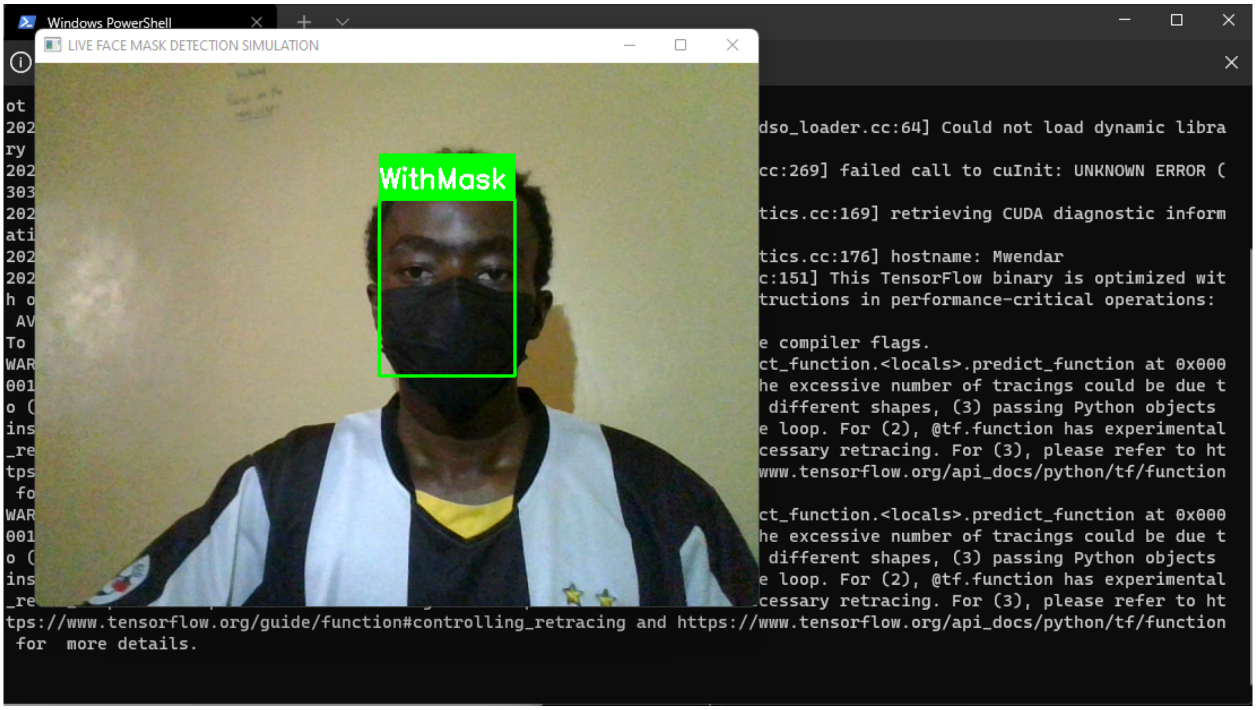



Figure 5.4 Mewithmask.png

However, as stated earlier in limitations of the system, the system cannot different when a mask is poorly or accurately worn and when a person covers their face with their hand as shown respectively in the figures below:

