Autonomous Surface Disinfection Robot to Combat SARS-CoV-2

Monthly Report –April 2022

IEEE REGION 3
ORLANDO SECTION

Overview

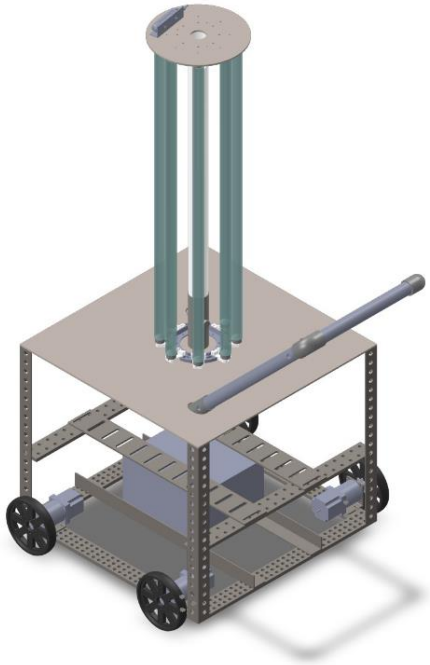
The IEEE Orlando Section's Autonomous Surface Disinfection Robot is a project with the goal of creating a robot that can autonomously navigate a room and disinfect all of its surfaces using UVC radiation. The following is a summary of the progress made as of the month of April 2022 across the multiple teams:

- Mechanical:
    - The entirety of the robot's frame has been designed, for which the AISI 1010-grade steel has been acquired and CNC'd.
    - The frame is in the process of being welded.
- Electrical:
    - The following components have been acquired:
        - 1x 12V DC 75Ah battery
        - 1x 12/24V DC-to-120V AC 300W power inverter
        - 1x Intel RealSense D415 depth camera
        - 1x Arduino Mega 2560
        - 4x TB6600 stepper motor drivers
        - 4x HKT22 optical rotary encoders
        - 4x 57STH56-2804B 1.8 degree 2.8A stepper motors with 15:1 gearboxes
        - 1x BerryIMU V3
        - 1x SLA-12VDC-S L-C relay
        - 2x WHSG4-UNV-T8-IS ballasts
        - 8x Philips TUV T8 30W 1SL/25 UVC lamps
- Software:

- The following packages have been created:
  - Frontend
    - Web application
  - Backend
    - Arduino
      - serial
    - ROS
      - a_star
      - asdr
      - berry_imu
      - coverage
      - discovery
      - mobile_hardware
      - rest
      - rotary_encoder
      - serial_command_client
      - stepper_motor
      - uvc_light

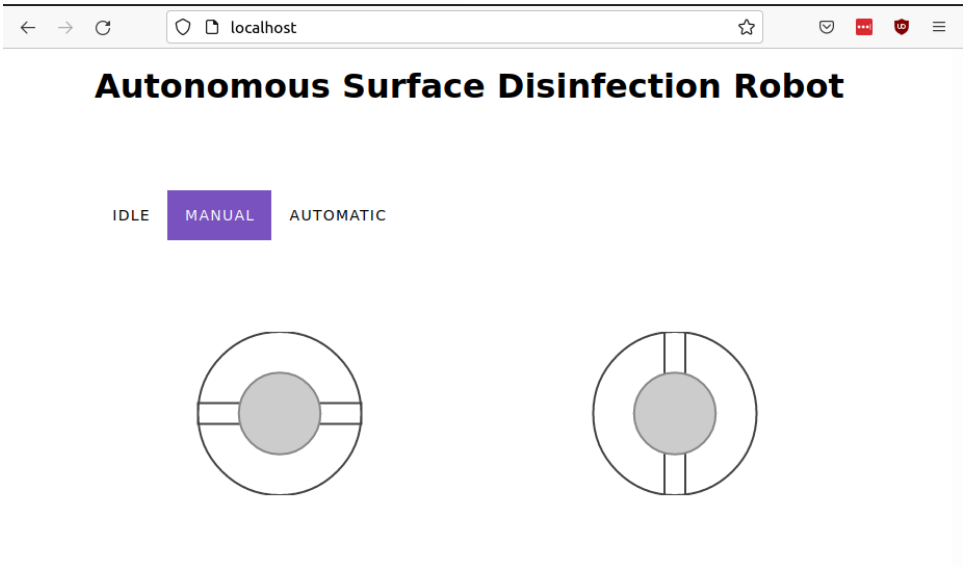
Progress

The mechanical team has made extraordinary progress and have completed the entirety of the frame's design. The steel for the frame has been acquired and CNC'd, and is currently in the process of being welded. An image of the full assembly (with battery, motors, wheels, lamps, and depth camera included) can be seen below.



Likewise, the software team has also made extraordinary progress. A multitude of necessary packages have been created. A frontend web application has been designed using Vue and Vuetify, providing a user interface that allows the robot's state to be controlled via a REST API. The three following states can be chosen by the user: "Idle", "Manual", and "Automatic". When in the "Idle" state the robot is completely idle, waiting for user input. When in the "Manual" state the user has two joysticks available to control the robot. The left joystick controls the angular velocity of the robot (rotation about its relative z-axis), while the right joystick

controls the linear velocity of the robot (translation about its relative x-axis). When in the "Automatic" state the robot begins its automatic disinfection process. A screen capture of the "Manual" state can be seen below.



