UNIVERSITY OF CENTRAL FLORIDA

Department of Electrical Engineering and Computer Science

Dr. Samuel Richie

Divide and Conquer 2.0

<u>Group 24</u>

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Project 1: Coronavirus Prevention System
Customers: N/A
Sponsors: Self

1. Motivation Description

SARS-CoV-2 of 2019, or simply COVID-19, is a strand of coronavirus that causes the COVID-19 pandemic that has been spreading quickly across the entire world since November of 2019. Starting March of 2020, the virus arrived on the land of the United States and has been terrorizing many communities and killed many people. As COVID-19 is spreading rapidly in many states in the United States, more than 7 million cases have been reported as of late September of 2020, and more than 204,000 people have lost their lives during the pandemic. As of recently, the number of new infected cases, as well as the number of new deaths, have not climbed as much as before, but the virus is in no way contained. The World Health Organization and public health officials in the States believe that wearing masks and maintaining social distancing of 6 feet or more could further help reduce the risk of transmission of the coronavirus. The message advocating for wearing a mask whenever possible is becoming more convincing and more vocal than ever before. Therefore, we too, believe that wearing a mask has serious positive effects during the era of COVID-19, which could save many thousands of lives.

Many places are inherently more vulnerable to become a catalyst of spreading the virus. By design, both physically and socially, these places create more opportunities for people to come in contact with another person. With higher contact rate, the rate of transmission will, correspondingly. be higher. These vulnerable places are restaurants, markets, schools, and workplaces. These places tend to be small in size but incur high traffic. Sometimes, people are squished together, shoulder to shoulder. In such cases, keeping a social distance of 6 feet is pretty much impossible. The best way to mitigate the spread of the virus in such situations is to wear a respirator, or as a minimum, a mask. Wearing a mask could help slowdown the COVID-19 spread rate. However, distributing mask can prove to be costly as many places need to hire a person whose purpose is to solely hand out masks. Buying an automatic mask dispenser is expensive, so such dispensers are not common. Entrepreneurs are capitalizing on the pandemic by selling masks, and anything mask-related at a steep mark up. Inventors are bought by such entrepreneurs to help them capitalize on the profit. Creating cheap and convenient products to help schools and small businesses stay open is just a secondary thought.

Our goal is just that. We want to dive into the venue where most other inventors stray from due to a lack of funds and profit. We want to build a low cost and effective robot that uses machine learning to algorithmically detect faces of people who are not wearing masks. The robot would then automatically open its storage compartment for the none-mask-wearing person to reach in a fetch a mask. By building such a robot, we can help people raise awareness of the importance of wearing mask, so that they can protect themselves and other people around them from getting into direct contact with the coronavirus. Moreover, by making use of the facial mask-wearing recognition, we may potentially be able to help researchers study human behaviors and predict future disease hot spots before it is too late. We may also be able to work with law enforcements to notify them of places where people are gathering but are actively avoiding wearing masks.

2. Design Requirements

2.1. Hardware Requirements

2.1.1. Body and Mask Case

The body will provide mounting for the various parts of the system. A mask case will be provided to hold face masks with a sliding door.

2.1.2. LCD Screen

Will provide prompt to the user. Controlled by the MCU.

2.1.3. Mask Dispenser Motor System

Will provide a mask dispenser activated by software. Upon activation the system will provide a mask using motors to open the Mask Case.

2.1.4. Button

Will provide an override button to manually activate the Mask Dispenser Motor System.

2.1.5. Temperature Sensor

Will provide a human body temperature sensor to the software mounted to the main case.

2.1.6. Distance Sensor

Will provide distance measurement intended for accurate temperature measurement to the software.

2.1.7. Alert System

Will provide a software-controlled alert system in the case the temperature reading is above a threshold. The alert system will consist of a speaker.

2.1.8. Microcontroller Unit (MCU)

Will provide a microcontroller for control and status monitoring of temperature sensor, distance measurement unit, alert system, and mask dispenser. Will provide I/O to the Image Processing Unit through the PCB.

2.1.9. Camera

Will provide a camera for the Image Processing Unit.

2.1.10. Image Processing Unit (IPU)

Will provide image processing to detect whether the person is NOT wearing a mask. Will provide I/O to the Microcontroller Unit through the PCB for status and control. Will connect to the Camera.

2.1.11. AC-DC Voltage Converter

Will implement an AC-DC voltage converter to provide power for low-power components in the design.

2.1.12. Custom PCB

The AC-DC voltage converter, temperature sensor, distance measurement unit, alert system, microcontroller will be located on the PCB. I/O will be provided for the attached back-end Video Processing Unit to connect to the PCB.

