Autonomous Sanitation Robot

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Motivation

- The recent COVID-19 pandemic has shown everyone how easy it is to spread germs in an environment.
- With areas of the highest foot traffic being hallways we need to maintain the cleanliness of hallways the most.
- This self-driving robot would help people such as building managers ensure that high traffic areas like hallways and lobbies are always sanitized and clean

Goals and Objectives

- Very light in weight for ease of mobility for users
- Autonomously patrol an area for potential sanitation areas
- Discerning environment and accurately deciding when to spray
- Liquid level sensor and LED that will show users if there is a solution present up to a specified value
- Speaker mounted to the top to notify users of its presence and when it will spray.

Specifications

Specification	Target
Run Time	2-3 Hours
Target Detection Range	2-5 Feet
Target Detection Accuracy	90%
Fluid Capacity	1 Liter
Time to Clean	20 Seconds
Recharge Time	<1 Hour
Camera Field of View	60 Degrees
Solution Detection	<5%

Block Diagrams

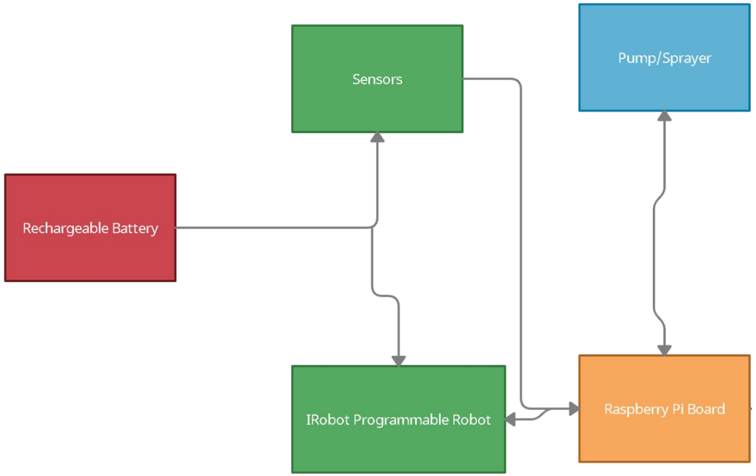


Figure 1: Block Diagram

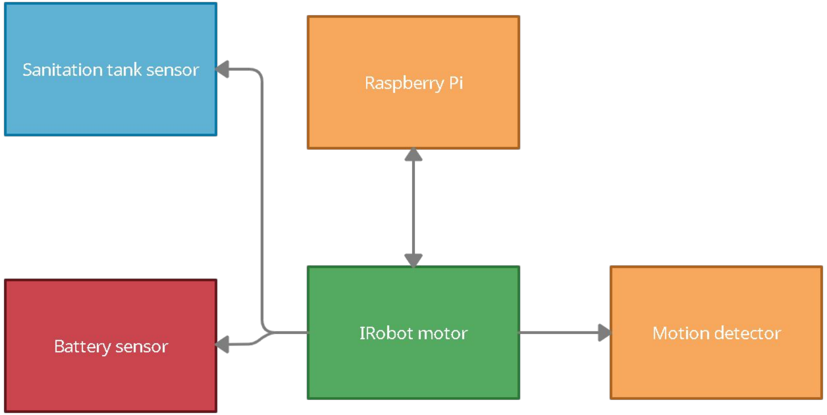


Figure 2: Software Block Diagram

Sensor Design Research

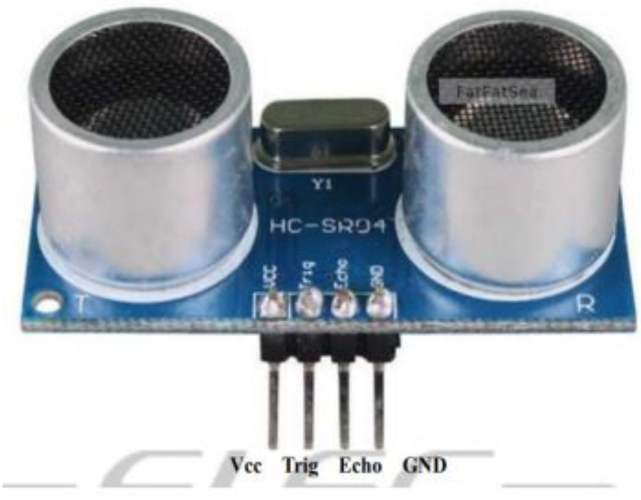
Sensor	Long Range	Power Consumption	Complex Surface Processing	Susceptible to Outside Influences	Cost
Ultrasonic	No	Low	No	Yes	Low
IR	No	Medium	Yes	No	Low
LIDAR	Yes	High	Yes	No	High