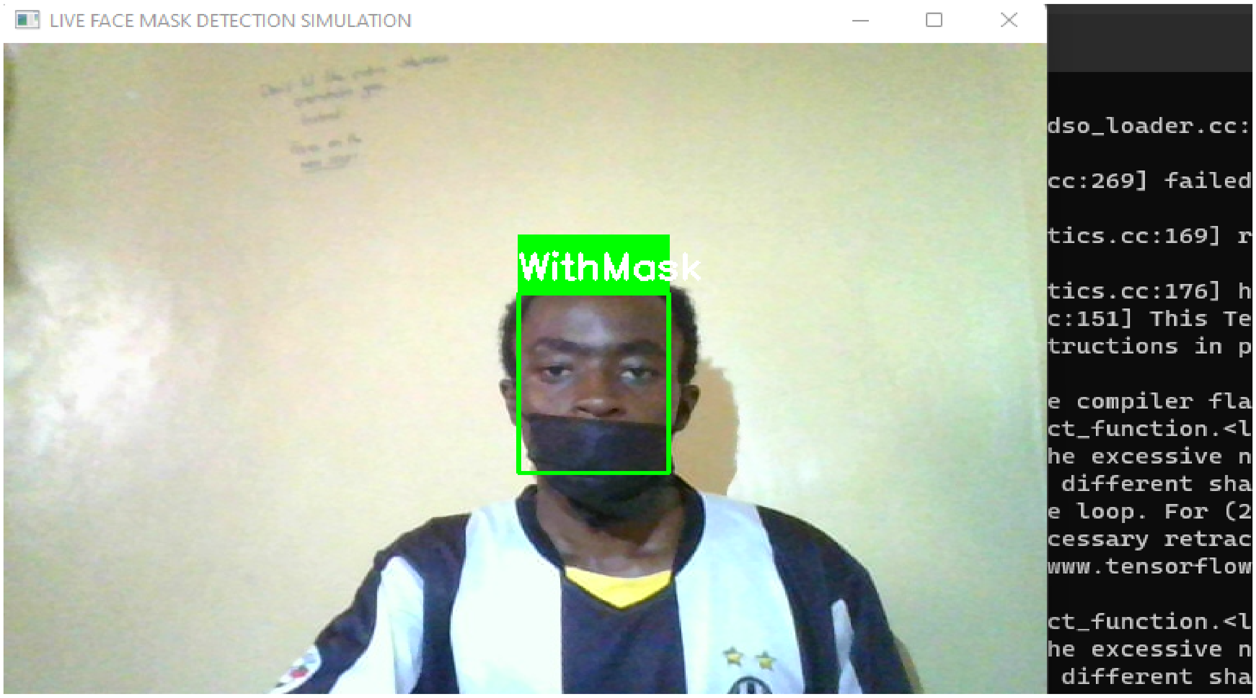



Figure 5.5: Improperwearing.png

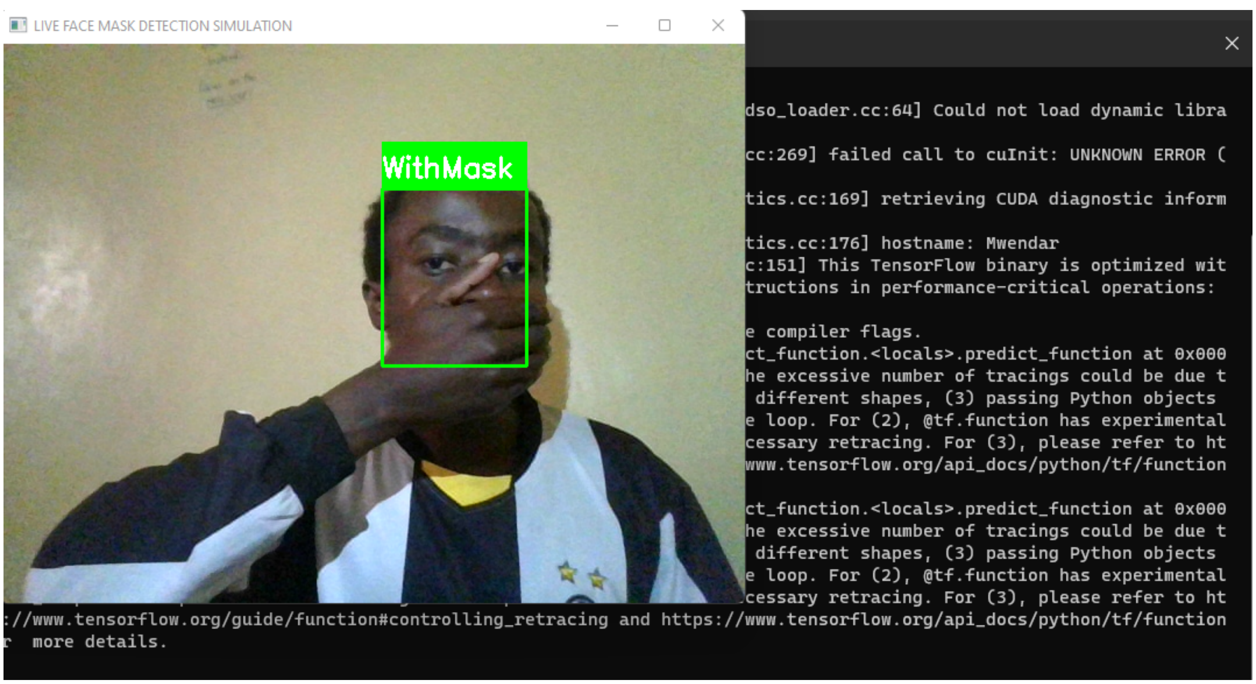



Figure 5.6: handovermyfaceerror.png

These are the minimum requirements needed in order to develop this system.

**Hardware and Software Requirements**

Hardware Requirements

1) A laptop with at least 4 Gigabytes of Random Access Memory

2) A working internet network

3) An external webcam with high resolution if the computer's webcam has low resolution.

4) A hard drive with at least 50 Gigabytes of space.

Software Requirements

1) An operating system(Linux, Windows or MacOS)

2) Python 3.0 and above

3 )A word processor

4) Please refer to the requirements.txt file to view all needed Python libraries.

## 5.2 Code references

1. https://github.com/Chando0185/Face_Mask_Detection
2. https://youtu.be/4WmLOAd1BvY
3. https://github.com/balajisrinivas/Face-Mask-Detection

# 6 CONCLUSION

From the above results, the model can be used to detect whether a person is wearing a face mask or not. can be trained better to increase its accuracy and reduce chances of errors occurring. [Figure 5.5 and Figure 5.6].

With further improvements, the system can be integrated with a backend for storing snapshots of people without masks, it can also have a reporting service whereby the perpetrators are reported to the relevant authorities and action taken.

Overall, it was a great learning opportunity.