Delivery Bot

End of Project Documentation

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Elevators Pitch

We are senior design engineering students building an autonomous robot that will deliver food/medical supplies to the ones in need during the pandemic of COVID - 19. Our Robot is to be placed in a nursing home/houses setting.

Executive Summary

This document will provide an insight on what are the possible competitions that we will face as a team and what is the size of the market. This will help us figure out how the market works and help us find out the demand of the product. It will provide information on things such as cost, chances of commercial success, supply, demand. After this review we all will have a solid idea of what to do with our robot in terms of putting in on the market. It will help us tackle our weaknesses, strengths, threats, opportunities etc. I will help us to achieve success in the market.

***Abstract*—The autonomous medicine delivering robot is a solution to decreasing the contact between infected patients and hospital staff. It will also need less medical staff to work at one shift. The system will consist of several different things combined to achieve the goal that we have set. Some of the things such as sensors will be used to detect the line so that the robot has a sense of direction. The system will be able to make decisions and go to the room that it's told to go to. This system will use different boards and sensors to make sure it delivers the supplies to the right room at the right time.**

Keywords— COVID-19, Raspberry Pi, Arduino, Motor Drivers, C, Python

I. Introduction

This report will provide an insight on how autonomous robots can benefit the medical workers. In this documentation we will attempt to explain what an autonomous robot is and what are the benefits of them if they are used in a medical environment. Along with that we will show the main societal problem that COVID - 19 has brought. Which has led to further challenges that this autonomous robot will help decrease. The report will entail the societal problem which is very dangerous and has taken many lives and affected even more. We are in a global pandemic and as engineering students we will be the innovators and come out on top and try to help society heal and look at how we can use our knowledge for the good of mother earth and humanity. Senior project is very important for us students and we will work together and try our best to collaborate as much as possible during this pandemic while maintaining the safety precautions entailed to us by the experts. The Societal problem that we will create a solution for is covid-19 which affects millions of people and is very devastating and spreads very easily and has harsh symptoms. The problem affects many health care workers and we are going to build something that works to ease the stress on nurses and other healthcare workers so that their safety is a top priority and they can feel at ease going to work knowing that we engineers have created something safe and effective for them. It will allow them to deliver items to their patients while still providing a high level of care and limit the spread of the disease. The biggest issue with this societal problem is that it spreads very easily so we students have done a lot of research to see how we can flatten the curve of the spread and we came up with this design idea so that we can flatten the curve and take off a lot of the pressure on the medical staff. We hope that this project will be something that makes engineers look good and people know that we are looking out for society and use our knowledge not for money but for humanity. This project will test us on everything we learned and the most important thing is how we work as a team and collaborate.

The cost of this project has been carefully calculated and projected and we have a great idea on what we will be spending for this project. Professor Levine entailed that this project will cost anywhere from a few hundred to a thousand dollars so we had to plan on what we were going to spend and see if we can do things on a budget which is important for us because we are college students and don't have that many funds. Sacramento State doesn't give us a senior project fund or grant so we have to pay for the senior project out of our own pockets which is a bit scary because the materials we need for the project are very expensive and there's a lot of components needed. This project will test many things and we are looking forward to building and designing this project and working with our instructors to make sure we stay on top of everything and that we make senior project the best experience so that we can show employers what we did and stand out from the competition

II. Societal problem

A. Awareness

As we see that the coronavirus pandemic has affected over 26.7 Million people worldwide [5]. The design that we are approaching would lean towards to be put in a nursing home. Nursing home residents are at the most risk because they are more prone to death from COVID because of their underlying conditions [6]. As seen more than 40% deaths are linked to nursing homes [6]. "In January 1, 2020, globally 4594 cases of the corona Virus were confirmed. China's total

confirmed cases were 4537 while 6973 were suspected, 976 were found severe, and 106 deaths were recorded. Similarly, outside of China 57 cases were confirmed and 16 countries were declared affected. According to data Japan affected number was 6, Republic of Korea 4, Viet Nam 2, Singapore 7. Australia 5, Malaysia 4, Cambodia 1, Thailand 14, Nepal 1, Sri Lanka 1, United States of America 5, Canada 2, France 3, Germany 1 and Pakistan 1" "On January 30, 2020. So far, there have been nearly 15,000 confirmed cases and 305 deaths. Over 300 people have recovered from the illness" [4] As we see that the cases went up by 10463 in a matter of months. It continues to grow exponentially. 72,314 cases, updated through February 11, 2020 [3]. "The disease is mild in most people; in some (usually the elderly and those with comorbidities), it may progress to pneumonia, acute respiratory distress syndrome (ARDS) and multi organ dysfunction" [1]. This shows us that the older people are at more risk to develop major problems from the virus. Thus, people in Nursing Homes are at the most risk. "31st of March 2020, based on the WHO reports, we have globally 693,224 confirmed cases and 33,106 deaths, distributed as follows: Western Pacific Region 103,775 cases and 3649 deaths, European Region 392,757 cases and 29,962 deaths, South East Asia Region 4084 cases and 158 deaths, Eastern Mediterranean Region 46,329 cases and 2813 deaths, Region of the Americas 142,081 cases and 2457 deaths and in the Africa region 3486 cases and 60 deaths" [2]. "There is no specific antiviral treatment recommended for COVID-19, and no vaccine is currently available. The treatment is symptomatic, and oxygen therapy represents the major treatment intervention for patients with severe infection" [2]. This shows us that the best way to keep yourself safe is to limit the contact with the infected patients. Thus, our idea would help out a lot of Doctors/Nurses in need. "It is a global pandemic that initially started in Wuhan, China, and is spreading extremely quickly, making its way to over 180 countries" [7]. "More than 60,000 health care workers have been infected, and close to 300 have died from COVID-19, according to new data from the Centers for Disease Control and Prevention." [8] This is a global pandemic and our autonomous robot will help make a huge impact and help the ones in need.

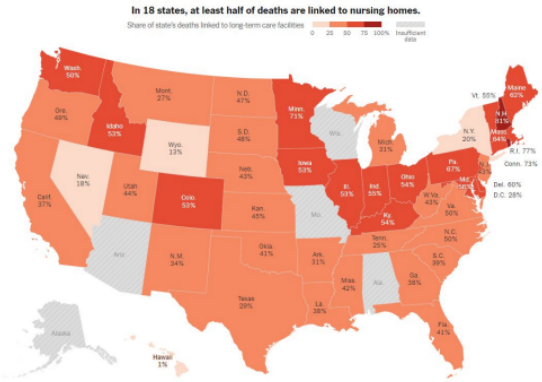

Figure 1: Cases of Coronavirus in Nursing Homes

If we are able to create a substantial impact on the medical community. It would help everyone make the quarantine better. It would also help contain the virus better. Since this virus is airborne and spreads very quickly if inhaled in. It would reduce the likelihood of someone getting infected. Thus this will let the doctors and nurses devote more time to patients who are suffering from other problems.

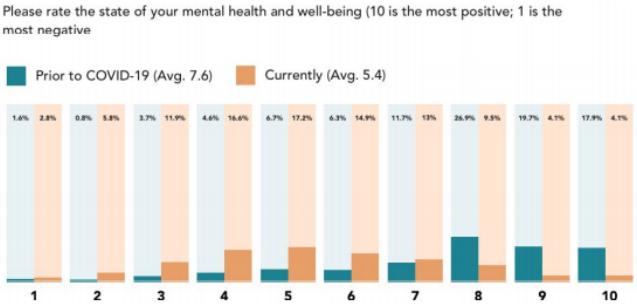

Figure 2: Stress Level of workers

As we researched that the mental health of the medical workers is taking a huge toll. Because of the facts that there is a shortage of workers. The current workers have to do overtime and work in very stressful conditions. A study showed that being a woman and possessing an intermediate professional title came with a lot of stress and depression. But the medical staff had even higher rates of depression at a young age because of the nature of their job. Due to coronavirus the level of stress skyrocketed and that is worrisome. A study found out that safety of the family had a huge role in the reduction of stress amongst workers. But healthcare workers working on the front line were

stressed about them contracting the virus. But they were more worried about taking the virus home to their family. Therefore most of the workers decide to live in quarantine once they go home because of the fact that they have a fear about the virus. They are also very scared to give the virus off to their family members. Staying away from family and being alone in quarantine plays a major role in increasing depression levels. The coping measures that are used by medical workers are protective gear, knowledge about the virus, constantly getting tested, positive self attitude and social support. Because of the fact that most of the workers are isolated in quarantine. They lacked social support which leads to a decrease in positive self attitude. Medical staff with higher levels of mental health problems had to seek help from psychotherapists because their mental health was not manageable by them. [9] Research done showed that epidemics in history had a severe and variable psychological effect on the people and especially the medical workers. This can lead to the worsening of problems that the workers are experiencing or it can lead to the development of new problems. All these problems lead to suicidal thoughts. Some workers who do not seek professional help end up committing suicide. As we can see that this pandemic is a serious problem that our society is facing. It has so many unknown consequences that our community will have to face. But we are sure that our robot will very likely create a positive impact and help the medical workers reduce their stress to some point and make their work lives easier and less stressful.

B. Why autonomous robots?

Due to the increase of demand in medical workers due to this pandemic. There is a major demand for something that will decrease the need of medical workers and help them lessen their workload. There have always been autonomous robots that are used in various different fields. With the virus growing exponentially the demand for autonomous robots has been increasing exponentially as well. In order to keep up with the shortage of medical employees and increasing infected patients with the virus, new technology and innovative methods are being tested. Each of them have different goals that they are trying to meet. This product will require hospital staff to hire less staff therefore they will be able to save money. Autonomous robots are helping solve various problems and with increasing technology it can become the next innovation in the medical field.

C. What are autonomous robots?

Autonomous robots are robots that are able to make their own decisions and complete a specific task given to them. They have been heavily used in different industries to get different jobs done. They come in various shapes and sizes. They adapt to the environment that they are put into. They are used in car manufacturing and they get the job done with very minimal error margin and in faster time.

Besides doing the job with minimal time. They are also able to overcome potential objects. A perception of a robot is that it needs to have five senses (eyes, ears, skin, smell etc). Camera (eyes), sensors (skin, smell). Just like our brain helps us make decisions. The robot needs to have some kind of brain to be able to make its own decisions. There are multiple decision making mechanisms available on the market. But the Raspberry Pi is one of the most popular one.

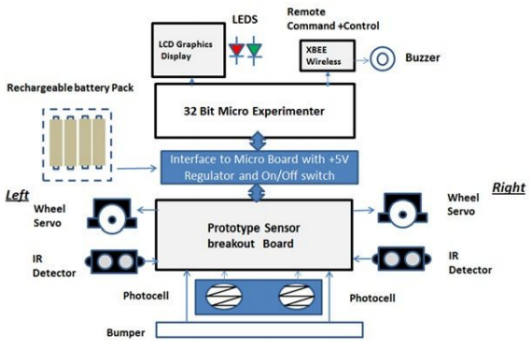

Figure 3 : Layout of autonomous robotS

Above figure shows what an autonomous robot consists of for it to be able to make its own decisions. There are many advantages to using autonomous robots. They can take over tasks that 3are repetitive in nature. Besides that they can decrease the amount of physical employees needed.