Distance Sensor Comparison

Sensor	**Voltage**	**Range**	**Price**
HC - SR04	5 DC	2 cm - 4 m	$3.94
Parallax Ping	5 DC	2 cm - 3 m	$29.99
IR Break Beam	3.3 - 5 DC	50 cm	$5.95
LaserPING	3.3 - 5 DC	2 cm - 200 cm	$22.99
Garmin Lite V3	4.5 - 5.5 DC	40 m	$131.25
Garmin Lite V4	4.75 - 5.25 DC	5 cm - 10 m	$68.75

Sensor Selection

- After our research we selected that the HC-SR04 sensor would work best to our needs
- Some of the reasons why are
  - The low cost
  - The low power and current consumption
  - Sensor that is familiar to our group



Chassis Research

Chassis	Sensors	Price in $	Language
IRobot 2	10+	200	Any
mBot Ranger	6	130	Scratch/Arduino C
Zumo	None	19.95	Any

Zumo Chassis

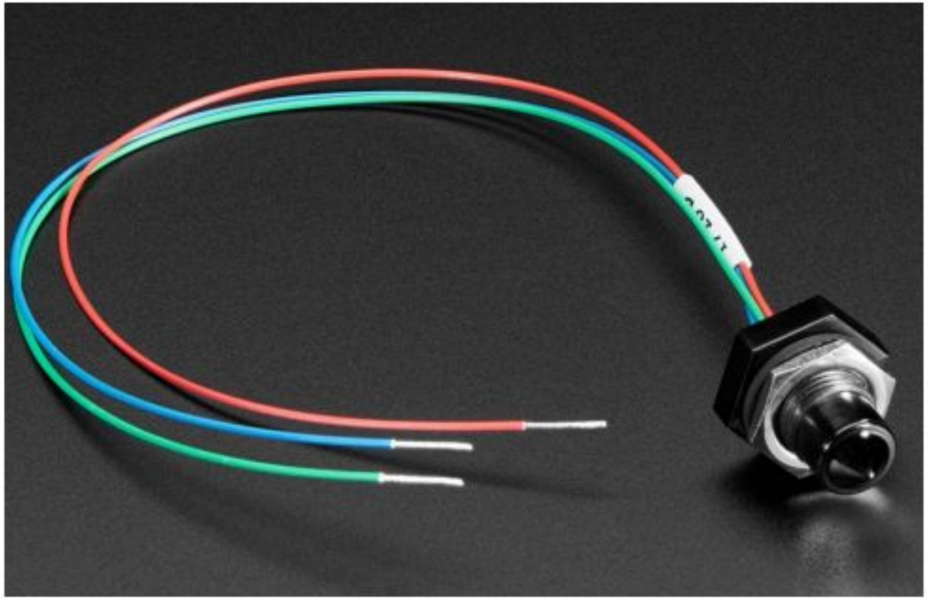
mBot Ranger

