Autonomous Surface Disinfection Robot to Combat SARS-CoV-2

Monthly Report - March

IEEE REGION 3
ORLANDO SECTION

Overview

As previous reports have stated, the objective of this project is to design and implement an autonomous robot that can navigate a closed room and use germicidal UVC radiation to disinfect all of the surfaces in the room. Recently, we have been transitioning from the research phase to the prototyping phase of development. Our team spent the month of January researching the method of using UVC radiation in order to inactivate SARS-CoV-2. That research led us to a 30W (12.0W UVC output) model of lamp for our robot to use. Moving on to the month of February, we begun testing using actual equipment.

The following is a summary of the progress made in the month of February:

- We successfully implemented the necessary steps to automate the activation of UVC lamps.
- After stress-testing, we have decided to move forward with the infrared motion detector system of human detection.
- We have a tentative plan for the algorithm the robot will use during the disinfection process.

The project is still moving forward according to schedule. In order to stay on track for our desired November 2021 completion date, the following months should be spent writing and verifying the robot’s software, wrapping up minor details of the circuitry, and creating a mechanical design.

OVERALL PROJECT TIMELINE

2020

November - December
- Research UVC technology
- Divide subcomponent teams

January
- Select UVC lamps
- Begin electrical designs
- Research necessary sensors

February
- Prototype with sensors and lamps
- Continue circuit design
- Begin mechanical design

March - April
- Prototype with sensors and lamps
- Design complete circuit
- Design complete mechanical system

May - July
- Purchase mechanical components
- Prepare material for presentation (publication, donation, etc.)

August - September
- Assemble robot gradually
- Verify robot's performance at every stage of assembly
- Upgrade components if testing reveals necessary changes

October
- Purchase finalized PCBs
- Test robot in diverse environments

November
- Complete final testing
- Make final preparations for the project's real world implementation