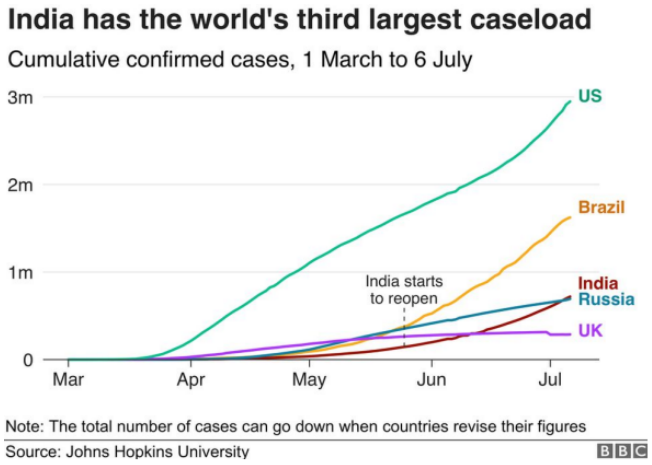

Figure 4 : Cumulative confirmed cases worldwide

The problem that we chose to tackle was the recent COVID–19 pandemic. When the virus started to spread around the world, the first people that were at most risk were the staff at the hospitals. Especially the doctors and the nurses who have to firsthand deal with the patients that tested positive for the virus. Since there is no vaccine that has been developed yet, the only way patients are recovering is by quarantine. But sometimes the doctors/nurses have to get in contact with the patients to deliver them medicine or any supplies that they might need. Thus, we thought it would be a good idea to develop an autonomous robot which would carry the medical supplies to the room. So that the doctors/nurses can decrease the amount of contact with the infected patients and stay safe.

The design approach that we would want to take is to build a robot chassis and put a DC motor for each wheel. Then put a tape layout that goes from the nursing station to each room. Put an infrared sensor on the robot to follow the line. Then we wanted to put a barcode reader on the robot. Because the robot needs to be able to make a decision at a turn/intersection. We would place a unique barcode at each intersection/turn and then have the robot read the barcode and be able to make a decision on which way to turn. Then there would be a box which would carry the supplies lying on the robot. We would want to use a raspberry pi microcontroller to run the code and control everything from it and use the Arduino board for the infrared sensors. We would program the robot using Python and C.

III. Design Idea

A. How does our design Idea address the problem?

Our Design idea is to create an autonomous robot which will deliver the supplies to the infected patients. By making a delivery robot for hospitals and nursing homes we can address a lot of issues that are going on in society right now. With a deadly virus that is affecting the whole world, the people that are the most exposed are the same nurses that are trying to save people from this virus. They are putting their lives at danger every time they enter a room with a patient that has COVID. We want to lower their exposure to the patients that have the virus. Having the delivery robot deliver supplies and food for the nurses will lower their exposure to the coronavirus. This robot will still be used even after the coronavirus. With nurses working extended shifts this delivery robot will help with that also.

Our product essentially is helping the nurses as much as they can to lower their work and help them with their extended shifts. Our robot will be able to deliver anything that does not require a doctor and nurse to be physically there. The robot will be able to deliver food and supplies to the patients autonomously. The robot will use sensors to travel to the patient's room. It will have to use motion sensors in the front to detect a tape on the ground and it will follow the tape. The two motion sensors will detect a black tape and just follow the tape and if it detects a different color it will stop and try to find the black tape. We will also add white strips of tape with the black tape to keep the robot detecting the right color. To find the right room to enter we will also be adding a camera to detect a QR code on the ground. Each QR code will be different for the rooms and when the robot reads the right code it will then decide if it needs to make a right or left turn to enter the room.

We will also include a temperature sensor that will use the raspberry pi to get the temperature of the patient. This will also lower the exposure between patients and nurses during COVID. The data that is collected through the camera will be

4uploaded to a website so that the nurses can just check the temperature from their desks.

B. What Technologies are needed for our design?

The technology that we really need for our design is sensors and a camera. We will be using sensors for our design to detect a line for where it is going. The use of cameras is very important as well. We need the camera because as our design moves and goes to different rooms. We will be placing a QR code that will be scanned by our design every time to go into the correct room. We will be also using a thermal camera to detect the temperature of the patient. It will be very useful as our design will lessen nurse to patient contact and which is our main goal.

C. What is unique about our idea?

According to our research as a team we have encountered that there is no design like ours out there. Doctors and nurses do still have to go to their patients. They have to give them medicines and also do the regular temperature checks all the time. With that it increases the exposures and it's a big risk for them. Our design will be able to help them to monitor temperature checks on their screens and watch medicines being taken. They just have to load up the robot with medicine or anything they need to deliver. Our system will be an autonomous system so it will require very minimal interference from the user which is very important in today's time because of the pandemic.

1. Features

Our system will have a lot of features that will help our robot to perform at it's best. Those features will be thermal camera, camera, and sensors. The thermal camera is very important as it would be used to scan the temperature of the patient. Instead of the nurse going for the routine checks this helps lessen risk of exposure. The system will have sensors that will help it to detect the surface so it can go straight and avoid hitting walls or anything on the ground. Lastly, the camera will be our scanner. To ensure our system goes to the right room.

2. Hardware

When we were looking for a robot chassis that would be strong and sturdy enough for us to operate on. The robot chassis had to have four wheels and preferably four dc motors so that we can build off of it. The robot chassis was something that we wanted to get off the internet for cheap but the robot chassis was costing upwards of a couple hundred dollars for the chassis. The robot chassis we were looking to have is just a metal robot frame with wheels and that didn't have much else. The important thing for us is for the robot chassis to be able to maintain a lot of weight because our delivery robot was going to have a lot of components on it and the robot should be able to support all the weight that we are going to be putting on it. We looked through amazon, ebay, and other retailers and like said above there was a problem finding a chassis that was cost effective and one that met our criteria. This gave us the idea that we indeed need to build the robot chassis from scratch so that is what our plan entailed and we agreed upon the group that we will indeed be building the robot chassis from scratch to save money and also save time. The robot chassis that we were looking into buying had a delivery date of about 1-2 months and this is going to delay our progress a lot because we won't be able to build on the robot chassis for such a long time so we had to make an engineering decision and build it from scratch.

Figure 5: Robot Chassis

Arguably the most important component that we have to buy is the microprocessors and this is usually something that tends to cost a lot of money so we have to be smart at what we buy because paying too much for a microprocessor can take away funds from other parts of the

project. We looked into getting a Raspberry Pi because it had all of the capabilities we needed and it's exactly what we were looking for. It is a very powerful microcomputer. It would do all the duties we need it to do. We also looked at an Arduino to control the motion sensors and it can work with the motor driver and raspberry pi so we can do alot of things with it.

Figure 6: Raspberry Pi

L298N motor driver is also an important component that we did research on to see how we can look at buying it in a cost effective way and this item did everything we needed it to and we are lucky that we can find it for cheap so that is exactly what we did and we were able to look on amazon and find one that didn't cost much. The motor driver is what allows us to control the DC motors that we are going to be using in the project and it can control the frequency and modulation of the wheels which can allow our robot to follow a line and stay on course.

Figure 7: Motor Driver

The project design entailed that we are going to need two IR sensors to control the robot. The IR sensors will be used to look for strips of tape on the ground. The sensors will be able to tell the differences between black and white lines of tape and when it sees black line of tape it will follow the tape to its destination.

Figure 8: IR sensor

The wheels are simple wheels that were found on the internet and they did the job we needed, it is important that these wheels are rubber because we plan on using the wheels in a nursing home or hospital and plastic wheels can slip easy on tile floors so there is a great incentive for us to use rubber wheels because they can stick bette to the ground. The DC motors that were found are simple 6-12V DC motors that are found on the internet. They are cheap and not much so we bought 4 and they didn't have anything wrong with them.

Figure 9: DC geared motors

The robot is going to go into rooms by looking at a QR code which it will take a picture of and that will allow it to turn into a room or such. The QR code reader is one of the most important components of our project because this will tell the robot which room to go into. There will be different QR codes for each room and when the robot comes to the right QR code it will decide if it needs to turn right or left to get into the room.

Figure 10: QR Code Camara

The temperature sensor is another important part of the robot because this will really make it that nurses and residents are not coming in contact as often. The temperature sensor will be able to get the temperature of the patient and with the help of the raspberry pi it will be able to relay that information back to the nurse. We will be combining the temperature sensor with an ultrasonic sensor so that we can get the patient's hand in the correct range to get the right temperature.

Figure 11: Temperature Sensor 7

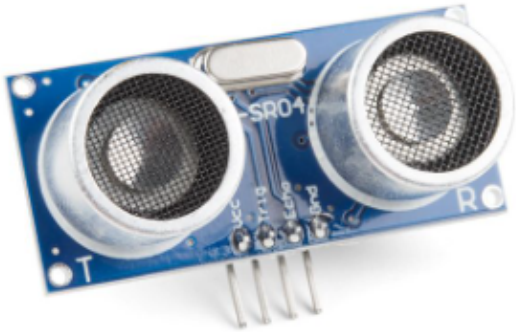

Figure 12. Ultrasonic Sensor

3. *Software*

We will be using the Arduino IDE version number 1.8.13 to program the Arduino uno. This software uses C as its programming language and most of us in this group have experience with C. The software is pretty straightforward and it is not too difficult to use. We will use this software to program the IR sensors, motor drivers and QR code camara. Then for the Raspberry Pi we will be using Raspbian to program the thermal camera. Raspbian's primary language is python and we don't have too much experience with python. We will also be using Raspbian and python to relay the temperature of the patient back to the nurse. We will need to do research on python and Raspbian before we start working with the thermal camera.

D. Project Necessities

To complete this project we need many components. Most importantly we need a good internet connection because of the fact that everything is virtual because of this pandemic. We also need a working space to work on the project together. After talks with everyone we do have a room allotted for this project and everything will be done there and whatever is being used will also remain in there. We are following all the safety measures in the pandemic. Working with masks and gloves on. Regarding consultation Professor Lavine has been a great support and whenever we have questions, we are able to ask the professor and he provides us with a reliable solution and gives us options to choose from. We do not need to purchase any extra software. Because Raspberry Pi has its own interface where we can write all the software therefore we do not need to purchase any extra software to get our job done. Also we are using Arduino to do some jobs. As for our softwares we are using Raspbian to program our raspberry Pi and we are using Arduino IDE version 1.8.13 for programming the arduino.

IV. Funding

A. Planning

The cost of this project has been carefully calculated and projected and we have a great idea on what we will be spending for this project. Professor Levine entailed that this project will cost anywhere from a few hundred to a thousand dollars so we had to plan on what we were going

to spend and see if we can do things on a budget which is important for us because we are college students and don't have that many funds. Sacramento State doesn't give us a senior project fund or grant so we have to pay for the senior project out of our own pockets which is a bit scary because the materials we need for the project are very expensive and there's a lot of components needed.

B. Budget Table

This table that is listed below is all the estimates that we have paid for the components, some of these supplies are already things we have and some we had to buy and this will be listed in the table and as much detail will be given as possible.