2.2. Software Requirements

Microcontroller

2.2.1. Mask Dispensing Control

The MCU will provide capability to drive the motors upon activation and open the mask case.

2.2.2. Peripheral Control

The MCU will provide control and status monitoring of the Temperature Sensor, Distance Sensor, Alert System, and LCD Screen.

Image Processing Unit

2.2.3. Facial/Mask Detection

The IPU will be able to run algorithms for facial detection and correctly determine whether the image from the camera contains a person and if so if they are wearing a mask or not.

2.2.4. Microcontroller Control

The IPU will be able to control the MCU and monitor peripherals. Minimum requirement is that the Mask Dispenser system is able to be activated through the IPU -> MCU path.

2.2.5. Statistics Tracking

The IPU will have a statistics system to track statistics: number of people detected passing by and number of people wearing/not wearing masks.

2.3. Performance Requirements

Mask Dispenser Motor System: The motors should be capable of opening the mask case within a second of activation.

Image Processing Unit: The IPU chosen should be able to do real-time Machine Learning algorithms such that a face can be detected in the image, along with whether a mask is worn or not with >50% accuracy. These determinations should be run in real-time such that the peripherals attached to the MCU can react within 10 seconds of the person being detected. A recommendation is that the IPU has a sufficiently capable Graphics Processing Unit to accelerate the Machine Learning algorithms.

IPU/MCU: The IPU/MCU should both have enough pins to interface with each other, and the MCU additional pins for interfacing with the connected peripherals.

Camera: The camera should be high enough resolution and framerate such that detecting human faces from <30ft is possible by the IPU.

Peripherals: The Distance Sensor should detect an object from 0 to 10 feet directly in front. The temperature sensor should take valid readings from one foot in front. The alert system should be reasonably loud enough as to be audible from 20 feet away.

3. Block Diagrams:

The diagrams are split into hardware (diagram 1) and software (diagram 2) so that they are easier to view and understand.