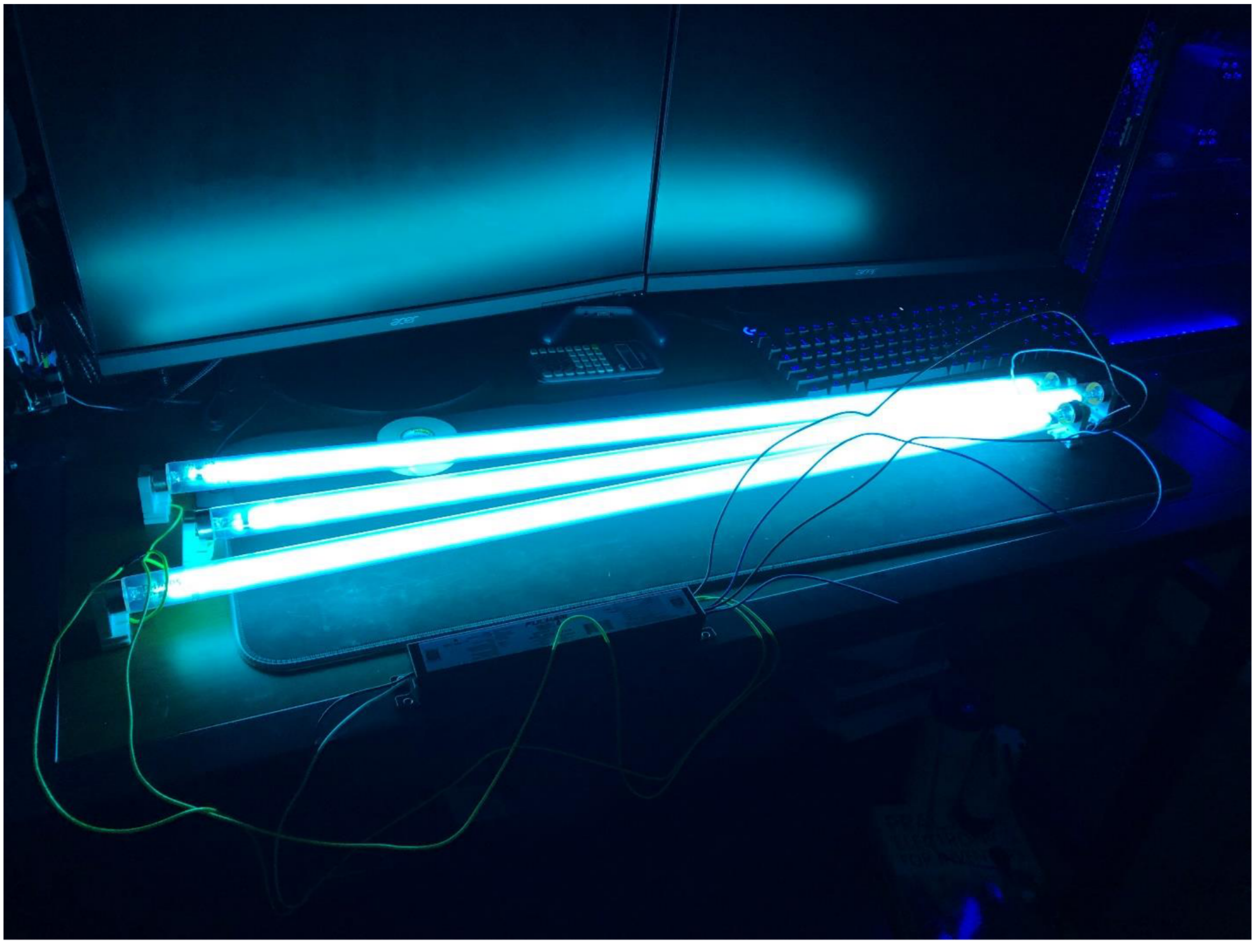
2022

Progress: Electrical Components

The electrical team devoted most of its efforts this month to verifying the UVC lamps we intend to use. We acquired multiple different fluorescent lamp ballasts for testing. The reason we chose multiple was because the lamp manufacturer did not provide a clear guide on what ballasts would be compatible with the lamps. After plugging the lamps into each of our test ballasts, we decided to use the WHSG4-UNV-T8-IS model ballast. This ballast is capable of providing power to four of our 30W UVC lamps at a time. Because of this, we are tentatively planning to use two such ballasts in the final robot with an array of eight lamps.

The datasheet for the selected ballast states that, while running four lamps, the total current draw should be approximately 0.72-0.93A. An exact figure is not available because the ballast was not designed for our specific model of lamp. Ideal calculations dictate that the total current draw should be $30W\ /\ 120V = 0.25A$ per lamp, or 1A per ballast. With a normal ballast factor of 0.88, it is natural that our ballast will output slightly less than the ideal current. For the sake of power calculations, we use the more conservative estimate of 0.25A per lamp to ensure that the necessary power can be delivered.

With eight lamps at 0.25A each, the total current draw of the AC components should be approximately 2A (240W of power). Therefore, it is necessary that we use a relay capable of carrying 2A in order to control the lamps. The relay we purchased for this purpose is an SLA-05VDC-SL-C, which activates at a DC input of 5V and has carrying capacity of 30A.



Three UVC lamps active at once for testing

It is expected that the lamps will consume most of the power in the robot. The following table provides a very basic look at how much power we anticipate will be necessary.

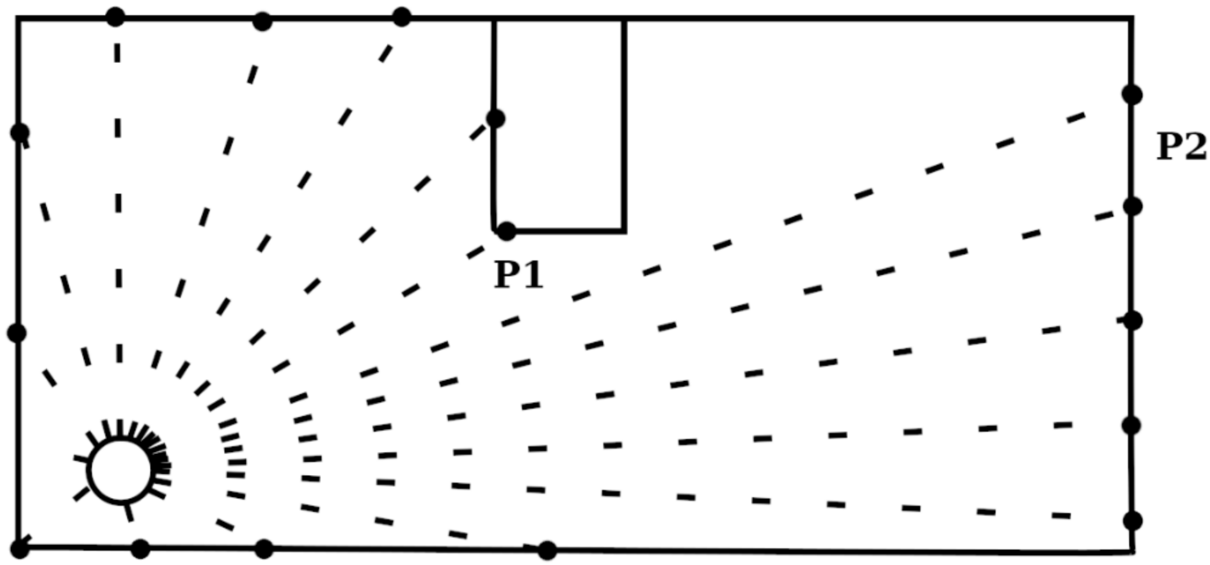
	Estimated current draw (A)	Voltage (V)	Power consumed (W)	Number of items	Total power necessary (W)
Lamps	0.25	120	30	8	240
Raspberry Pi	3	5	15	1	15
Motors	0.6	6	3.6	4	14.4

This totals up to 269.4W necessary for robot function. Initial estimates called for a 400W power inverter with a 420W battery. We will likely use high estimates similar to those in the battery and inverter in order to ensure system robustness.