Table 1: Budget Table

Item	Estimated Cost
Metal beams for robot chassis	$15
Nuts and Bolts for robot chassis	$3
Raspberry Pi 3	Already owned
Arduino Uno Smd	$23
L298 Motor Drivers	$10
IR sensors	$10
Soldering kit	Already owned
Rubber wheels	$12
Jumper wires	Already owned
DC motors	$20
QR code Camera	$25-$35
Thermal Camera	$60-$75

As you can see from the table these are the costs that we have for our project. We had some parts that we needed so we didn't have to spend so much time and money finding those parts.

V. Project Milestones

We marked pasfic points throughout our project timeline in which we had to finish major parts of our project in order to keep us on time to finish our project. We used a pert diagram and Gantt Chart to keep us on track. We also made a list of all the major features we need to finish and the data we need to finish them by.

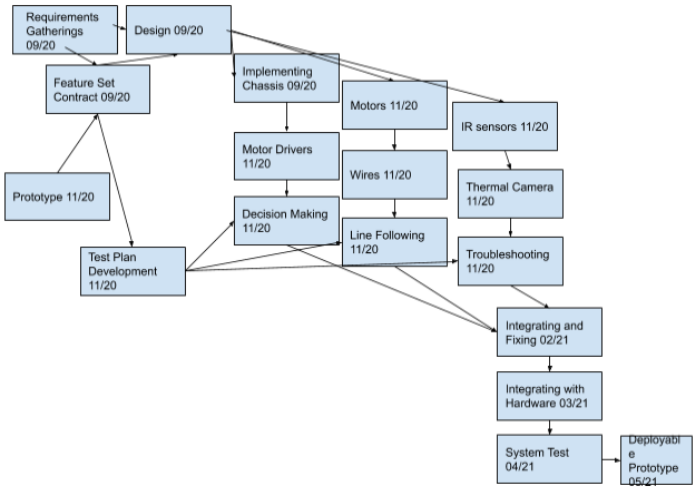

Figure 13: Pert Diagram

Table 2: Major Milestones

Major Milestones	Milestone Date
Societal Problem	09/2020
Design Idea	09/2020
Feature Set Contract	09/2020
Ordering Parts	11/2020
Motors	11/2020
IR Sensors	11/2020
Motor Drivers	11/2020
Wires	11/2020
Thermal Camera	04/2021
Decision Making	11/2020
Following Line	11/2020
Arduino Raspberry Pi	11/2020
Working Prototype	12/2020
Device Testing	02/2021
Market Review	02/2021
Automation Reached	03/2021
Deployable Protype	04/2021

VI. Work Breakdown Structure

The main point of the work breakdown structure is to help us in solving our societal problem. Our work breakdown schedule will break down and simplify our feature set to different levels that will take care of our engineering solution and the skill set of our team. It will focus on the important aspects of the project which is making an autonomous robot to deliver medicines so that it could help make an impact on the medical community. The WBS will focus on getting the software and hardware needs done for the project. Every little detail and feature will help us pave the road to a successful prototype. Throughout this work breakdown we will go over all the hardware and software that we will be working on and how we plan to build and design our delivery robot in the time given. Most of the work being done is together as a team because we are spending a lot of time together making our robot and are still following all the safety precautions, social distancing standards as well as wearing masks and washing our hands often while working on the robot together. We felt as though it is a lot better to meet up in person to work on the robot rather than do it in a modular form and then put it all together at the end because we can help each other and have four brains working together at once going step by step together. This is a lot easier for us because we can all work on all the parts of the project together and learn everything rather than just doing one part of the project each which doesn't look too good on a resume compared to being involved in all parts of the project from the software to the hardware. We spent a lot of time on the hardware and software of this project and are hoping that everything comes together as we want it to.

Table 3: Condescend WBS

Level 1	Level 2	Level 3
1 Robot		1.1.1 Hardware 1.1.2 Software 1.1.3 Communication
2 Physical design	Algorithm and Circuits	2.1.1 Microcontroller 2.1.2 Power 2.1.3 Camera
	Algorithm and circuits	2.2.1 Hardware 2.2.2 Software
3 Data Collector	Data Collection	3.1.1 Setting up robot 3.1.2 Communication with user

A. Robot

This is the overall plan to break down our robot into further sections. Each level helps us explore and divide up the work to continue building our robot. The main purpose of our robot is to deliver medicines to the desired room and decrease the contact between infected patients and doctors/nurses. The robot will follow a line and then use the camera to read the barcode to make decisions regarding what turn to make. We will also be using a thermal camera to get the patient's temperature to collect data and then help learn the virus better.

The robot will be built on a self engineered chassis by connecting different metal plates and the motors.will be mounted onto the four corners of the chassis. All the wiring will be done by mostly Sulaimaan because that is his area of expertise.

The software design is a very critical part of the robot. Because every hospital is going to have a different map of rooms. There the robot will have to be carefully programmed according to the unique map of the facility. Therefore this part of the project is equally divided between Sahibvir, Pawanjit and Ajaypal. Since we are Computer Engineering majors, therefore we will heavily focus on the software part of this project.

There will be different pieces communicating together in order for the whole thing to work and come along. There are sensors, cameras, motors, two microcontrollers working together. Most important communication medium that we will be using is wires. Therefore we have to make sure each connection is stable and there is minimal voltage loss at each connection. We will be trying different techniques to come up with the best way to connect wires so that we get a tight connection.

B. Physical Design

1. Microcontroller

The microcontroller is arguably the most important part of this project and we will be using two microcontrollers which are the Raspberry pi 3 and an arduino uno R3. The Raspberry pi 3 will consist of the brain and is our main microcontroller in which it will tell the arduino what to do and also tell our arduino when to turn at intersections. The arduino is going to be our small brain which will control the sensors and motor driver which is also known as an H bridge. Our motor driver will make our robot follow a line because it will be talking to our IR sensors and this will allow the robot to know when to turn left or right to stay on track with the line. The work that will be done to integrate these microcontrollers will be split up between the four of us in our group and we will work hard to make sure that we have our microcontrollers up and running because the project can't start until we have a microcontroller. We all have some small experience with microcontrollers. For example in our CPE 185/EEE 174 course we learned about the STM 32 Nucleo, Raspberry pi, and Parallax so we have quite the experience with microcontrollers but our biggest challenge is going to be learning how to program the arduino which is a bit difficult. We don't have much experience with the Ardruino and Ajay does have some experience because he built something using an arduino so we are going to have to do some of our own research into the functions and programming of the arduino because it's going to have the most features involved in it.

The work will be split up between the four of us for the microcontrollers we ordered and they arrived so we are working on them together slowly by slowly getting them integrated. The arduino is what we focused on first and we met up at Sulaimaan's house and took the correct safety precautions while working and we all worked together to get the arduino integrated. So for our work breakdown for the arduino is that we all

spent time together and went step by step together as a team to get it all integrated. We did equal amounts of work on the arduino and worked as a team. We felt that it is a lot easier to meet up and do the work rather than meeting up on zoom or someone doing one part and mailing it to someone else because this way we can go through each step and we have four people which means we have four brains working on each step and we always stop to discuss what we are doing and if someone in our group is lost we take time to explain it to them because at the end of the day we don't want anyone in our group feeling left out, we want everyone to get the full experience because we will need to know this stuff in our careers and we want to be able to explain all this stuff to our employers down to the hardware and software.

The Raspberry Pi 3 work breakdown is going to be the same way as we did for the arduino because we like working together as a team so we will go step by step and integrate and program the Raspberry Pi 3 at Sulaiman's house while taking the correct safety precautions and get our Raspberry Pi 3 up and running. The idea is to brainstorm together and plan everything out together so our work breakdown is going to be split equally between the four of us and we are going to build and design it together.

2. Power

This is definitely the most difficult part of our project because we are already having problems getting an adequate amount of power while not frying our robot. This is really hard to do because we want to have enough power to power our motors but then also not have a lot of power to fry our arduino board. We build a 65VDC power supply by going to walmart and buying 9V batteries and putting them in series which was a bit of challenge at first because for some reason the solder we used wasn't conducting any current so we had to remove all the solder from the batteries and use copper wires wrapped around each terminal instead of copper. We connected the positive terminal of one batter to the negative terminal of another battery and did this to seven batteries until we got about 65Volts and then when we hooked it up to our circuit which consisted of our arduino, switch, H bridge, and 2 IR sensors. The 65Volt battery was getting really hot when we hooked it up to the circuit and then the wires at the positive and negative terminal started getting really hot and when they touched they corroded each other and there were small sparks and we got really scared and pulled the wires away from each other. We had the same issue when connecting the battery to the switch and it started giving us small shocks when we touched it and our arduino and motor driver kept on turning on and off really quickly until the arduino got fried. We were very confused at what happened we thought 65Volts wasn't going to fry our board but we were wrong and we tested the arduino individually to see if it would work but it didn't because it was fried and we had to order a new one but this time when we ordered it we got a warranty on the arduino board so that if we fry it again we can get another board for free with the warranty. When our new board arrived we tested the board with a smaller voltage of about 20 Volts and it worked fine but it wasn't enough to get all four of our wheels moving so we then had to brainstorm again and decided that we need to get DC motors that consume less voltage because this will make it so we don't have a large battery that will fry our board and also we won't need a lot of power in general because our motors will consume less power.

The work breakdown for building and designing of the powersource was divided between us and we worked on it together at Sulaimaan's house while following all safety precautions and making sure we kept social distancing and hand washing often as a priority to keep the health and safety of our group our

number one priority. All the soldering, designing and planning was done together because we felt we should all be in person working on the project together so we can bounce ideas off of one another and have four brains there to make sure that everything is double checked and all the wiring and everything is how it should be.

3. Camara

We are going to be using a Raspberry pi/Arduino compatible camera for our project and this will allow us to easily get the camera integrated because getting a camera that can easily be integrated into a Raspberry Pi or arduino will save us a lot of time which is important so we don't have to spend so much time researching how to make a camera compatible with our microcontrollers. It's a lot more convenient if we have one that we can just hook up the microcontroller so we can focus on the programming and getting it configured.

The work breakdown for this part of the project will be splitted equally among us and we will look to share the responsibilities with one another and meet up at Sulaimaan's house because he has a lot of tools and a big open space for us to work in while maintaining all the health and safety standards that are outlined to us by the CDC. The work for this part of the project will include programming the Camera to read a barcode and sending that information to our microcontrollers and having the robot turn in the direction that the barcode indicates. We hope that this will go very smoothly and we won't have to spend a lot of time on this part but we still need to do a lot of research and see how we can implement the camera into our robot to make it compatible and not take up too much power. We will program and integrate the camera into our project together and work as a team to make sure that our robot is running very efficiently and it's good that we are meeting up in person to do the work for the camera because we have all the tools and brain power to get the robot working.

C. Data collector

We are going to try to implement and add a temperature sensor to the robot that will take the temperature of the patients and will record that data onto a file. This will help doctors get data that they can further study. It will also help determine long term effects of the virus. The robot will keep track of how many times it visited each room and that data will help us tell how many doctor visits have been saved. Therefore this is one of the most critical parts of this robot. This part of the robot will require our focus on the end. Because this part is not too technical compared to the other portions of the robot. Therefore we will not be dedicating too much time onto this part. We are still researching ways to collect more data with the hardware that we have so that we can provide as much data as possible.

