Automated Mask Enforcement

Team 29- Teja Gupta, Faruk Toy, Kalpit Fulwariya

ECE 445 Project Proposal- Spring 2021

TA: Ali Kourani

1 Introduction

1.1 Objective

With the coronavirus pandemic, there is a need for people to wear masks while they go out in public. 41 US states and territories including Illinois have implemented mask mandates, and Joe Biden recently decreed that masks must be worn in all federal buildings and while traveling [1]. Studies from the CDC have shown significant decreases in the number of cases in areas where mask mandates have been implemented [2] and there are several studies demonstrating the efficacy of masks at blocking droplets that spread Covid [3]. Despite this evidence, there is a growing anti-mask movement in the United States with many individuals refusing to wear masks when entering stores [4]. While many stores may have a person stationed at the front to be able to check whether everyone entering the store is wearing a mask, these people are at an increased risk of getting infected and having them stationed there imposes an additional salary cost. Additionally, for buildings with multiple entrances, such an arrangement is not feasible. There is a need for an automated system to monitor people entering a building without placing the lives and well being of workers in jeopardy.

Our goal is to create an effective system to be able to monitor individuals coming into a building and enforce mask policies. Our system will track individual entrants using a camera. The camera will then feed the live video feed to an acceleration module to detect whether someone is wearing a mask or not. If it detects someone approaching with a mask, it will unlock the door, otherwise it will remain locked thereby preventing those without a mask from entering. The solution could potentially be extended to integrate with the existing sliding doors or accessibility door unlock solutions as a creeping feature.

1.2 Background

With the coronavirus pandemic, the CDC has recommended the use of medical masks to slow the spread of the coronavirus [5]. There are a plethora of studies showing the effectiveness of masks in slowing the spread and the efficacy of masks in containing the spread of similar viruses [3]. However, despite these guidelines and studies there is still an increasing number of people that refuse to wear masks in the United States. Groups such as The Free Face Society and Umask America are encouraging Americans to go without masks [4]. According to a Pew Research study, only 65% regularly wear masks when going outside to stores [6]. While most Americans are taking the necessary precautions, there is still a fairly large minority that refuse to follow the guidelines and laws that have been set.

These individuals not only pose a risk to themselves but those around them as well. Roughly 74 million essential workers are at an increased risk of the coronavirus and 61% percent of that number are at a severe risk [7]. With the rise of a population that refuses to wear masks, there is a need for a system that prevents these people from entering buildings while not risking the lives of the essential workers.