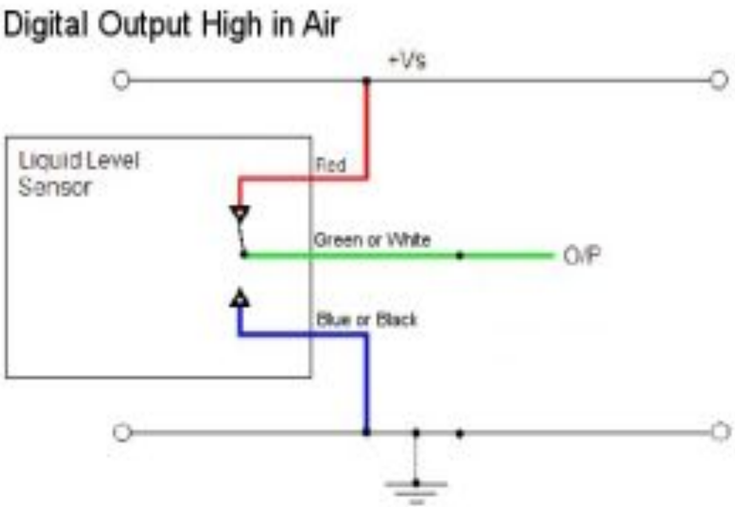
IRobot Create 2 Open Interface Based on Roomba 600

Chassis Selection

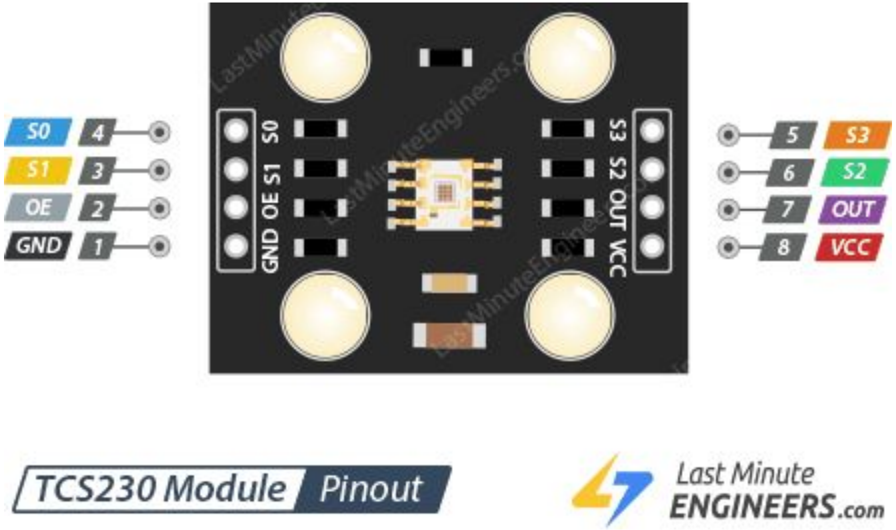
- Once again weighing our options we selected the iRobot Create 2
- Some of the key features that attracted us to this model were
  - The number of available on board sensor
  - Compatibility with microcontroller and other external hardware/Computers
  - Open interface commands and flexibility in language coded
  - Mounting area on faceplate

Liquid Level Sensor



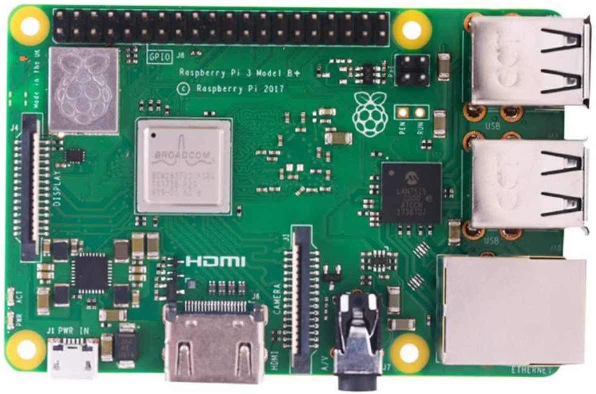


TCS3200 Color Sensor



Raspberry PI

- Raspberry PI 3 B+
- Affordable
- Highly intelligible code to work with our sensors to feed to the microcontroller
- A lot of examples online
- Runs a Linux environment