Communication with the user has to be an important part of the robot. The main reason we have to limit the amount of user contact is so that the nurses can focus on other parts of their work. We have limited the amount of user contact with the robot. The user nurse will need to load the supplied on to the robot and punch in the room number in which the robot should go. The patient will pick up the supplies and then the robot will head back to the nurse. This is the only user communication that our robot would require. Rest of the tasks it should do on its own. We are still researching ways to take the user input to go to a specific room. We are looking for ways to connect the raspberry pi using the Wifi connection to get the input of the user for it to go to a certain room. This part of the project is equally divided up into Sahibvir, Pawanjit and Ajaypal. Because this is a more software intensive part of the project.

Table 4:Assignments table

1b Design idea Review and Changer Orders	Team	Unknown	10	
1c Spring timeline Update	Team	Unknown	10	
2 Device Test Plan	Team	Unknown	10	
3 Market Overview	Team	Unknown	10	
4 Feature report and Presentation	Team	Unknown	10	
5 a Midterm progress review	Team	Unknown	10	
5b Testing Results REport and Presentation	Team	Unknown	10	
7 Deployable Prototype Review	Team	Unknown	10	
8 End of project documentation	Team	Unknown	10	
9 Deployable prototype presentation	Team	Unknown	10	110

Table 5:Work Breakdown Structure Table

Project Breakdown Level 1	**Task Breakdown level 2**	**Task Breakdown level 3**	**Assigned to**	**Fall semester**	**Spring Semester**	**Hours Fall and Spring**
Chassis	Temperature	Thermal Camera	Sulaimaan, Pawanjit	12/6/2020		15
	Temperature	Software	Sahibvir, Ajaypal	12/6/2020		15
	Temperature	Wiring	Ajaypal, Sulaimaan	12/6/2020		5
Motors	Wheels	Software	Sahibvir	12/6/2020		15
	Wheels	Wiring	Pawanjit	12/6/2020		5
Sensors	IR Sensors	Software	Sahibvir, Pawanjit	12/6/2020		15
	IR Sensors	Wiring	Sahibvir, Pawanjit	12/6/2020		5
	IR Sensors	Control	Ajaypal, Pawanjit	12/6/2020		20
Control Module	Software Design		Team	12/6/2020	5/8/2021	30
	Hardware Control		Team	12/6/2020	5/8/2021	30
	Synchronous between hardware/software		Team	12/6/2020	5/8/2021	50
Temperature measurables			Team	12/6/2020	5/8/2021	10
Voltage Measurables			Team	12/6/2020	5/8/2021	10
Weight Measurables			Team	12/6/2020	5/8/2021	10

VII. Risk Assessment

A. Motors

There can be several issues with the motor and we had a few issues with our DC motors that caused delays in our project. The DC motors that we ordered in the beginning are 6V-12V DC motors from amazon and the motors work fine independently and in pairs but when we connected them all together in parallel the motors weren't working. The motors would barely spin or one or two would spin and the rest of them would just make a buzzing sound. We thought that maybe the motors weren't getting enough power so we increased the power many times and all 4 motors refused to spin together. This was very upsetting and we even tried hooking them up to the motor driver and the motors still wouldn't all spin together. We did a lot of research and were 100% positive that they were hooked up correctly and were confident that the DC motors were defective. We bought them from amazon and assumed that we were sold faulty motors so we ordered new

DC motors from a different company on amazon and this time the motors that were ordered were 3V-6V and they arrived and they worked perfectly. All 4 of the motors would spin together and they worked really well with the motor driver. The first pair of motors that were faulty put us back a couple weeks because we spent a lot of time trying to figure out why the motors wouldn't work together and we spent a lot of time troubleshooting the motors and couldn't do much while we were waiting for the new motors to arrive so we were set back a bit but when they new motors came in we overcame our setback.

B. Failure of Motor Drivers

This was definitely our biggest issue and there were a lot of problems we had with our motor drivers and we were setback a few times because of our motor driver issues. The motor driver we used for this project is the L298N motor driver which controls the rotation direction and speed of the motor and we hooked up the motor driver to a 65V battery because we were foolish and didn't realize that we didn't need that much power and only needed 12V so because we hooked up our motor driver to a 65V battery the motor driver along with the arduino board fried. The motor driver had burn marks under it and it would no longer, luckily we had another spare because when we ordered the motor driver it came with two of them. We talked to professor Levine and he told us that 65V volts was too much and we only actually needed 12V for our circuit so we made our battery smaller so that it had 12 Volts and we hooked up the 12V power supply to the motor driver and it worked fine but once we hooked up the USB from the computer into the arduino which was connected to the motor driver as well the motor driver was fried again. We soon figured out that the motor driver was fried because we had two power supplies hooked up to it. We had the 12V battery and the power from the USB connected to it when we uploaded the code into the arduino. The motor driver wouldn't give us a stable voltage output and we tried to fix the motor driver but decided that because it was fried we could no longer use it. It took us a lot of time to figure this out and luckily we weren't electrocuted or anything so we decided to order a new motor driver and we had to wait for the motor driver to arrive before we could continue any physical work. Once the new motor driver arrived we set it up into our circuit and this time we removed all the power from it while we uploaded the code to the arduino and this time we were confident that the motor driver would work and make our motors spin in the direction intended from the code. But the motor driver still didn't work and with some research we figured out that the motor driver has a voltage enabler and that the voltage enabler has to be removed if the input voltage is greater than 12V and our input voltage was about 12.6V so we removed the enabler and our motor driver made our motors spin in the direction we wanted it too. The motor driver did exactly what we wanted it to do such as make our motors rotate in the direction we wanted it too and the speed we wanted it too. We were able to get our robot following a line. We overcame the setbacks from the motor driver and we were at times lost and confused and felt as though we didn't know what to do but we never gave up. We stayed hopeful and overcome this obstacle.

C. Failure of Raspberry PI

There can be potential risks with the failure of the Raspberry Pi such as frying the board. We have not had any major issues with the Raspberry Pi and didn't fry it because the Raspberry Pi can handle tons of voltage and doesn't get messed up easily. The fact that we used a Raspberry Pi reduced our risk greatly because the Raspberry Pi is reliable and if used properly it can do a lot for any project. Setting up the Raspberry Pi was

simple but there were minor issues with the SD Card in which the Raspberry Pi wasn't reading the card and was acting as if the Raspberry Pi didn't have a SD card. We tried to run our Raspberry Pi but we kept on getting an error message saying that the SD card is not being detected so we had to download the Raspbian Program in order to refresh and reboot our SD card and clear the memory on it. Once we did this we were able to get our Raspberry Pi to detect the SD card and this wasn't a major issue just a minor one. We were very thankful to be skilled in Raspberry Pi and knew exactly how to reboot our SD card.

D. Failure of Arduino

We used an arduino uno R3 in this project and this arduino model is the standard arduino for projects our size and it's a very good board but it is very sensitive to high voltages. We had a setback and a possible injury to ourselves when working with our arduino. As said earlier in the beginning of the project we built a 65V DC power supply using 9V batteries in series and we hooked it up to our arduino and a giant spark erupted and the voltage pins in the arduino got fried and corroded. When the 65V DC power supply made contact with the arduino Vin pin we thought the whole robot was going to catch on fire because of how how the arduino was getting and how many sparks were erupting so we quickly unplugged the battery from the arduino and were left with a fried board. We had to check and make sure how badly the board was fried and if we could still use it so we hooked it up with the USB and the computer couldn't recognize the arduino. The arduino was hooked up to the computer but the computer was acting as if the arduino wasn't even there. On top of that the arduino board was very hot and almost gave us a burn when we touched it. The board was fried and could no longer be used so we decided to order a new one and this time we paid an extra $3 for warranty so in case we fried the board again we would be able to get a free board with the warranty. When the new arduino board came in we lowered the input voltage to about 12Volts and the arduino worked perfectly and we had no problems with it. We had a big setback with the fried board and had to wait for the new one to come with set up back a few days. We were glad to have professor Levine tell us that our beginning power source of 65Volts is too high and dangerous. This helped us figure out that we needed to lower the voltage and finally be able to get our arduino to work in our circuit. We had an obstacle with our arduino board but overcame the obstacle by not giving up.

E. Wiring Failure

In this project we had many wiring failures that put us back in time and we eventually overcame these obstacles. One of the biggest issues we had was that our wires would often move a lot and get disconnected from the ports. We also had issues in which we taped together wires with electrical tape and the tape would fall off and the wires would split apart. It was difficult at times for us because we would upload the code and expect the robot to move but it would just sit there and then we would go through the entire circuit and realize that our wires had been disconnected or even at times we had issues in which we had live wires with no insulation and the wires would touch the metal chassis and create a circuit with the metal chassis and our robot would stop working. We eventually had to insulate all live wires and get wire connectors so that we didn't need to tape wires together when we needed to connect them together. We also glued down our arduino board and motor driver to the chassis so that they wouldn't move around too much and cause our wires to shake and disconnect. We realized that wire connectors are a really good idea for projects because we could connect two wires together and clamp them together and it would give us a strong

stable connection and the wires wouldn't disconnect. Our wiring issues were minor compared to our other issues but it was definitely annoying when we would have our code uploaded and be expecting our robot to move but it would just sit there and realize that one of our wires got disconnected. Definitely the most dangerous part of our wiring issue was when we were using our 65V power supply and we accidentally connected the positive and negative terminal together with our copper wires and the copper wires started corroding and gave off a big spark. The copper wires weren't able to handle that much power and so much heat was being given off that the wires corroded. Thankfully we didn't get electrocuted but were very close to the circuit and moved away so we didn't get any shocks.

F. Designing the Circuit

Designing the circuit comes at a cost because in the beginning we used a 65V homemade power supply and when we hooked it up to our circuit it fried our boards and corroded our wires. We learned to lower our voltage to 12V and were able to overcome the obstacle. Designing circuits can be difficult at times when the circuit is complicated and we have tons of wires going to many different places it can be hard remembering which wire goes where. We did have a small issue with this in the beginning but we realized that if we color coded our wires we would know which wires belong to the arduino or motor driver. And by using red and black wires we could differentiate between the wires connected to the power supply and the wires connected to ground. We believe that having a messy unorganized circuit makes it very hard to troubleshoot so when we designed our circuit and built it we tried to make it as organized as possible and easy to follow so we can easily troubleshoot it.

G. Failure of Sensors

The sensors that we used in the lab are the IR sensors which are infrared sensors and they were used to differentiate between the black tape and the white surface and they worked very well and didn't cost a lot. The wiring for the sensors is a bit confusing in the beginning because a few of the wires have to be soldered in parallel and once we got the wiring figured out we were able to test the sensors. We created test code and tested the sensitivity of our sensors and were able to tweak the potentiometer on the sensors so that the sensors can detect the black tape very easily and not accidentally think a white surface is black tape. It took some tweaking and testing to finally get the sensors to the correct sensitivity for our project and we were able to set them up properly in our circuit. We ran our line follower code and were able to get the sensors to accurately detect and follow the black tape and the sensors talked to the motor drivers and made our robot turn as it should. Any problems we had with the sensors were minor and mostly related to the sensitivity of the sensors but we were easily able to get the sensors to the correct sensitivity and overcome this obstacle.