1.3 Physical Design

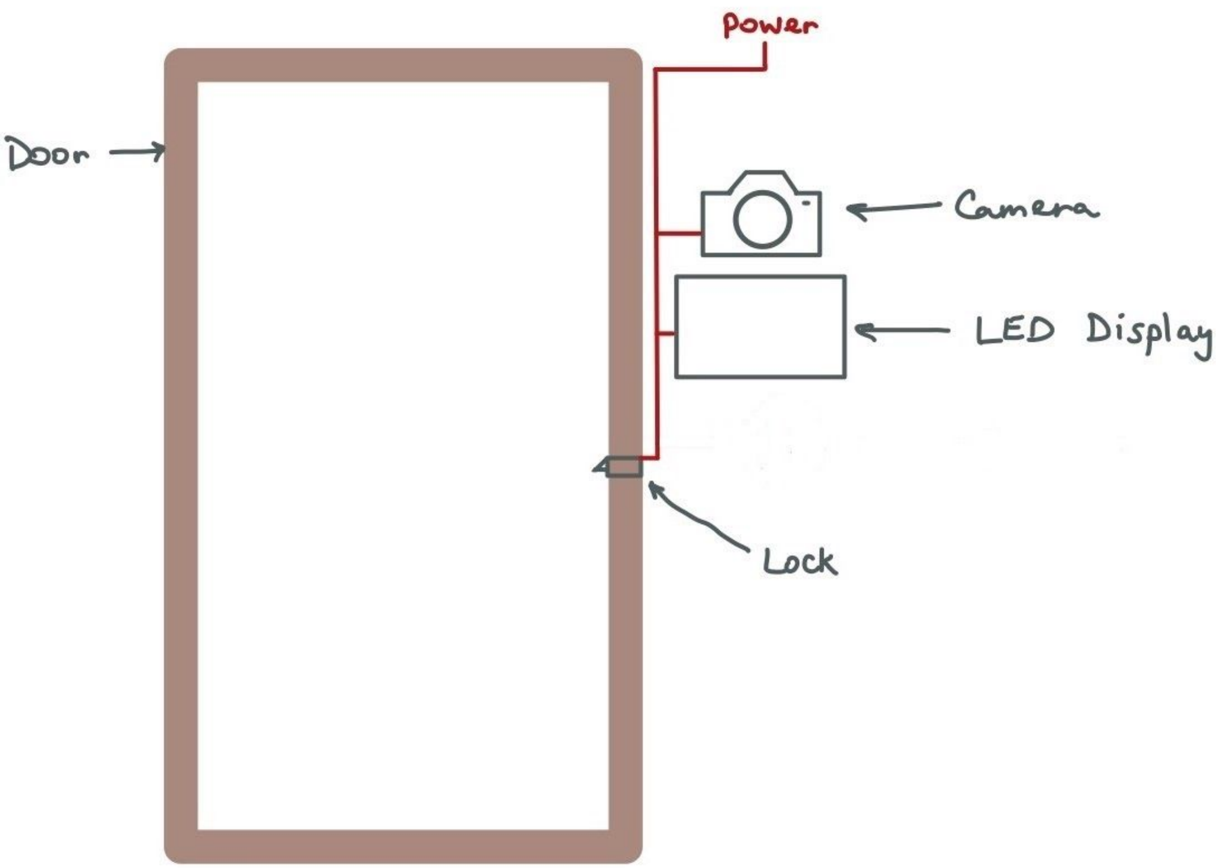

Figure 1. Physical Design

1.4 High-Level Requirements

- Must be able to detect whether someone is wearing a mask or not with accuracy of >80%
- There can not be a delay of >1s between detecting a face and unlocking the door