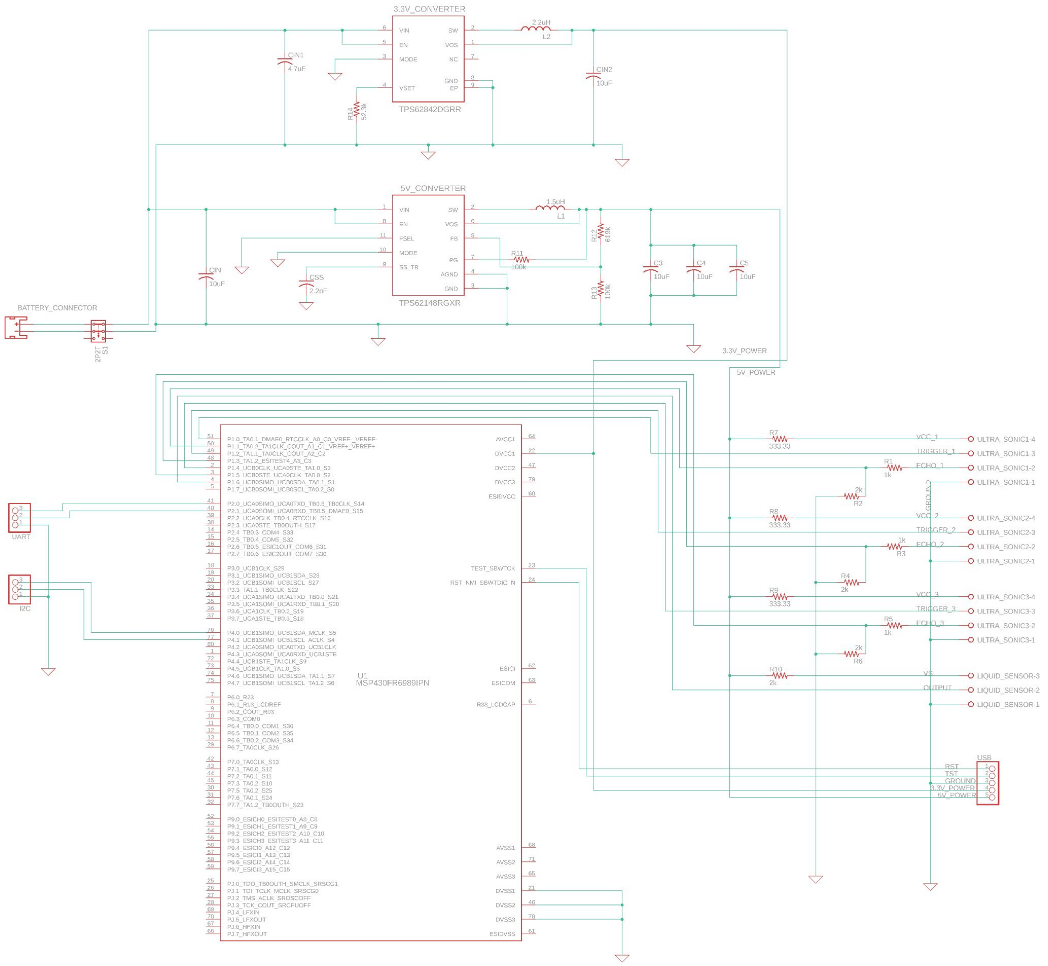


Coding with Microcontroller and Raspberry PI

- IDE is Code Composer Studio
- Raspberry Pi and MSP430FR6989 written in C
- The computer programmer on the team has the most experience and feels comfortable in C
- A lot of examples and tutorials online
- Can use old code from a previous embedded systems class that utilized a serial communication between two systems using UART