H. Working Together

Since we are going through a pandemic where the virus can be contracted through the air. Sometimes we have to work together to get some tasks done that cannot be done by a single individual. To prevent us from contracting the virus we are using all the safety measures outlined by CDC. We are using masks all the time when we meet up as a group. Sanitizers are kept on us and are frequently used as well. We are and will be wiping down the equipment that we are using. We are also keeping the social distancing factor into account as well. That is one of the reasons we picked Suliamaan's place to work because he has an open space where we can work in while

maintaining all the CDC listed guidelines. If one of us contracts the virus, we have made sure that we all have medical insurance that will cover up the medical cost for us. We have also located the places to get tested in case one of us shows the symptoms to the virus. If all of us contract the virus we are going to have to approach modular design where we will work on parts of the robot and drop off parts at our peers houses to put them together.

I. Personal Issues

There can be multiple personal issues that may arise and hinder the progress of the project. We all have issues and family outside of school that we need to care of. Especially during the pandemic each of us has to go out to grab groceries. That increases the risk of any of us contracting COVID. Which will prevent that individual from working on the project. To solve this issue the rest of the group members will equally divide the work of the person who is sick. There can be other personal scenarios that may prevent the person from working on the project. In that case we would also divide up the work equally between the rest of the group members. We are thankful that we are able to communicate very effectively and understand one another's personal problems and overcome these issues as a team and work together. This project taught us how to work well in a team and how to effectively communicate with one another so that we are always on the same page and know how to move forward when one of us has personal issues.

VIII. Design Philosophy

When we started doing this Autonomous Robot System, we never had in our minds how the actual robot would look like. We were just going with the basic mindset thinking like a board with wheels and then our microcontrollers and sensors would be placed on top then placing a food tray on it. We were thinking that a four inch robot would be successful enough to get accurate temperature of the patient and it would be easy for the patient to reach for food. Our team decided to get together and do some tests to see if it would work realistically the way we wanted because our goal was for it to be used in homes or nursing homes. Our setup before can't work realistically because the patient's hand would definitely hit the ground when taking temperature. So with that we had discussions, on what will work in a realistic situation. So that's when we decided we have to increase the height of our robot so that taking temperature and grabbing food would be easy to do. So in Spring semester our team changed the design and increased the height of the robot about six inches more to get accurate measurements, also it became convenient for the patient to give their temperature and grab food.

IX. Deployable Prototype Status

There are a lot of different factors that are going to play a major role in our testing. Here are the following factors that need testing. Line following, QR code reading, Temperature reading, Robot going into the desired room, Durability of the physical robot, Durability of the wiring, Durability of the wheels, Durability of the motors. The most critical aspects are line following, QR code reading and temperature reading and website user interface. Since those are the main features of the robot and they are the most important aspect of the robot, which make the robot do the tasks that its desired to do. Therefore we need to test those three features extensively. To test our line following, qr code, temperature reading and website user interface. We are giving the robot the same input over and over again to see if it follows the line and reads the qr code and therefore goes into the desired room. This will help us gain that confidence in our robot so that we are sure that it follows the instructions given.

A. Line Following Testing

For line following the main part of the testing will come how far the two IR sensors are placed. To find the right spot we will place the sensors at a different positions and keep running the robot to see which position follows the line the most accurately. We will make the line curvy and bendy so that we are sure that the robot follows the black tape in any circumstance. We will also test the line following in different lighting so that we are sure that the lighting does not affect the performance of it. We will test the IR sensors on different surfaces with different colored floors so that we make sure that it detects the difference between black tape and the color of the floor. If it does not then we will calibrate the sensor to desired sensitivity that will work for all of our testing scenarios.

B. QR Code Testing

For QR code testing we have to test multiple things. First of all we have to make sure that the camera reads the QR code and displays the correct output. We will test that by testing single input and then different inputs to make sure they are the correct inputs. The camera reads the QR code and we have to make sure that the placement of the camera is correct so that it reads the QR code that is placed on the wall. The positioning of the camera will determine if the QR code is being read or not. We will keep running the robot and position the camera at different spots to find the right spot that will work for all the scenarios. To achieve this we will have to keep trying different positions and see which one gives us the most accurate results.

C. Temperature Sensor and Ultrasonic Testing

We will verify the temperature of the testing person with a thermometer and then we will have the person measure their temperature using the temperature sensor that we have installed on the robot. Then we will compare the two values to see how close our temperature sensor is. If it's off then we will do further calibrations in the software to make it accurate. The sensor will be tested by observing the expected voltage per the manufacturer's guidelines. Since the ultrasonic sensor is going to be used with the temperature sensor. We are going to test the ultrasonic sensor for its accuracy. We will measure the distance of an object with a ruler and then place the object at the same distance to see if the ultrasonic sensor tells us accurate results. If it does not then we will further calibrate the sensor to display accurate distance.

D. Map Algorithm Testing

For map algorithm testing. We will keep giving the robot the same input again and again to see if it goes into the desired room. This will help us make sure that almost all of the time the robot is going into the accurate room.

E. User Interface Testing

For User Interface testing. We will verify that our website is easy to navigate and that the user can navigate the stuff needed in a short amount of time. We will verify that the website has text that is big enough for the user to read. We will make sure the text color is dark and clear. We will make sure to look at the standards and try our best to meet the industry basic standards. We will also make sure that the robot has a password on it to login. So that no one on the outside is able to access the robot. Only the user has access to it. We will overload the website with inputs to see that it does not crash or does not malfunction.

F. Physical Robot testing

For our physical robot testing. We need to make sure that the robot does not fall apart. We are going to screw down everything on the robot so that everything is rigid. We will test different weight loads to see how much the robot is able to stand. Then we can put a weight limit that will tell the user to not go over a certain weight limit so

that the robot functions properly. We will also test our robot in the sun to see if it works appropriately and does not malfunction.

G. Test Timeline

Table 4: Test Timeline

Name	Task	Start Date	Finish Date
Pawanjit/Ajaypal	Line Following	1/8/2021	4/5/2021
Sahibvir/Sulaimaan	QR Code reading	1/8/2021	4/5/2021
Ajaypal/Pawanjit	Temperature Sensor/Ultrasonic Sensor	1/8/2021	4/5/2021
Pawanjit/Sulaimaan	Website and User Interface Testing	1/8/2021	4/5/2021
Sahibvir/Sulaiman	Physical Robot Testing	1/8/2021	4/52021

X. Marketability Forecast

A. Innovation

Major key components of the project's success is innovation. Then the product should be determined if it is application innovation, disruptive innovation or product innovation. Our project is not something totally new in the market. But what makes it set apart is that it is more sophisticated and does the job with confidence. Our robot is not creating a new market or new product therefore it will be considered application innovation.

The goal of our team is to reach the growing market of Autonomous robot systems. This market is growing very fast because of the pandemic and the popularity and demand of the product is increasing at a fast pace. There are multiple companies trying to come up with the next best autonomous robot to benefit financially.

Figure 14: Starship Autonomous Robot

Starship technologies product is more focused on food delivery. They are testing out their prototypes at different universities and trying to deliver food to customers. This product is similar to ours because the task it performs is very similar to ours. But the cost of this product is $5500. If we compare that to ours. Our robot costs 400% more than the cost of our robot.

Savioke is another brand who are more focused towards putting their robot in healthcare. Their robot does a very similar thing to ours where they are testing it for food delivery in hotels and provide room service to people. The cost of their robot is 2000 dollars. This is the double the cost of our robot.

Figure 15: Savioke Autonomous Food Delivery Robot

The above companies have provided a deeper insight on what the goals of the companies are. Their main goals are that they are trying to target the consumer for their product. We have our strengths and weaknesses compared to the companies in competition. We also think that the market is very open because there isn't one

company which is more popular than others. They are all at the same level. This tells us that one company does not have a huge advantage over the other company. Therefore this provides us with the chances to shine in the market. Our product needs to meet the demands of the consumers and needs to offer them a reliable product compared to the competition. The major component that would set our robot apart would be how easy it is for the user to operate the robot and navigate through it. Our product has to be affordable and between some certain range or cost. Our robot will shine in this area because of the cost of our robot it will attract more customers.

B. Market size

The autonomous robot market is estimated to be around 8.3 Billions dollars. The market is growing it at an exponential rate. Because the demand for these robots has increased since COVID hit. There are many other factors to consider when launching the product. We need to consider if the market is stable, growing at a good rate etc. The growth of the industry is projected to be very high in the near future. The world is on the verge of hitting a new pandemic every year. Thus the demand for autonomous robots is increasing at a fast rate. The growth rate of this market is calculated to be about 19.6%.

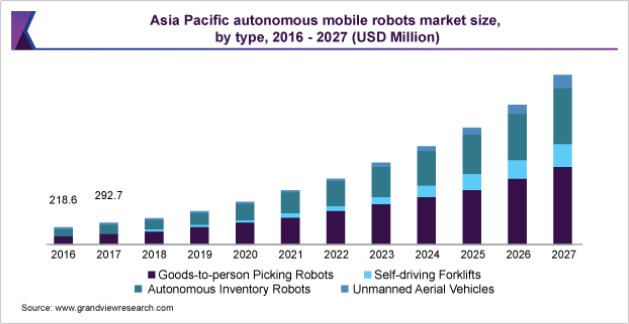

Figure 16: Growth rate of market

Due to the fact that there is no monopoly in the market, it gives a high hope and confidence to jump into the market and have an advantage over some of the companies. Since our system uses a little different approach compared to the other companies we are confident that our product will attain success in the market. This market will avoid new comers and growers. People have little interest in making their own robot that will deliver supplies etc. We had little insight on this topic when we started to design our robot. Social media would be a good way to put our product out there and attract different kinds of buyers. We can also demo our system in different nursing homes and get their input on what changes they would want us to make to the system so that our product fits their needs perfectly.

C. Industry Cost Structure

We will develop our product from the stereotype that we have created and will consider small forms of factors and small amounts of supplies required. Therefore our build is very low cost. Material Required. Chassis, IR sensors, USB camera, Raspberry PI, Arduido, Battery pack, wires, temperature sensor, infrared sensor. The materials that are mentioned above are the most important facts and are the majority of the cost of the robot. Since we as a team will build the robot. This will help us cut down the cost of labor and will make our system very cheap compared to the competition. Sulaimaans house will act as our floor space, which will cut down our price to rent a place to assemble our product. Considering our pace we should be able to make 2 to 3 robots per day. We will have the wiring layout and supplies ready to go and therefore we will be able to mass produce our robots at a fast pace.

D. Success Key Factors

SWOT analysis is used to plan strategically. This will help us look at the strengths, weaknesses, threats, opportunities etc that our product and our team will face. The main factor that makes us stand apart and gives strength to our design is the fact that our robot is very low cost. It is cheap to build and follows a modular design analogy. Which we can work on different parts of the robot and can eventually combine the different parts to make a finished product. It also shows that it can be easily repaired. If one module stops working we can underline the issue and replace that module and the robot would work normally. This will help us bring the price of the robot a lot lower than the competition which will help us attract customers. Since we can repair the robot with small modules this will allow us to give a better warranty to the consumer. Opportunity:

There are some popular brands in the industry who started with given the best warranty on their products compared to all the different companies.