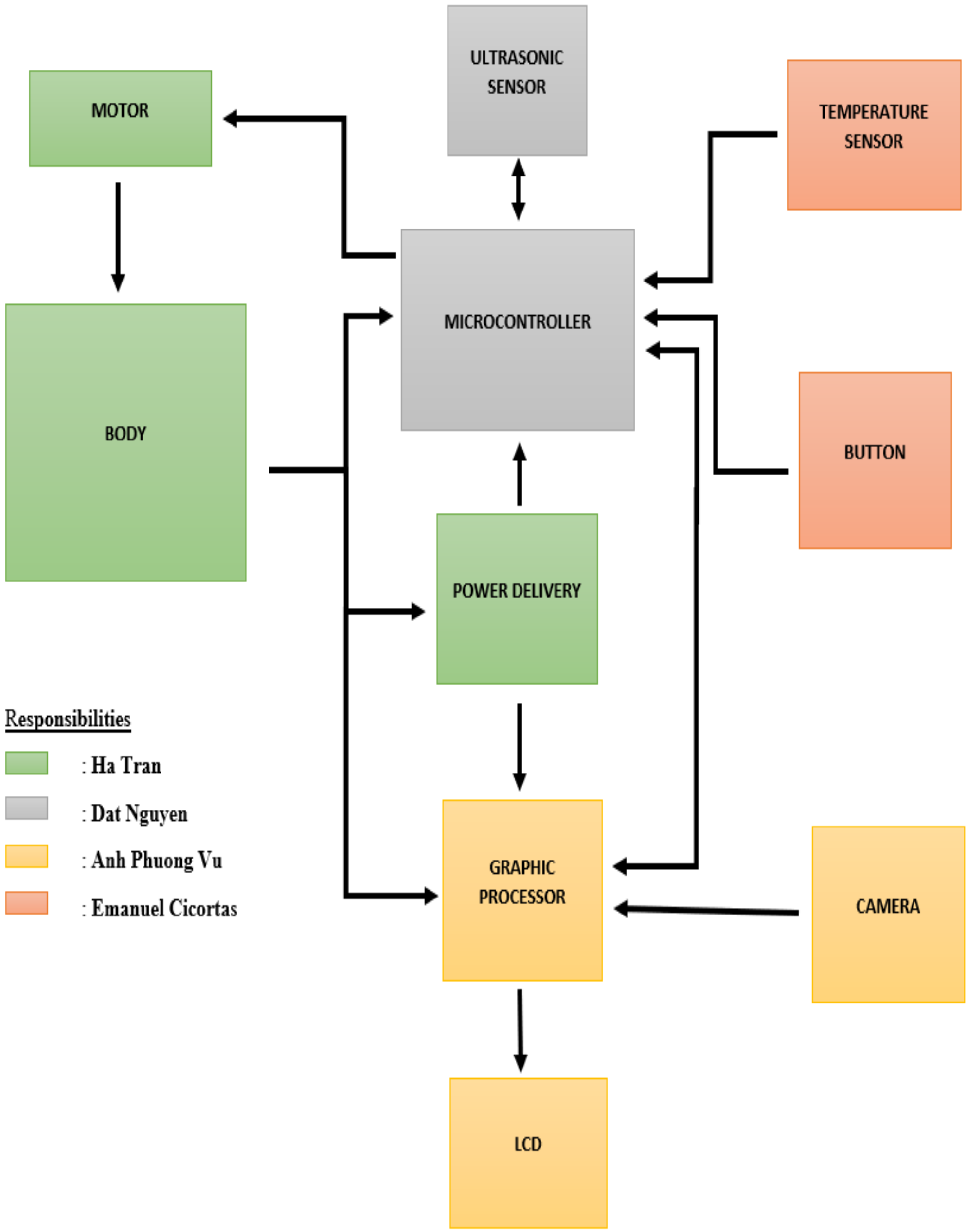

Diagram 1: Block diagram for hardware

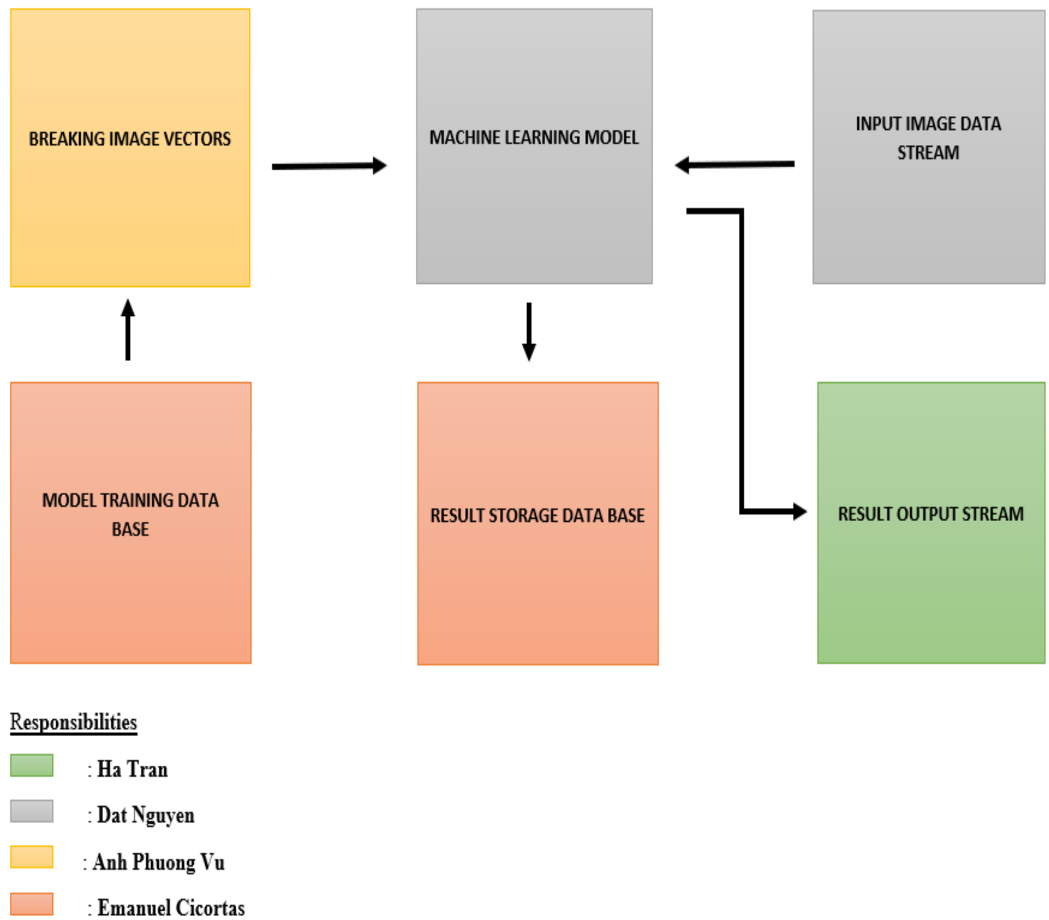

Diagram 2: Block diagram for software

4. Estimated Budget:

For this project, we do not currently have a sponsor. As stated in the project's description, most people don't care, and don't want to invest in such a low-margin project. We are willing to spend our own money on this project to produce a proof of concept. From our conservative estimate, the amount of capital needed for this small-scale project is approximately $725. We hope that our estimation is close to the actual cost of the program as our budget is extremely limited. The expenses are broken down in **Table 1**.