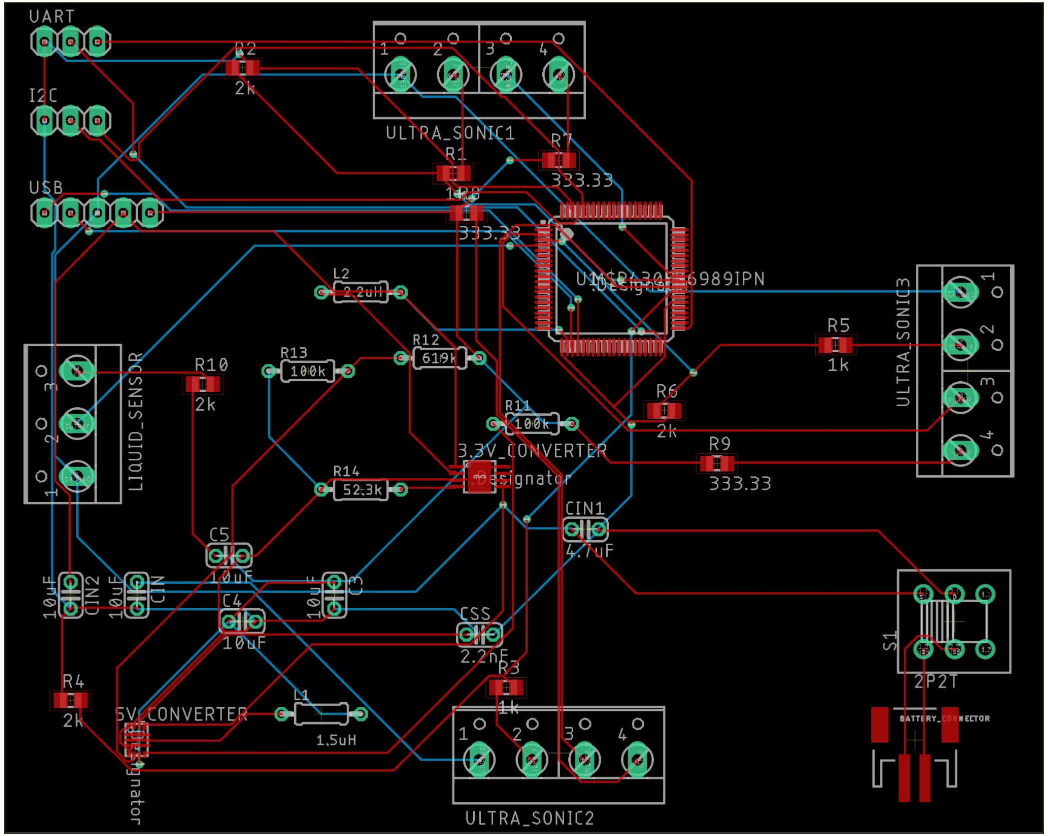
PCB Schematics

- In this design we are utilizing a 6V external battery pack to power the board and all of its components.
- We have multiple connections for UART, I2C, and USB.



PCB Board Design

- In the Board design all the sensors are not board mounted. They have a screwdown pin terminal for the board connection.
- The ultrasonic sensors will be mounted to the edges of the chassis
- The liquid level sensor will be mounted to the reservoir



Sprayer System

- This system will comprise of the sprayer head (seen to the right) and a reservoir.
- The sprayer head will be connected to the PCB utilizing a relay to turn on and off the sprayer.

Disassembled Sprayer Head

Microcontroller Table Comparison

Specs and Return Time	8051 Microcontroller	PIC Microcontroller Family	MSP430FR6989
Number of Bits	8-Bit Controller	12-bit program word architecture	12-bit SAR ADC
Memory	40KB of ROM and 128 bytes of RAM	50KB of ROM and 128 bytes of RAM	128KB of nonvolatile memory
Pin Layout/Type	40 Pin Dual Line Package	28 Pin Package	81 GPIO pins
Clock Frequency/Type	16-bit Clock Timer	16-bit Crystal Clock Timer	Crystal clock frequency of 16 MHz
Number of Channels	5 interrupt sources	Serial peripherals such as: SPI, USART	16 ADC channels, 4 UART channels
Cost Per Unit	$4.95 USD	$1.85 USD	$4.73 USD

Why the MSP430FR6989 Microcontroller?

- After doing some research about the following microcontrollers we determined the FR6989 would work best with the iRobot System.
- The amount of memory and GPIO pins were a key pick in determining what kind of controller we wanted while still keeping cost reasonable.
- Another added benefit this controller can easily communicate with other controllers, such as the Raspberry Pi system, through the UART channels.

MSP430FR6989
12-bit SAR ADC
128KB of nonvolatile memory
81 GPIO pins
Crystal clock frequency of 16 MHz
16 ADC channels, 4 UART channels
$4.73 USD

MSP430FR6989 Microcontroller (Continued)

- We wanted a controller that could handle the amount of data we would be sending through it from the Raspberry Pi system and wanted enough pins on the controller so we could have both systems communicate with all the deliverable parts, such as the LED'S, Liquid Sensors and Ultrasonic Sensors.
- We ultimately landed on the MSP4306989 because it was a controller that we could program through its URAT channels and handle the load of deliverables we have for the iRobot System as an whole.
- Moreover, we determined that this controller was one that we as a group had the most experience with and would meet all the demands of our Senior Design Project.