For example Hyundai started to offer the best warranty and now they are one of the most renowned and reliable car brands in the market. We will be using the starting price as our selling point and given customers extended warranty which will help us overcome our competition. We will extend the extended warranty low cost for the buyer this way we will collect money to cover up the repairs on their robots that we will be selling. Since ouro replacement parts are very cheap by allowing the extended warranty we will be adding to our profit margins. Weaknesses: The weaknesses of our system would be the parts we are using whether they are reliable or not and how long the parts last before they malfunctions. Using inexpensive parts means less reliability and more room for error. The only way we can overcome this issue is to offer a warranty better than the competition. Since the parts are really cheap this will help us get the customers attention and win their trust.

XI. Conclusion

Throughout this report we hope that you have learned great things about the Delivery Bot that will change the way we reduce the spread of contagious diseases by using an autonomous food delivery robot to limit the contact between hospital staff and contagious patients. The delivery robot is not supposed to take over the healthcare industry overnight but it is intended to get the ball rolling on introducing technology into the healthcare field which can be very beneficial in reducing contact between patients and hospital staff.

Throughout this project we have overcome many obstacles such as not being able to use the lab at Sacramento State and having to meet remotely with the team or meeting while taking the correct safety measures so that we can get our project done while still following the correct CDC guidelines. The beginning of the project was very difficult for us to get into the rhythm of things and we didn't have any experience creating a project of this magnitude so we had to learn things as we worked on the project.

We were able to overcome all obstacles such as getting infected by covid-19 to having our microcontrollers get really hot and disintegrate the wires connected to them. Thankfully none of us were injured when dealing with the bad microcontrollers that we were sold from a shady website. We were successfully able to complete the project and meet all of our feature sets even though we had many obstacles.

At the end of our first semester we were able to complete all the features sets but didn't have them fully integrated and we were also able to add another feature which is the temperature sensor module to the robot and we were able to do this as well and have a fully integrated working delivery robot by the end of the second semester senior design.

Overall the project taught us a lot and we are grateful that we have such an amazing set of professors that we would be guided by and this made the project a whole lot easier knowing that we were under the supervision of industry professionals with many years of experience. We will take everything we learned from senior design and apply it to our future careers and we are confident that we will be able to be great engineers because of what we learned in senior projects and how to meet goal deadlines and work in a team and how to learn new skills and adapt.

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Glossary

1. Arduino: an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices.
2. L298N: is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.
3. Raspberry Pi: is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It’s capable of doing everything you’d expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.
4. QR Code: is a two-dimensional version of the barcode, typically made up of black and white pixel patterns. Denso Wave, a Japanese subsidiary of the Toyota supplier Denso, developed them for marking components in order to accelerate logistics processes for their automobile production. Now, it has found its way into mobile marketing with the widespread adoption of smartphones. "QR" stands for "Quick Response", which refers to the instant access to the information hidden in the Code.
5. IR sensor: is an electronic device that measures and detects infrared radiation in its surrounding environment. Infrared radiation was accidentally discovered by an astronomer named William Herchel in 1800. While measuring the temperature of each color of

light (separated by a prism), he noticed that the temperature just beyond the red light was highest. IR is invisible to the human eye, as its wavelength is longer than that of visible light (though it is still on the same electromagnetic spectrum). Anything that emits heat (everything that has a temperature above around five degrees Kelvin) gives off infrared radiation.

6. An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound (i.e. the sound that humans can hear). Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target).
7. Autonomous: Independent in mind or judgment; self-directed
8. Temperature Sensor: a temperature sensor is an electronic device that measures the temperature of its environment and converts the input data into electronic data to record, monitor, or signal temperature changes

Appendix A. USER MANUAL

Parts Included

- Arduino R3
- Arduino Nano
- Raspberry Pi 4
- 12V Rechargeable Power Supply
- Wood Chassis
- 4x 6-12V Geared DC Motors with Wheels
- IR Sensor
- Temperature Sensor Module
- Ultrasonic Sensor
- Jumper Wires
- L298N Motor Driver
- LCD Display

Healthcare Setting Setup

In order for this robot to be set up in a healthcare setting make sure that the Delivery Bot is fully assembled and that you have access to the Delivery Bot website in which the robot can interact with the healthcare staff. A Delivery Bot technician will be required to layout the black tape into the hospital hallways as well as into the room of the patients. The technician will place barcodes at the correct intersection correlating with the room numbers and once the technician has set up the black tape and the barcodes the technician will then allow you to access the website in which you can enter in the patient's name into the slots which correlate to the patients room number. Once the technician has checked to make sure everything is set up properly you can move onto the next step which is operating the delivery robot.

Operating the Delivery Robot

Once everything is set up by the technician the healthcare staff can put food/medical supplies onto the robot and enter in the patient's room number and the robot will follow the black tape and enter the patient's room and the patient will retrieve the food/medical supplies and wave their hand in front of the temperature sensor which will display the temperature back to the website which can be viewed by the healthcare staff. The delivery bot will then return to the nurses station and the healthcare worker can load more cargo on the robot for it’s next delivery.

Cargo Weight: 25lbs

Operating Voltage: In order to operate the Delivery Bot you will need a 12V power supply with a current of 2.5A-3A which will be enough to adequately operate the delivery bot and have all of it’s features fully functioning.

Appendix B: Hardware

There are several hardware components we used for our project. We used Raspberry Pi, Arduino Uno, Motor Driver, DC Motors, IR Sensor, QR Code Camera, Temperature Sensor, Ultrasonic Sensor. It is discussed below specifically how we used each hardware component to make our robot efficient.

A. Raspberry Pi

Figure 17: Raspberry Pi

Raspberry Pi is the main hardware component of our project as it is known as a mini CPU. It helped us to program the entire project for us. Programmed IR sensors to detect the color on the floor and detect lines accordingly. Then the camera detects the QR code and informs the DC motors together with the IR sensors to either do left, right or just go straight.

B. Arduino Uno

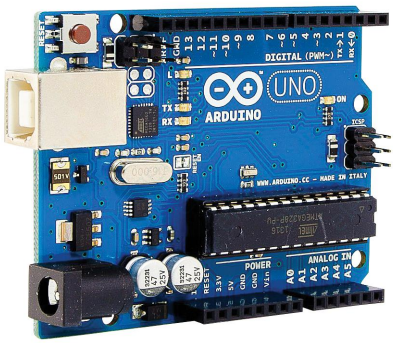


Figure 18: Arduino Uno

It's the brain of our project. To make our project fully autonomous we needed Arduino Uno help to make it possible. We have IR Sensors, Camera, DC Motors, Motor Driver, Temperature Sensor, Ultrasonic Sensor and LED Screen connected into it. We used Arduino Nano for Temperature Sensor, Ultrasonic Sensor and Led Screen connected to it for the project to be more faster and efficient.

C. Motor Driver

Figure 19: Motor Driver

This was one of the necessary hardware components as well because this helped our robot to be in line. The L298N motor driver helps us control the DC motors we used in our project. It helps us control the speed and the direction for the DC motors at the same time.

D. IR Sensor

Figure 20: IR Sensor

We used two IR sensors for line direction of our robot. The IR sensors helped the robot to detect black and white. We had placed black tape and had that tape in the center of two sensors. So whenever the robot moves and senses the black tape it can reset itself to be straight.

E. DC Motors

Figure 21: DC Motors

This was really important because in order for our robot to move we needed these DC motors. The motors we used could take up to 6-12V which were good enough to move our robot at a decent pace.

F. QR Code Camera

Figure 22: QR Camera

This camera was necessary because we used it to read QR codes that were displayed in the route to make sure the robot turns in the right room and makes stop when it enters and does the necessary action and through reading the codes it can go back to it's starting location.

G. Temperature Sensor and Ultrasonic Sensor

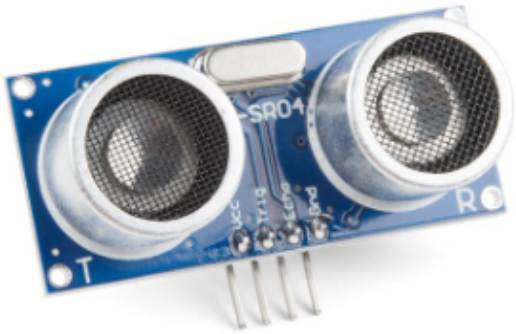


Figure 23: Ultrasonic Sensor

Figure 24: Temperature Sensor

Aside from delivering the food to the patient, our robot also takes the temperature of the patient. So for that we used a temperature sensor and we used an ultrasonic sensor with it to get better accuracy of the temperature with that ultrasonic sensor patients get to know how far they will place their hand. We have an LED display that tells the patient how much closer he/she should bring their hand.