- Must be able to be powered indefinitely by a 120V AC power supply

2 Design

2.1 Block Diagram

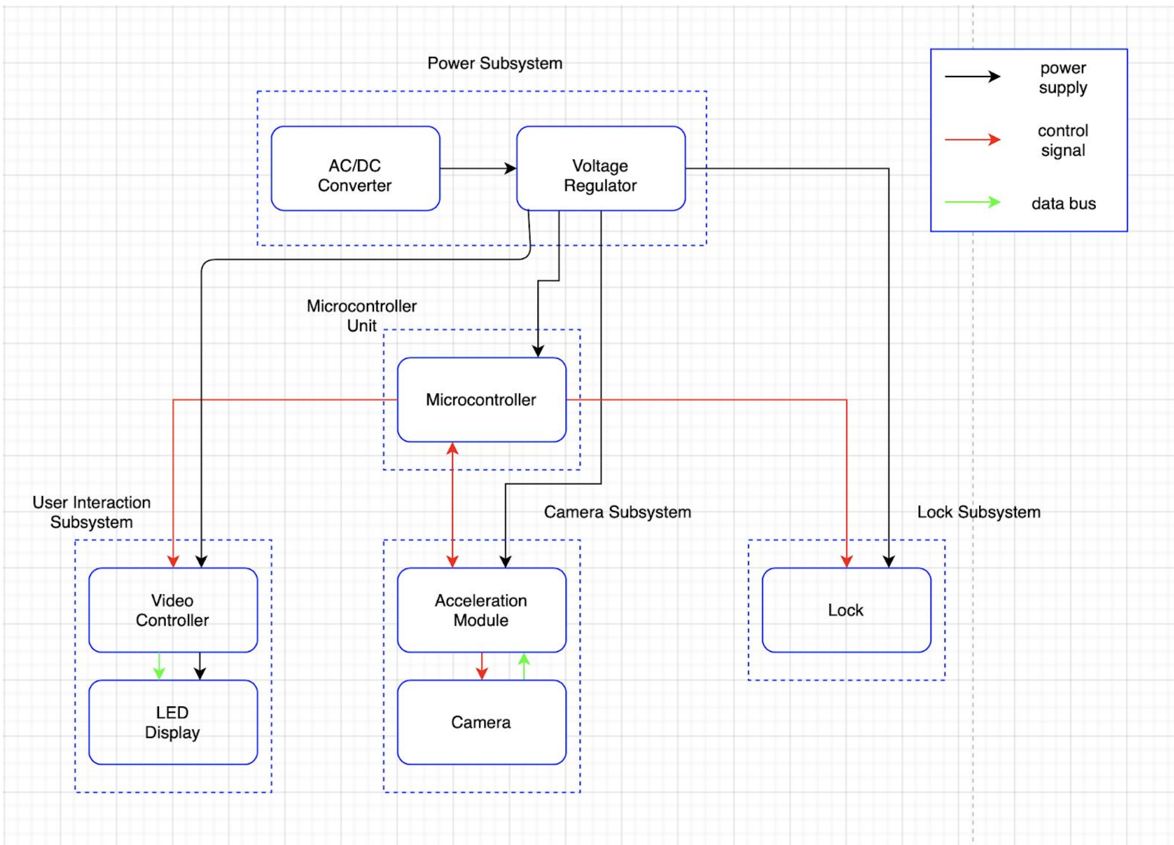

Figure 2. Block Diagram

2.2 Power Subsystem

This system is used to provide power to all the other subsystems in our design. This includes the Control, User Interaction, Camera and Lock subsystems. This power system will require the use of an AC/DC and a voltage regulator to step up or step down to a particular voltage level.

2.2.1 AC/DC Converter

We will try to use an AC/DC converter that plugs into a wall to power our devices.

Requirement- Generate 12+/-0.5V DC voltage from a 120V wall outlet

Requirement- Must be able to provide at least 2A to power all subsystems

2.2.2 Voltage Regulator-

We should be able to step up/down the voltage to 5 volts in order to power the google coral miniboard. It should also step up/down voltage to 9-12 volts to power our lock.

Requirement- Must be able to provide 5+/-0.5 volts with above 600 mA from the output of AC/DC converter

Requirement- Must be able to step down voltage to 9-12 volts with 500-650 mA from the output of the AC/DC converter

2.3 Camera Subsystem

This subsystem will use a camera to detect whether a person is or is not wearing a mask. It will then relay this information back to the microcontroller.

2.3.1 Accelerator Module

This component will run the neural network necessary for detecting whether or not someone is wearing a mask as well as relay this information back to the microcontroller. We are considering using a google coral mini-dev board for this.

Requirement- Be able to detect people within 5 feet of the door.

Requirement- Have a testing accuracy of >80%

Requirement- Can't take more than 1 second to recognize mask/no mask.

2.3.2 Camera

This is a camera that will be used to look at the surroundings and provide real time footage to the accelerator module.

Requirement- Data Bus must be compatible with accelerator module

2.4 User Interaction Subsystem

This subsystem will play a small GIF showing how to wear a mask when the user is not wearing one.

2.4.1 Video Controller

This module will hold the video that is to be played and control the screen takes input from microcontroller

Requirement- Data Bus is compatible with a screen

Requirement- Able to store a small GIF (size not determined yet)

2.4.2 Screen

A display that will take in input from the video controller and play the GIF

Requirement- RGB display of at least 16x16 LED Matrix or LCD display for sufficient visibility at around 5 feet from the screen

Requirement- Has frame rate compatible with the GIF we are trying to show (FPS not determined yet)

2.5 Controller Subsystem/Microcontroller

This is the subsystem that will coordinate the other subsystems taking in input from the camera subsystem and outputting to the locking and user interaction subsystems.