MSP430FR6989

Speaker Table Comparison

Speaker	Form/Dimensions	Operating Voltage	Impedance	Misc
Degraw	31mm x 70mm	5V	4 Ohm	Included amplifier
MakerHawk	31mm x 28mm	3.3V or 5V	4 or 8 Ohm	Operate at 3.3V or 5V
Gikfun	31mm diameter	5V	4 Ohm	Not Prewired

Speaker Selection (Degraw Speaker Kit)

- We wanted a Speaker that would be able to signal to oncoming pedestrians that the iRobot system is going to spray its solution.
- So we landed on the Degraw DIY Speaker Kit would be the best fit for our project.
- The speakers are easily mountable , with an included amplifier; the only drawback is that the Degraw system has a high power draw but we should be able to lower the volume knob and lower the amount of power drawn into the system.
- All of the speakers are in the $10-$15 range but only the Degraw system comes bundled with an amplifier.

Degraw DIY Speaker Kit

Cleaning Solution Comparison

Cleaning Solution	Cost	Effectiveness	Misc.
Medical Grade	$24 per Gallon	Highly effective	Ready made solution to be used immediately
Consumer Grade	$36 per Gallon Concentrate	Moderately effective	Concentrate to be diluted
Self-Made	$10 per gallon	Moderately effective	Needs to be self mixed to proportions

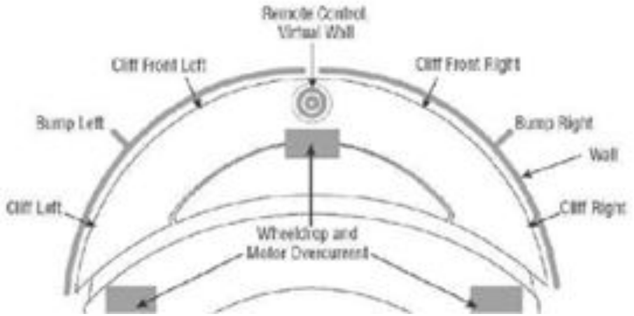
Final Cleaning Solution (Micro-Scientific Opti-Cide3)

- For this selection we wanted to choose the grade of cleaning solution that could have the most effectiveness of getting rid of bacteria and combating viruses.
- This was an easy choice of picking the hospital grade solution help us achieve this task.
- The Opti-Cide 3 Hospital Solution by Mirco-Scientific gives us the best confidence that it will be the most effective to properly clean and sanitize all germs and dirt in a given area.
- This formula advertises that it is Antiviral, Antibacterial and Antifungal; thus this would be the most optimal solution for our goal

Micro-Scientific Opti-Cide3

Existing Products and Technologies

- We wanted to take inspiration from some similar technologies that already existed when determining what our Senior Design Project would ultimately be.
- Logic and chassis design were taken from Roomba systems; Cleaning and Sanitation parameters were taken from Electronic Mop and UV-C Robots.
- We wanted to combine the ideas of being fully autonomous, cost effective and have the ability to sanitizing a specific area, all combined into one whole system.



Roomba Sensor Diagram

Existing Products and Technologies

- The Roomba is know from being fully autonomous and can read/maneuver an environment at ease.
- The UV-C Robot is very good and cleaning and sanitizing a selected area but is unable to freely maneuver around its environment.
- The Jet Mop has a trigger spray system but is unable to fully sanitize the area that it is in.
- On top of all this we wanted a product that would be able to move around movie theaters chains and gyms, while still being affordable and effective for the average consumer.