Appendix C: Software

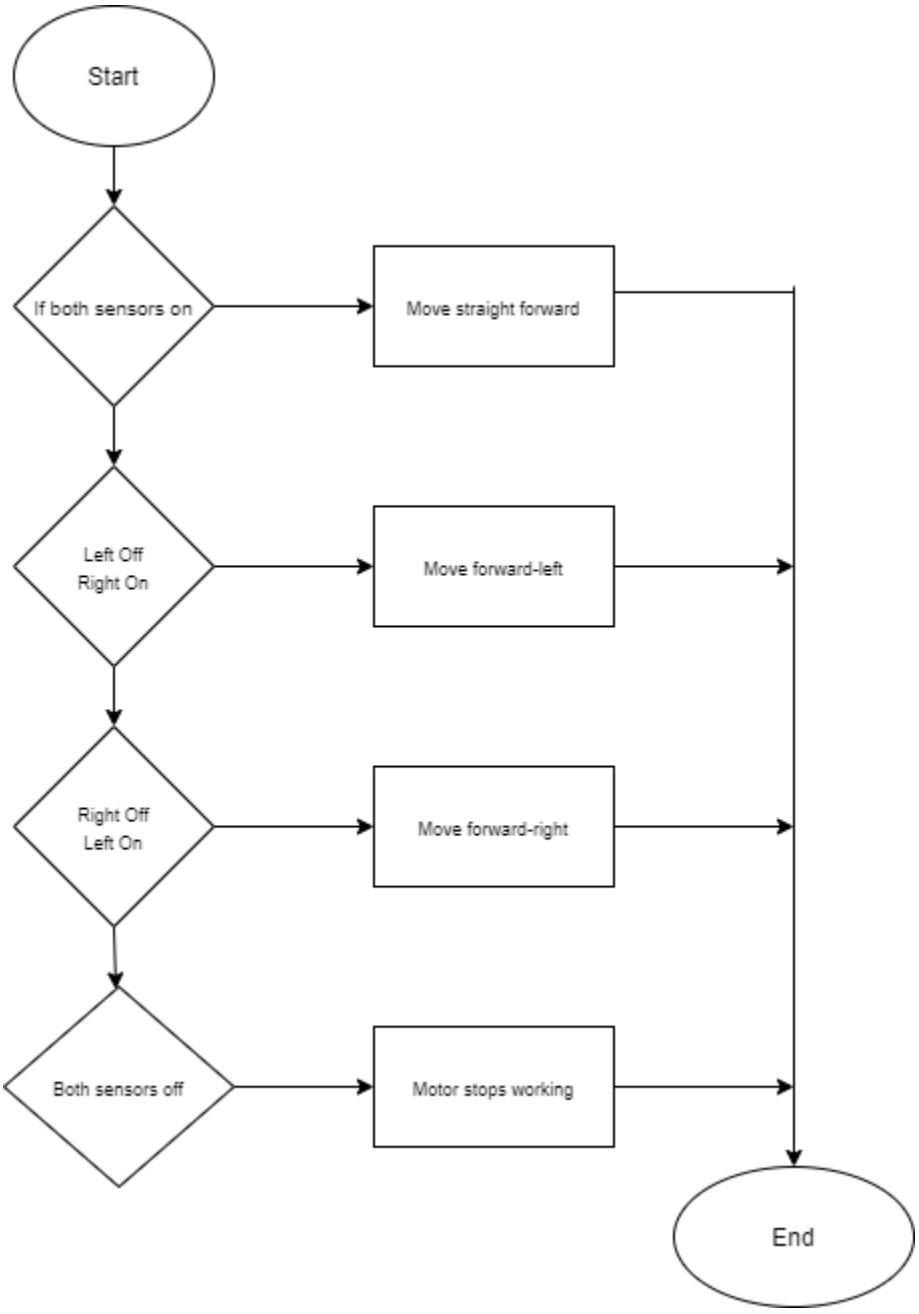


Figure C1: Infrared Sensor Line-following Subroutine

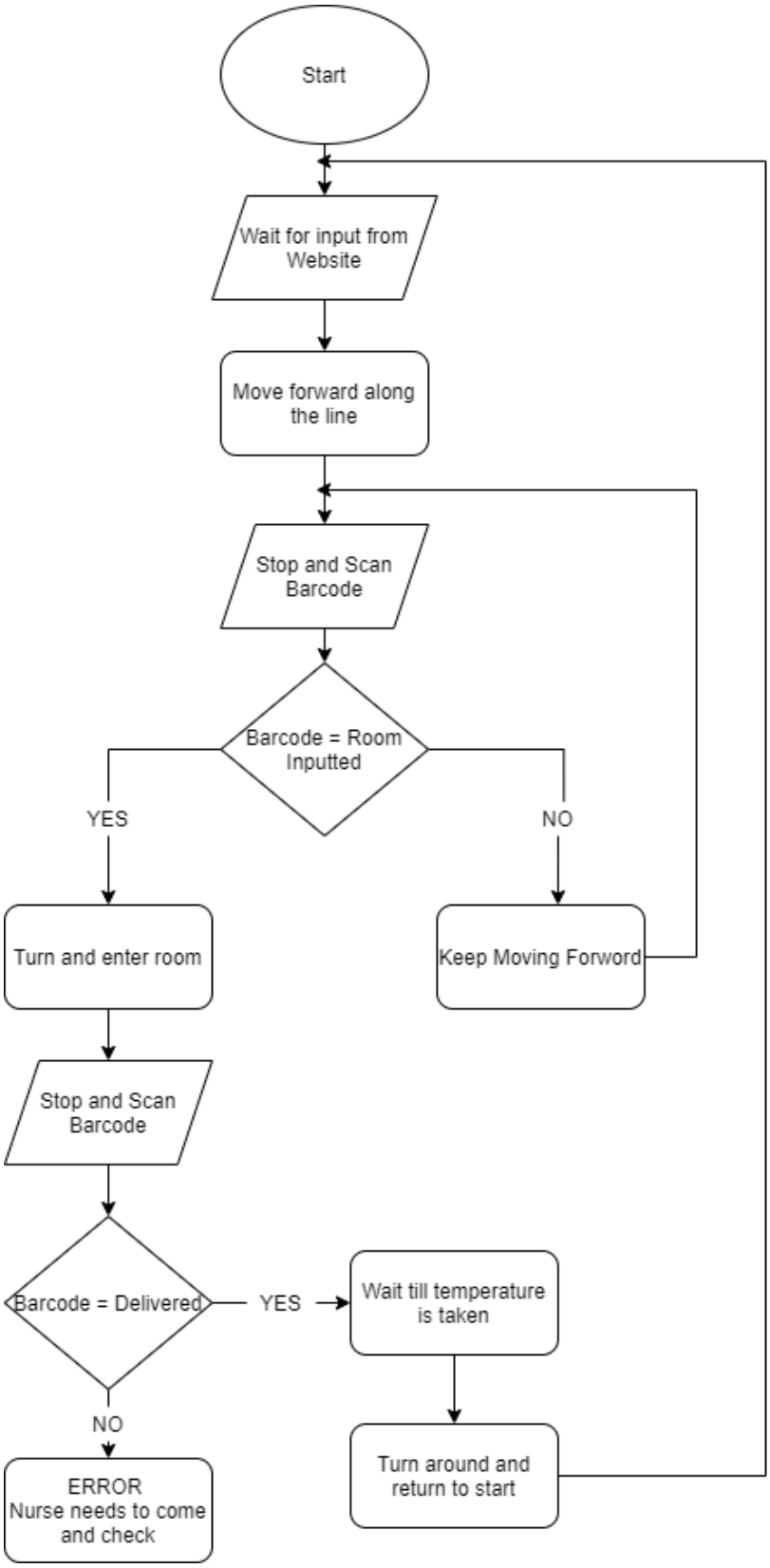
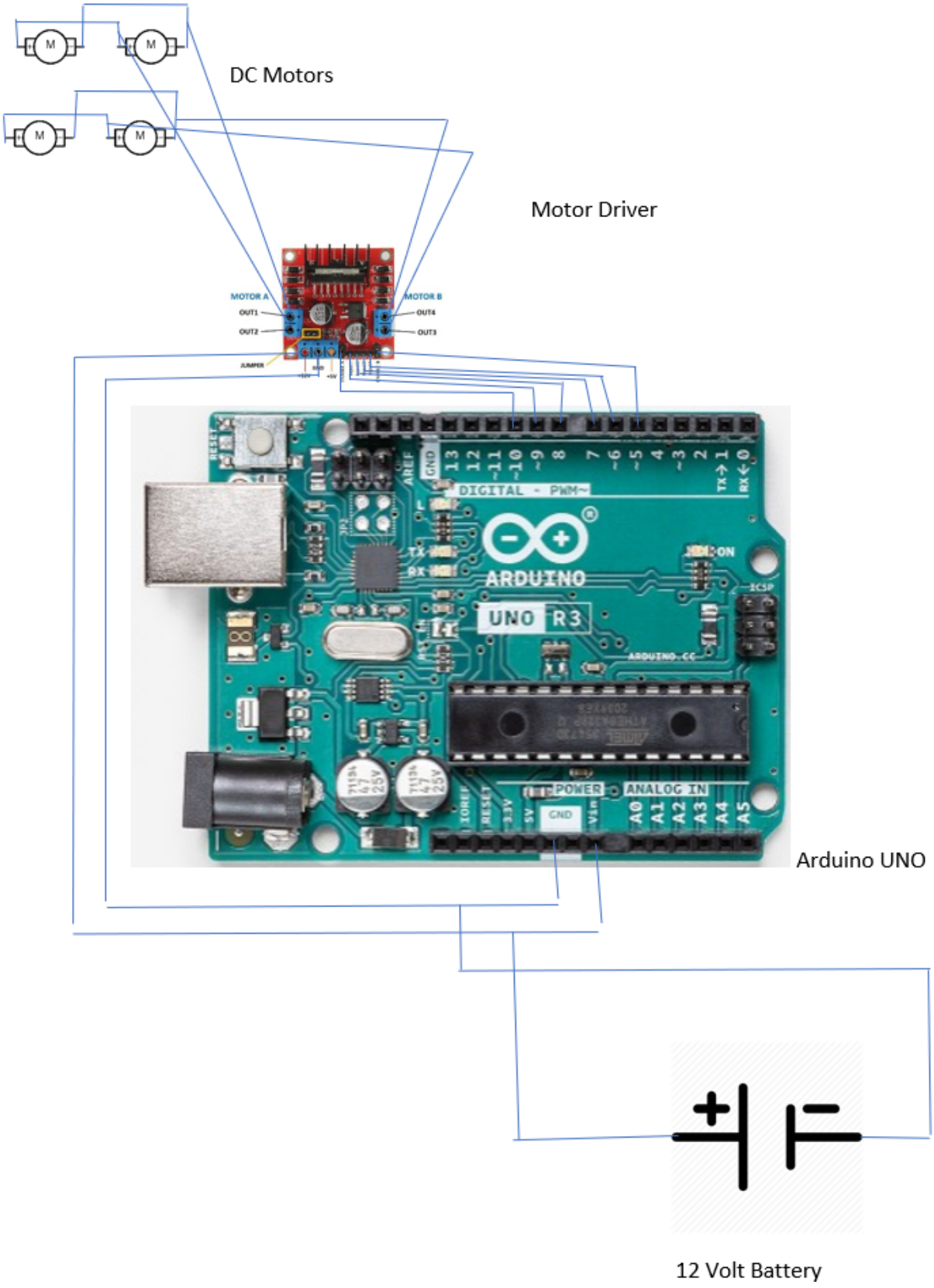