Requirement- Need to be able to take a two bit signal using SPI interface from the acceleration module and send data to the display via SPI or I2C interface

Requirement- Should have at least 24K RAM for the GIF and onboard storage or support for flash storage for loading the GIF and the code

2.6 Lock

This subsystem will use a motor to engage and disengage the mechanism.

Requirement- Must have the ability to be switched on and off based on input from the microcontroller.

2.7 Risk Analysis

The part of the project that poses the largest challenge to the completion of this project is the camera subsystem. This system is probably the most important and most difficult subsystem in this project. With the camera subsystem, the main way to tackle the challenge of detecting whether someone is wearing a mask or not is using convolutional neural networks (CNN). There are many potential issues that could come as a result of using CNNs. CNNs (and neural networks in general) require large amounts of data to train. There are not a lot of publicly available datasets of people wearing masks. With the data available that is publicly, we have run into two major issues. The first is that many of the datasets use simulated data. In other words, they essentially use pictures of people with a mask photoshopped onto them. This simulated data may cause our CNN to perform weaker when dealing with real masks. Another issue we run into is a lack of diversity. One the datasets we were able to find used pictures exclusively of people of Chinese descent. This could cause issues with racial bias. The issue of racial bias has been documented in a variety of other applications [8]. Another issue that could potentially result is one of latency. CNNs are known for being computationally intensive and this could possibly result in noticeable delays in detecting people in real time video footage and responding accordingly. The reason this is such an issue is that there are studies demonstrating that even small delays in response time can cause users to use a product less [9]. Accuracy is also a major issue. Even small error rates can be very detrimental considering that this application could potentially deal with hundreds or even thousands of people. Overall, we can’t be sure that our classifier would be able to generalize from the datasets we have found to data from real-time video footage.

3 Ethics and Safety Issues

There are several ethical concerns that we need to address with this project. Since our system uses cameras to track individuals, there are many potential ethical concerns that may result from the use of our system.The first is the issue of privacy. Our system uses cameras to track the entrants to a building. This could place us into potential conflict with IEEE code of ethics #1: “protect the privacy of others…[10]”. If misused the camera subsystem we have could be very invasive and risk the privacy of our potential clients. This would also place us into conflict with the ACM Code of ethics 1.6 which states, “Only the minimum amount of personal information necessary should be collected in a system. The retention and disposal periods for that information should be clearly defined, enforced, and communicated to data subjects [11]”. To combat this risk we refuse to record any of the participants entering a building and make sure any frames analyzed will only be stored temporarily. We will also make sure that no facial recognition is being run over the video data.

Another issue that we may run into is unintentional racial discrimination. Since a lot of data we use to train the camera subsystem may be biased to people of a particular racial group, in this case East Asian people, our system may not work as well when detecting people of other races. This might place us into conflict with IEEE code of ethics #7: “ to treat all persons fairly and with respect, and to not engage in discrimination based on characteristics such as race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression [11]”. This same principle may also place into conflict with the people who may possess some sort of facial disfigurement or disability for the same reasons.

There are also several safety concerns that need to be considered as well. With the system we have in place we will not be able to detect people who are wearing masks incorrectly. For example, if someone is not covering their nose, our system could potentially let them into the building, posing a risk to everyone that is inside. Another risk is if our system misidentifies someone without a mask and lets them into a building. Both of these scenarios would be a violation of the IEEE code of ethics #9 “avoid injuring others [11]”. To prevent the first risk, there is a simulated dataset available of people wearing masks incorrectly that we could potentially use. Since it is simulated, there is most likely a high rate of error when dealing with actual mask wearers. There is no easy way to prevent the second risk aside from doing everything to ensure our classifier has a low error rate on real world samples.