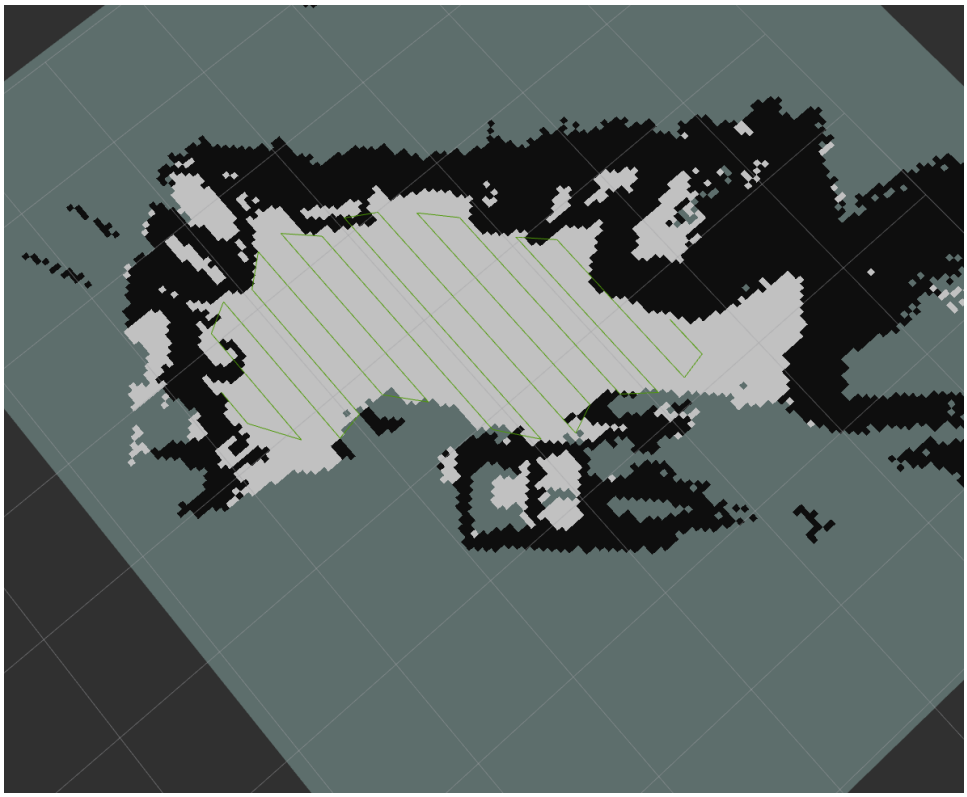
The backend aspects of the robot are controlled by the Robot Operating System (ROS), which is not an operating system as the name would suggest, rather it is a set of frameworks that provide XMLRPC protocols for communication and allows for hardware abstractions. All of this heavy lifting is performed on an HP EliteDesk 800 G2 (4-core 2.5Ghz CPU, 16GB RAM, 512GB HDD) that does not come equipped with the GPIO and I2C interfaces needed to interface with the hardware. As such, all GPIO and I2C are offloaded to an Arduino Mega 2560, which the central computer controls via USB.

The ROS packages currently implemented are the following:

- a_star
    - The A* algorithm for creating an obstacle-avoiding path for a given occupancy grid. Will be used in the future to create our own “move_base” package that issues velocity commands to navigate to a given goal.
- asdr
    - The core package of the robot that implements a finite state machine using the HFSM2 library and allows for complex behaviors.
- berry_imu
    - The BerryIMU is connected to the Arduino via I2C. This package is used to communicate with the Arduino and read from our inertial measurement unit.
- coverage
    - The coverage path planner that generates a coverage path for a given occupancy grid.
- discovery
    - The breadth-first search algorithm that discovers the nearest “unknown” cell in a given occupancy grid. This package is used to programmatically generate a complete map of an unknown room.
- mobile_hardware
    - This package issues read instructions to the optical rotary encoders and write instructions to the stepper motor drivers when issued motor velocity commands.
- rest
    - The REST package implements the REST API to allow for communication between the web application and the robot via HTTP.

- rotary_encoder
    - The optical rotary encoders are connected to the Arduino via GPIO. This package is used to communicate with the Arduino and read from our optical rotary encoders.
- serial_command_client
    - This package implements the actual behavior used to communicate with the Arduino via USB.
- stepper_motor
    - The stepper motor drivers are connected to the Arduino via GPIO. This package is used to communicate with the Arduino and write to our stepper motor drivers.
- uvc_light
    - The UVC lights are connected to the Arduino via GPIO. This package is used to communicate with the Arduino and turns the lights on and off.

Shown below is an image of a coverage path generated on an occupancy grid using the “coverage” package. Black represents an obstacle, light grey represents navigable floor, dark grey represents unknown regions. The green line is the coverage path that the robot will navigate while disinfecting.



Next Steps

Over the next month the frame will be welded, after which our team can begin mounting all of the components on the robot for initial real-world testing. Software-wise, the “Automatic” state of the web application needs to implement visuals to indicate the whereabouts of the robot within the map of its room, as well as display the percentage-of-completion of the disinfection process. Additionally, the mechanical team is researching the possibility of designing a motor-to-pinion gear-to-internal gear mechanism that would allow the depth camera to perform a 360-degree rotation about the top of the robot, which would obviate our current implementation where the depth camera is fixed on the top of the robot and the robot itself performs a 360-degree rotation.

Certification

I, Casey Sanchez, hereby approve of this documentation of the IEEE Orlando Section's Autonomous Surface Disinfection Robot project sponsored by IEEE Region 3, the UCF Office of Undergraduate Research, and the UCF Student Government Association, and I certify that the above information is a true and accurate depiction of the project's current progress up to the month of April 2022.

2022-04-01 Casey Sanchez

Date Signature