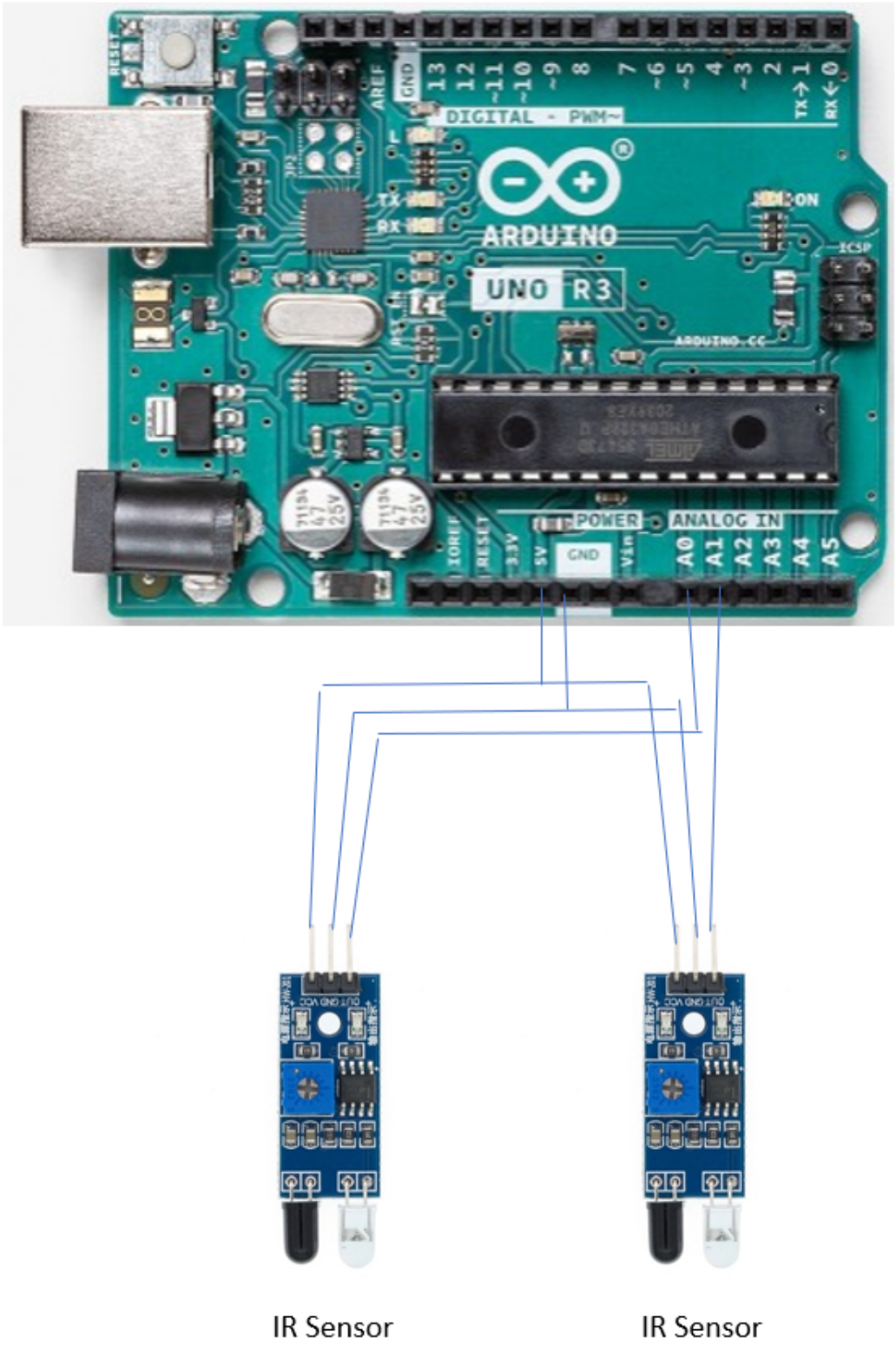
Figure C2: Logic Algorithm Flowchart

Figure C3: Software used


DC Motors
Motor Driver
MOTOR A
MOTOR B
OUT1
OUT2
OUT3
OUT4
ARDUINO
UNO R3
DIGITAL ~ PWM~
ANALOG IN
POWER
Arduino UNO
12 Volt Battery

Motors schematic

Arduino UNO



IR sensor Schematic

QR code (camera) module schematic

Appendix E. Vendor Contacts

Since everything was virtual we did not have multiple advisors. Our main advisor and go to person was Professor Levine. Whenever we had questions to tackle any task he was always there with solid advice. During our first semester we had a lot of questions that Professor Levine was able to provide us with some solid ideas. For example we planned on using IR sensors that detected different color tapes and went to different rooms. But instead of doing that Professor levine insisted us to look into using Cameras to detect QR codes and using that to make decisions. Then we were having problems with the robot turning and we showed the logic to professor Levine and he was able to suggest a different approach. He has always been pushing us to try new things which will make our robot robust and better. We were having problems with the robot's calibration messing up when we added weight onto it. The suggestion made by professor levine helped us take care of the calibration issue. First we were using a timer where the robot was turning for some specific amount of time that we figured from testing. But then we changed up the turning algorithm where we turned until one of the sensors detected tape and then readjusted itself to make sure the tape was in between both of the sensors. Overall professor Levine was able to push us to the limits and he understood everything that we were going through and accommodated according to tha

Appendix F. Resumes

Sahibvir Nijjar sahibvirnijjar@gmail.com US Citizen

Objective

Seeking to build practical experience through a Computer Engineering internship while furthering my Bachelor's of Engineering

Education

California State University of Sacramento – Computer Engineering (GPA 3.027)
Fall 2018 – Present (expected graduation Spring 2021)

Skills

Java, C++, C, Python, LINUX, Verilog, VHDL, Microsoft Office, Adobe Acrobat, Windows, Mac OS, Circuits, Assembly Language (X86)(MIPS), Raspberry Pi (programming), Cadence Software
Self-Motivated, Detail Oriented, Team Player, Organized, Time Management, Adaptable, Punctual, Creativity, Public Speaking, Communication Skills
Multilingual – English, Punjabi, Hindi, Urdu

Experience

Department of Consumer Affairs – Engineering Student Assistant (Web Developer)
May 2020 – Present
•Worked for the Office of Information Services under the IT Technician.
•Remediating PDF's according to the ADA Compliance rules using Adobe Acrobat DC (Professional) to make it accessible for people with disabilities.
•Managed to change their website according to ADA Compliance rules to make it accessible for people with disabilities.

Elk Grove Unified School District – Instructional Assistant
August 2017 – Present
•Assisting special needs children through a classroom setting to help them succeed and gain an education.
•Setup computers in the classroom for students to use with the necessary software and provided technical support to resolve software and hardware issues.
•Assist with daily lesson plans and clerical duties.

Project

Four Way Traffic Light System
Built a four-way traffic light model using Raspberry Pi and Parallax Microcontroller in my CPE185 (Intro to Microcontrollers) class. Used python to program the lights (main logic algorithm) and the Parallax (programmed in C) to control all the sensors. Synced both microcontrollers to work together.

Memberships

Sikh Student Association – Vice President of Outreach
Society of Women Engineers
MEP (MESA(Mathematics, Engineering and Science Achievement) Engineering Program)

Sulaimaan Bhatti

bhattisulaimaan@gmail.com | Sacramento, Ca | US Citizen | (916)952-5144

OBJECTIVE

To obtain a position in a professional environment

EDUCATION

Bachelor of Science, Electrical and Electronics Engineering — Expected Spring 2021
California State University, Sacramento — GPA 3.68

KNOWELEDGE AND SKILLS

- C/C++, Python Scripting, PSPICE, x86, MATLAB, Verilog
- Circuit Analysis/Design, Embedded Hardware, Analog/Logic Design, Semiconductors
- Complex problem-solving skills, Working well in teams, Quick Learning

PROJECTS

Programmable Electronic Blender

- Engineered the embedded software and hardware for a working programmable Electric Blender using a STM32 Microcontroller.

Alarm system

- Built the hardware and wrote the C code for a functioning Pyroelectric motion sensor alarm system using a parallax microcontroller, piezo speakers, LCD display, and LED's.

Mobile Robot

- Constructed a mobile robot using two microcontrollers to make the robot run a 20 yard course with many turns, loops, and obstacles in the robots way.

WORK EXPERIENCE

HP, Summer Scholar — 6/2020 – 8/2020

- Went through an in-depth learning experience of each of HP's departments and learned the ins and outs of how the multi billion dollar company operates.

Teleplan, Electronics Tech, Roseville/California — 6/2017-8/2019

- Used Electrical testing equipment to troubleshoot electronics
- Perform root cause analysis to find and correct/repair electrical devices.

Campus Involvement

Institute of Electrical and Electronics Engineers, Active m*ember* — Fall 2019-Present

Power and Energy Society, Active m*ember* — Fall 2019-Present

Accomplishments

Teleplan, Employee of the Month

Sacramento Airport Customer Service Passenger Assistant- Employee of the Year

AJAYPAL S. GILL

CELL: (209)-570-9269 | EMAIL: AJAYPALSGILL@CSUS.EDU

LANGUAGE SKILLS- NATIVE: PUNJABI, HINDI, ENGLISH,TAGALOG

COMPUTER ENGINEERING GRADUATING SENIOR 2021

Education

- B.S., Computer Engineering | CSU Sacramento GPA:3.20
  Expected Graduation: Spring 2021

Skills & Coursework

- Computer Interfacing | **Skills: Python, C, C++, Arduino IDE, Raspberry pi**
  - aaUsing the following design components: interface modules of parallel and serial input/output, timer modules, and interrupts programmed microcomputer systems based projects in the Computer Engineering Laboratory.
- Advanced Computer Organization| **Skills: Technical Writing; Introduction to EDA Tools & HDL**
  - Studying design and performance issues of computers with respect to Instruction set architecture, computer arithmetic, processor design, interfacing I/O devices,and hierarchical memory design and analysis.

Selected Projects

- Project I: RC CAR|
  - Designing a RC Car controlled by Raspberry Pi that had a camera which was doing live streaming while had sensors that were detecting from which side there is motion.

Team Experience

- Team member| Pizza Restaurant October 2016-2018
  - Adapted to customer service skills being a shift manager and also handling the kitchen to be able to knock out rush hours easily with amount of people I had and ensuring best quality is being provide to the customers.

Pawanjit Singh
Email: ipawanjit@gmail.com

CAREER OBJECTIVE

Seeking to build practical experience and business relationships with a solid company that provides challenges and growth opportunities where I can utilize my skills, education, and experience to advance my team and company.

EDUCATION

California State University - Sacramento, **Sacramento, CA**

Bachelors in Computer engineering *September 2018 - Present (expected graduation May 2021)*

Relevant Coursework: Computer Interfacing, Computer Hardware System Design, Computer Networks and Internets, Advanced Computer Organization, Electronics, Network Analysis, Signals and Systems, Advanced Logic Design, and CMOS and VLSI

WORK EXPERIENCE

ABM Aviation, INC. **Sacramento, CA**

Supervisor/Passenger Assistant *March 2017 - February 2020*

- Seasoned managerial and operational experience with emphasis in customer and quality service
- Ability to readily adapt efficiently and work under tight time constraints, pressure, and changing economic climate environment
- Ability to manage, train and provide technical direction to staff to optimize resources
- Conducted and ensured all policy, procedures and regulations were strictly followed
- Closely assisted and collaborated with management, internal and external department leaders and staff, State and Federal agencies leading from the front and demonstrating relationship building and positive customer results

Subway **Sacramento, CA**

Assistant Manager / Sandwich Artist *May 2012 - March 2017*

- Organized work areas to foster efficiency and model exceptional kitchen etiquette
- Reduced customer waits times by quickly and efficiently operating customer window and sales register
- Supervise, train, and provide direction to staff and handle customer service concerns with positive resolutions
- Managed salary budgets, promotions, and performance reviews. Managed risk, compliance, audit, and workflow management for store
- Prepare meticulous financial accounts payable and receivables reports and tracking of records in excel and MIS data

SKILLS

- **Programming Languages**: Python, C/C++, Java, HTML, Assembly Language (X86) (MIPS) , Verilog, VHDL,
- **Operating Systems**: Windows , Mac OS, Unix/LINUX
- **Tools**: Multisim, OrCAD PSpice, Cadence Virtuoso, VMWare
- Effectively prioritize and manage competing multiple priorities
- Enthusiastic, knowledge-hungry learner, eager to exceed challenges
- Excellent listener and communicator who effectively conveys information verbally and in writing
- Excels at building trusting relationships with customers and co-workers with good interpersonal skills
- Responsible, positive, and dependable individual
- Productive/motivated worker with solid work ethic who takes initiative with minimal supervision

RELEVANT EXPERIENCE AND PROJECTS

Senior Design Project

- **Autonomous delivery robot:** Currently me and my senior project group are working on an autonomous delivery robot that will be able to deliver food and supplies to family members that have covid or are just sick. The robot will also be able to take the temperature of the person and relay that back to a family member.

Traffic light

- Built a Traffic light model using microcontrollers (Raspberry Pi and Parallax Microcontroller) in class CPE185 (Intro to Microcontrollers). Used python to program the Raspberry Pi and used C to program the Parallax. Synced both microcontrollers to work together.

ACTIVITIES: United Way and Red Cross Volunteer, Guru Nanak Mission Hospital Charitable Volunteer
LANGUAGES: Trilingual In English, Punjabi and Hindi
REFERENCES: Available upon request