Another issue that could arise from our device are electrical hazards. Since our product will be powered by 120 V AC wall electricity, we will have to be cautious. We will implement our product so that it will satisfy all the safety standards put in place by OSHA [12]. Our device might be installed outside of a building. Therefore, weather plays a big role in our safety considerations. If there is a heavy rain outside, water can leak into the product and cause short circuits. This would not only damage the product, but also it can possibly create a fire in the building. To combat this risk, we will ensure that the casing around our product will be waterproof.

References

[1] K. Hubbard, “These States Have COVID-19 Mask Mandates,” *U.S. News & World Report*, 08-Feb-2021. [Online]. Available: https://www.usnews.com/news/best-states/articles/these-are-the-states-with-mask-mandates. [Accessed: 11-Feb-2021].

[2] H. Joo, G. F. Miller, G. Sunshine, M. Gakh, J. Pike, F. P. Havers, L. Kim, R. Weber, S. Dugmeoglu, C. Watson, and F. Coronado, “Decline in COVID-19 Hospitalization Growth Rates Associated with Statewide Mask Mandates — 10 States, March–October 2020,” *MMWR. Morbidity and Mortality Weekly Report*, vol. 70, no. 6, pp. 212–216, 2021.

[3] J. Howard, A. Huang, Z. Li, Z. Tufecki, Z. Vladimir, H.-M. van der Westhuizen, A. von Delft, A. Price, L. Fridman, L.-H. Tang, V. Tang, G. L. Watson, C. E. Bax, R. Shaikh, F. Questier, D. Hernandez, L. F. Chu, C. M. Ramirez, and A. W. Rimoin, “Face Masks Against COVID-19: An Evidence Review,” Apr. 2020.

[4] J. Guynn, “Trump's COVID-19 diagnosis is not slowing virulent anti-mask movement on Facebook,” *USA Today*, 03-Oct-2020. [Online]. Available: https://www.usatoday.com/story/tech/2020/10/02/facebook-anti-face-mask-groups-trump-covid-19/3597593001/. [Accessed: 11-Feb-2021].

[5] “COVID-19: Considerations for Wearing Masks,” *Centers for Disease Control and Prevention*. [Online]. Available: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/cloth-face-cover-guidance.html. [Accessed: 13-Feb-2021].

[6] R. Igielnik, “Most Americans say they regularly wore a mask in stores in the past month; fewer see others doing it,” *Pew Research Center*, 27-Jul-2020. [Online]. Available: https://www.pewresearch.org/fact-tank/2020/06/23/most-americans-say-they-regularly-w

ore-a-mask-in-stores-in-the-past-month-fewer-see-others-doing-it/. [Accessed: 11-Feb-2021].

[7] S. Reinberg, “Nearly 74 Million Essential Workers at High Risk for COVID in U.S.,” *U.S. News & World Report*. [Online]. Available: https://www.usnews.com/news/health-news/articles/2020-11-09/nearly-74-million-essential-workers-at-high-risk-for-covid-in-us. [Accessed: 11-Feb-2021].

[8] J. G. Cavazos, P. J. Phillips, C. D. Castillo, and A. J. O'Toole, “Accuracy Comparison Across Face Recognition Algorithms: Where Are We on Measuring Race Bias?,” *IEEE Transactions on Biometrics, Behavior, and Identity Science*, vol. 3, no. 1, pp. 101–111, Sep. 2020.

[9] Schurman, E. and Brutlag, “The user and business impact of server delays, additional bytes, and HTT09P chunking in web search.” In Velocity Web Performance and Operations Conference. Jun. 20.

[10] Ieee.org. 2020. IEEE Code Of Ethics. [online] Available at: [Accessed 11-Feb-2021].

[11] Acm.org. 2020. The Code Affirms An Obligation Of Computing Professionals To Use Their Skills For The Benefit Of Society.. [online] Available at: [Accessed 11-September-2020].

[12] Osha.gov. 2002. Controlling Electrical Hazards. [online] Available at: https://www.osha.gov/sites/default/files/publications/osha3075.pdf [Accessed 18-Feb-2021]