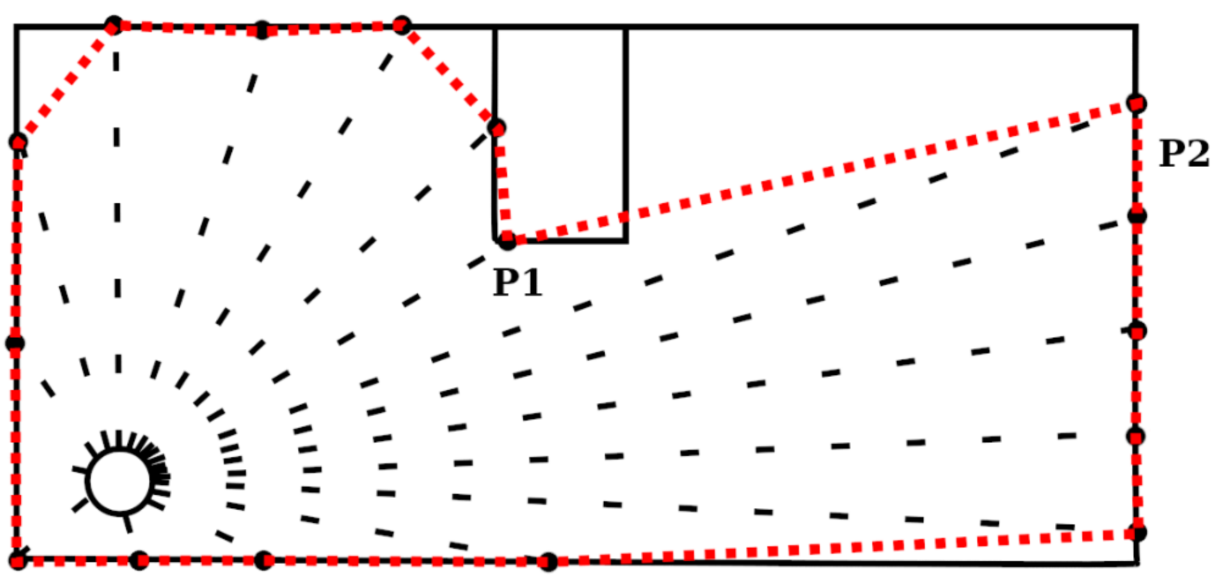
Progress: Software Components

As was mentioned in the previous month's report, our team has been prototyping with basic infrared motion sensors as a means of detecting the presence of humans in a room while disinfecting. After extensive testing, we determined that such sensors are highly accurate. As such, we intend to move forward with them as the primary detection mechanism. The downside to this system is that the motion detectors can only be employed at times when the robot is motionless. This means that the robot will need to frequently stop in place to use its sensors. According to the algorithm that we have been planning for the robot to use during the disinfection process, however, this should not be an imposition. Frequent stops will most likely be necessary for proper disinfection, anyway.

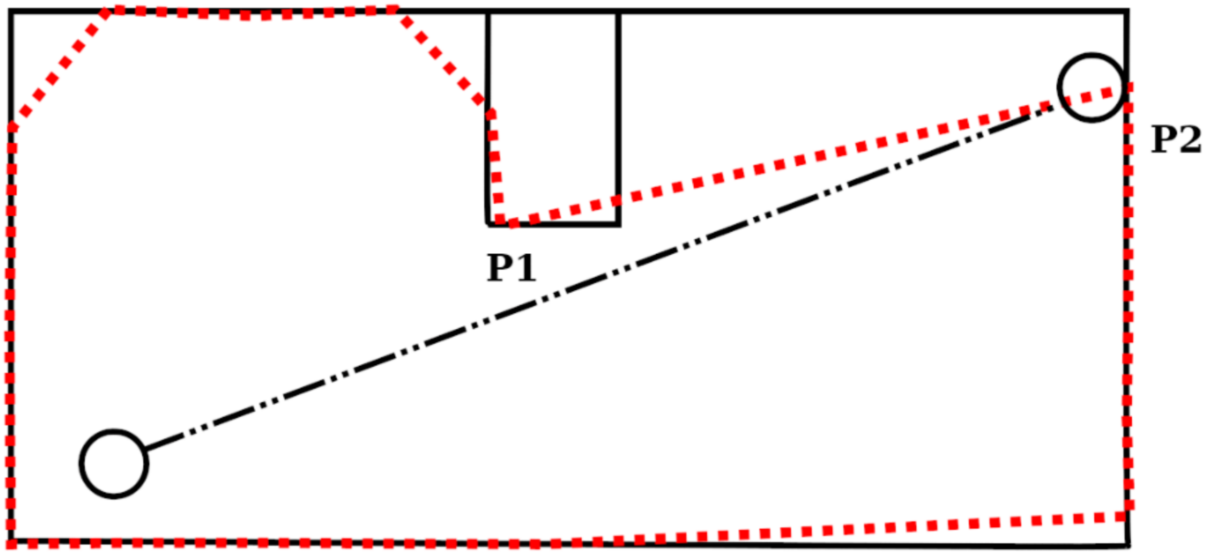
At this point, we are hoping to use a 2D LIDAR sensor as the robot's means of discovering its environment. This sensor has the ability to quickly generate a point cloud detailing where the nearest obstacles are to the robot. The following images demonstrate the algorithm we intend to use for navigation.