Item	Quantity	Price Estimate
PCB manufacturing	1	$150
Image Processing Unit	1	<=$300
Microcontroller	1	$50
Motors	1	$10
Camera	1	$45
Display screen	1	$20
Plastic for body	1	$20
Wires and other components	Varies	$100
Temperature sensor	1	$20
Ultrasonic sensor	1	$10
Total		$725

Table 1: Components and budget estimation.

5. Prototype Illustration:

Diagram 3 shows a tentative design of the end-product.

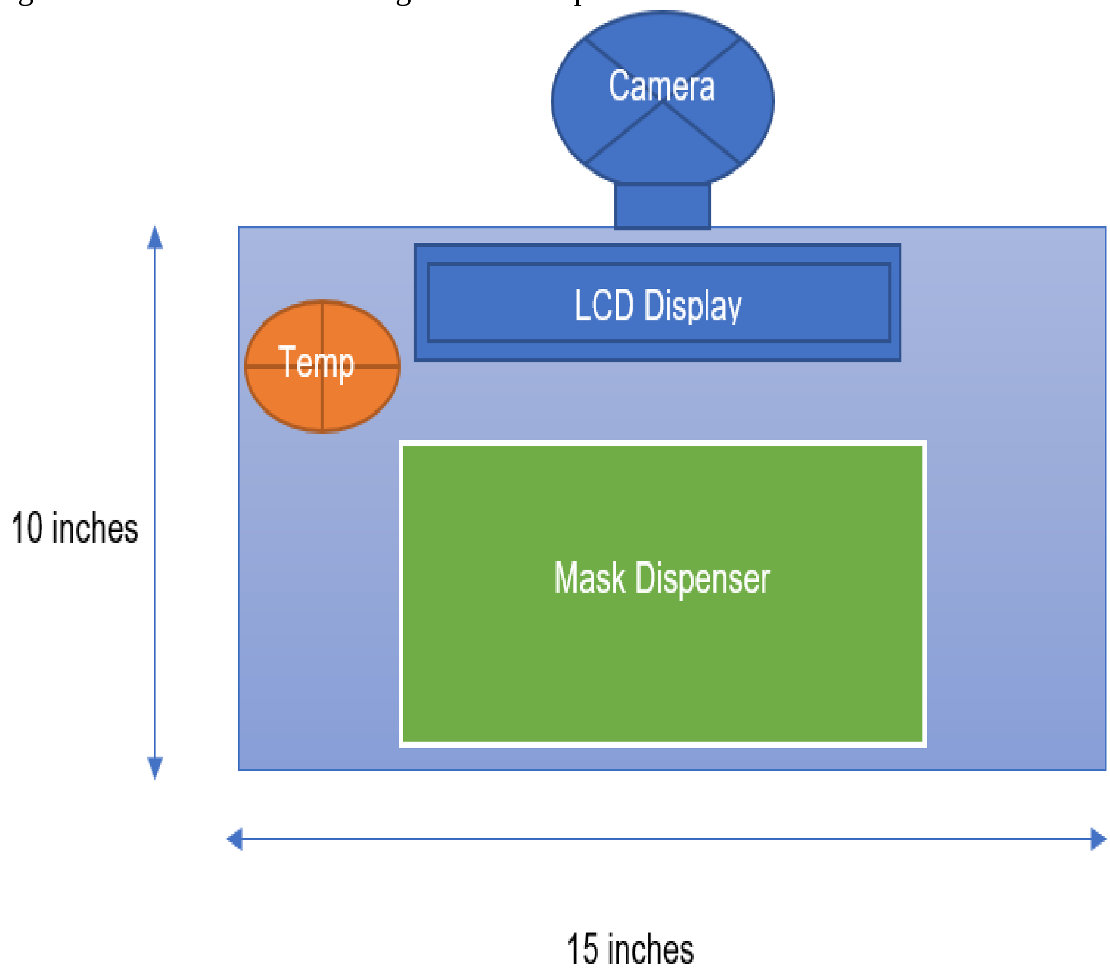

Diagram 3: Illustration of prototype

6. Milestones:

Table 3 shows the milestones of the tasks in form of a Gantt chart.