Jet Mop Spray Trigger Mechanism

Engineering Standards

- Motors, batteries, circuit board, disinfectant sprayer have been technically regulated
- We used various IPC standards for designing our PCB
- We have looked at different vendors for the PCB to compare cost and efficiency of the design
- Through power designer and webench we looked extensively for what kind of power sources would be the safest and most efficient

Ethical and Health Constraints

- Safety is of the utmost importance when releasing this product, this is why we wanted to make our product react to its environment around it with speed and agility.
- As a group we determined to add extra ultrasonic sensors mounted to the top of the chassis so we can meet our requirement of being able to react to its environment quickly.
- We have chassis designed with bumpers so if it does ever come into contact with something it won't do any harm or damage to it.
- We have also added a sound application to our system, in that when our system is about to spray its solution it shall emit a chime to indicate to all pedestrians that it is about to spray.
- Finally, the wiring and the control system of the PCB will be safety-proofed by our preferred vendor and will have every cable or electrical wire fastened down as to not get snagged onto anything.
- Disinfectant liquid used in hospitals

Current Budget

Component	Industry Price	Quantity	Total
iRobot	$199.99	1	$199.99
Custom PCB	$60	3	$60
Liquid Level Sensor	$38.25	1	$38.25
Color Sensor	$16.48	1	$16.48
Raspberry Pi	$40.48	1	$40.48
Raspberry Pi Voltage Convertor	$9.95	1	9.95
Total			$365.15

Recent Assigned Roles

Allan: Testing to see how our two boards will communicate

Abel: Deriving power information for PCB and some component testing

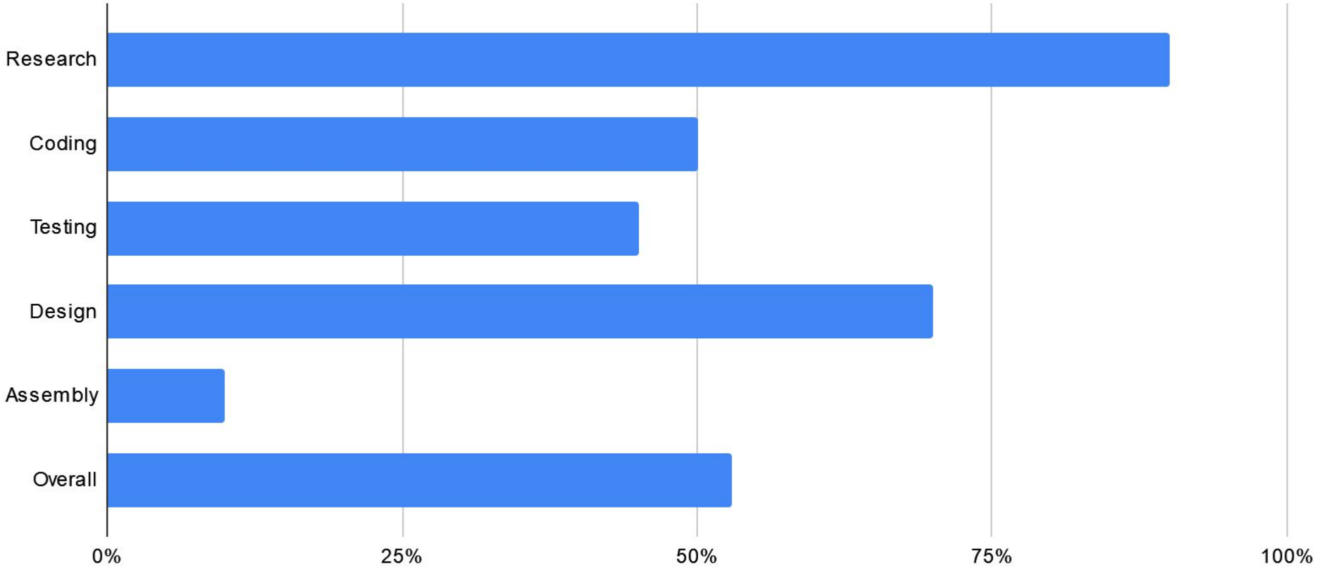
Shawn: PCB layout and design

Rishi: PCB vendor information and design

Current Objectives

- Install sensors on the Create 2 Programmable Robot
- Solder components onto PCB board
- Continue writing code for the Programmable Robot and sensors

Current Progress



Questions?