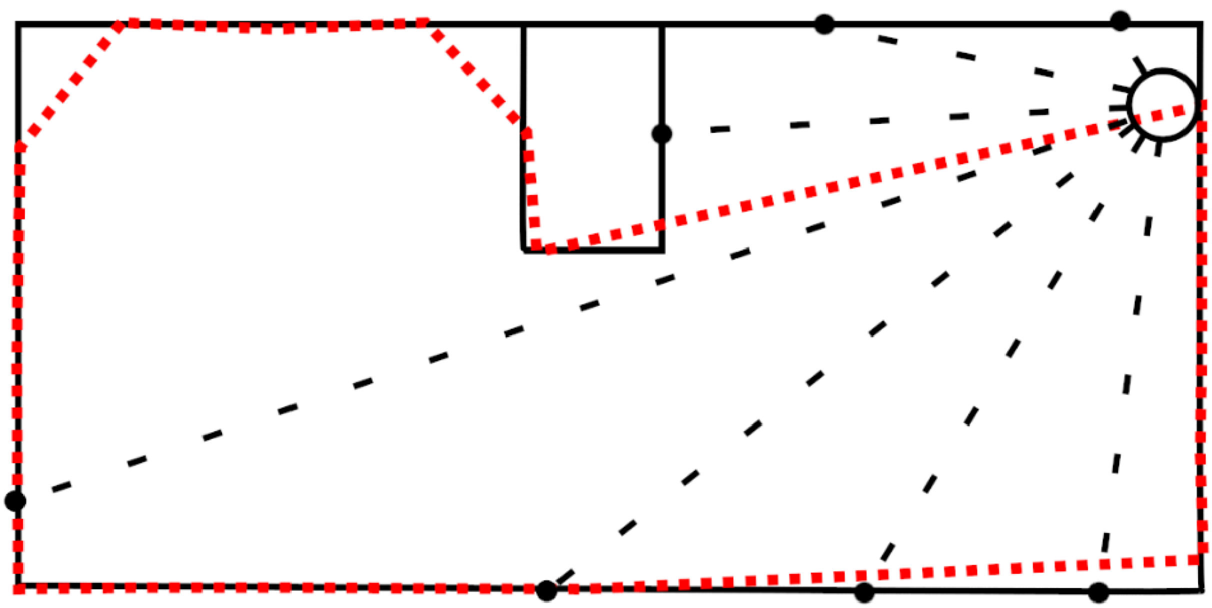
At first, the robot collects a point cloud. Actual point cloud density will be much higher than in this pictorial demonstration.



The point cloud is converted into a polygon that becomes the working model for the shape of the room.



The robot plans to travel toward the longest edge of the polygon. The longest edge of the polygon conceals a region that has not yet been mapped.



At its destination, the robot collects a new point cloud to be added to the existing map.

This algorithm will be used to create a map of the room the robot is traversing. After the room is fully mapped, midpoints will be marked throughout the room where the robot will go to begin disinfecting. The robot will most likely stay at each midpoint for 20-40 seconds. During this time, the motion detectors can be used since the robot will be standing still.

Next Steps

In the coming days/weeks, our team will focus on preparing a mechanical design for the robot, planning the robot's charging system, and writing the code that will be used to operate the robot's entire functionality.

Certification

I, Taylor Barnes, hereby approve of this documentation of the IEEE Orlando Section's pandemic project sponsored by IEEE Region 3, and I certify that the above information is a true and accurate depiction of the project's current progress through the month of March 2021.

3-1-21	Taylor Barnes
Date	Signature