PROJECT NAME	PROJECT DUR	START DATE	END DATE
SD	246	Aug 27, 2020	Apr 30, 2021

Today's Date
Sep 26, 2020

August | September | October | Nov

TASK I	TASK	START DATE	THEORETICAL END	ACTUAL END DAT
1	Brainstorming	Aug 27, 2020	Sep 11, 2020	Sep 17, 2020
2	Divide and Conquer 1.0	Sep 11, 2020	Sep 18, 2020	Sep 18, 2020
3	Divide and Conquer 2.0	Sep 22, 2020	Oct 02, 2020	Oct 02, 2020
4	Research Component	Sep 18, 2020	Oct 02, 2020	
5	Purchase of all components	Oct 02, 2020	Oct 15, 2020	
6	Component testing (repurchase if ne	Oct 15, 2020	Nov 02, 2020	
7	Writing Document	Sep 20, 2020	Nov 20, 2020	
8	Prototype of HW and SW	Oct 02, 2020	Nov 20, 2020	
9	Building body	Jan 15, 2021	Feb 01, 2021	
10	Begin HW Testing	Feb 03, 2021	Mar 05, 2021	
11	Test and tweak SW	Mar 10, 2021	Mar 30, 2021	
12	Test Entire Project	Mar 31, 2021	Apr 10, 2021	
13	Prepare Presentation	Apr 11, 2021	Apr 24, 2021	
14	Presentation	Apr 25, 2021	Apr 25, 2021	Apr 25, 2021

Table 3: Project Milestone Gantt Chart

7. House of Quality:

Table 4 shows the initial house of quality of the project.

Title: Coronavirus Prevention System

Author: Dat Nguyen, Phuong Anh Vu, Ha Tran, Emanuel Cicortas

Date: 10/2/2020

Notes: This is an initial House of Quality that is subject to many future chan

Legend		
⊙	Strong Relationship	9
O	Moderate Relationship	3
▲	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
—	Negative Correlation	
▼	Strong Negative Correlation	
▼	Objective Is To Minimize	
▲	Objective Is To Maximize	
X	Objective Is To Hit Target	

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
				Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	X	▲	▼	▼	▲	▲	▲	▲	▲						
				Quality Characteristics (a.k.a. "Functional Requirements" or "Hows") / **Demanded Quality** (a.k.a. "Customer Requirements" or "Whats")	Size	Quality	Cost	Power	Performance	Distance	Accuracy	Precision	Consistency						
1	9	7.4	5.0	Acrylic body	⊙	O	O	▲	▲	▲	▲	▲	▲						
2	9	8.8	6.0	Camera	O	⊙	⊙	O	O	O	⊙	⊙	⊙						
3	9	8.8	6.0	Bi-directional motor	O	O	⊙	⊙	▲	▲	▲	▲	⊙						
4	9	13.2	9.0	Microcontroller	▲	O	⊙	⊙	▲	▲	O	O	⊙						
5	9	13.2	9.0	Graphic processor	▲	⊙	⊙	▲	⊙	▲	⊙	⊙	⊙						
6	9	11.8	8.0	Ultrasonic sensor	▲	▲	⊙	▲	▲	⊙	O	O	⊙						
7	9	5.9	4.0	temperature sensor	▲	▲	⊙	▲	▲	O	⊙	O	⊙						
8	3	7.4	5.0	Button	▲	▲	O	▲	▲	▲	O	▲	O						
9	9	8.8	6.0	LCD screen	O	O	⊙	O	▲	▲	O	O	▲						
10	9	14.7	10.0	Facial recognition	▲	▲	▲	▲	▲	▲	⊙	⊙	⊙						
				Target or Limit Value	15 x 10	High quality	Low cost ($700)	Low power consumption (<40W)	Fast computation	At least 2 meters	High accuracy	High precision	As consistent as possible						
				Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)	1	8	5	5	7	2	4	4	6						
				Max Relationship Value in Column	9	9	9	9	9	9	9	9	9						
				Weight / Importance	211.8	352.9	694.1	311.8	223.5	223.5	523.5	473.5	726.5						
				Relative Weight	5.7	9.4	18.6	8.3	6.0	6.0	14.0	12.7	19.4						

Competitive Analysis (0=Worst, 5=Best)						
Our Company	Competitor 1	Competitor 2	Competitor 3	Competitor 4	Competitor 5	0 1 2 3 4 5

Our Company, Competitor 1, Competitor 2, Competitor 3, Competitor 4, Competitor 5

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Table 4: House of Quality