Beach Swarm - Phase II

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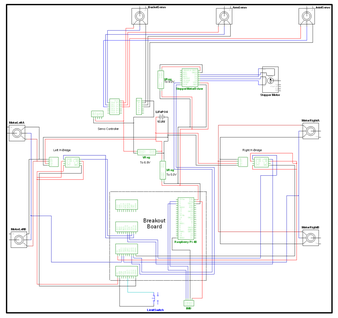
Abstract

Beaches are becoming more littered by trash that is discarded by humans worldwide. Currently, there are methods for cleaning trash from beaches that usually entail large, expensive machines that may not be accessible for all types of beaches. This project is focused on developing a multi-robot solution for cleaning beaches in an effective manner. Using the engineering design process, our team gathered information about beaches to design prototypes, tested designs, and build a functioning proof of concept multi-robot solution.

Project Goals

- Smallbot must maneuver on sand and drive at a speed of 0.5m/s
- Bottom half of the Smallbot must be water resistant
- Onboard gripper must collect both bottles and cans
- Onboard bucket must have the capacity to store at least one can and one plastic bottle
- Smallbot must be equipped with a variety of sensing components to ensure proper maneuvering and localization throughout the cleaning routine: IMU, Apriltags and a camera
- Vision system must detect plastic bottles and cans as litter

Electrical Design

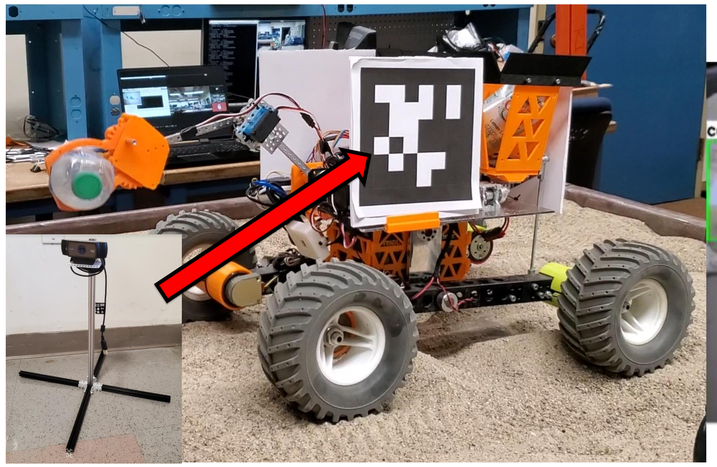


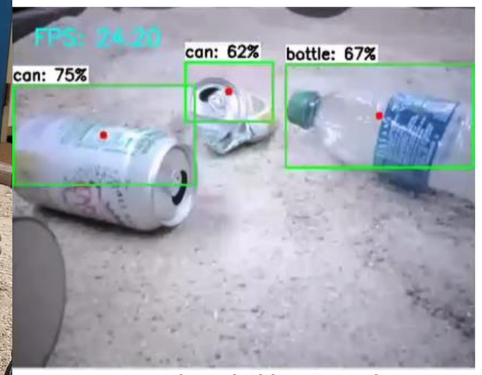
Smallbot Schematic

Smallbot

- 12.8V Battery: to power the Smallbot for 6hrs
- Voltage regulators: for stepper motor driver, servo controller, and Raspberry Pi
- H-Bridges: used as motor controllers for speed and direction
- Raspberry Pi Breakout Board: used to connect additional electronics to the Pi
- Servo Controller: to actuate the servos onboard the Smallbot

Results





Camera View of Object Detection

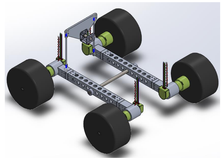
Visualization of Working Multi-Robot System

- Basebot uses Apriltags for Smallbot localization
- Reliable TCP communication between both systems
- Smallbot follows path planned by Basebot
- Smallbot collects cans and bottles
- Smallbot places litter in bucket and returns to start location
- Smallbot dumps litter from the bucket
- Object Detection with TensorFlow Lite Model
- Reliably recognizes multiple objects at once: bottles, cans

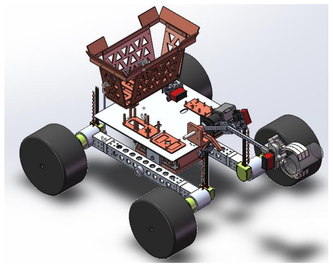
Mechanical Design

Smallbot

- Rocker-bogie can be drivetrain over uneven terrain
- 2 Degree of Freedom Arm
- Storage Bucket



Rocker-bogie Drivetrain



Smallbot Full CAD Design

Gripper

- Two finger geared by servo
- 3D printed with grooves to help gripping bottles and cans

Gripper design

Software Design

Smallbot

- Uses TFLite, machine learning model to detect litter

Basebot

- Generates a path for the Smallbot to follow based on visual feedback from the camera
- Uses Smallbot's onboard Apriltags to localize the robot directing Smallbot to follow path

Communication

- Basebot uses TCP communication to send commands to the Smallbot

Localization with Apriltags

TCP Communication With ESP32 as the AP

Future Work

- Expand on Basebot functionality by implementing Smallbot swarm
- Improve gripper to collect a wider variety of trash
- Further train object detection model to recognize a wider variety of objects
- Increase bucket size to hold more objects

Acknowledgments

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