MALC

The Marine Autonomous Litter Collector

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Abstract

Millions of sea creatures die each year due to the consumption and entanglement in the 322 million tons of plastics that our ocean holds. This project aims to aid the removal of plastic pollution from our oceans by building an autonomous device that will collect waste and bring it to a base station for processing. The criteria is to have an autonomous and manually driven vehicle that can carry 5 kilograms of trash and run for 10 minutes. These are the basic needs to have a device capable of picking up trash.

The device was tested in a pool so that it could have a controlled environment where the speed of the boat and how well it could collect trash could be tested. The trash that the device collected was multiple two liter soda bottles, water bottles, and plastic bags. Through many trials of testing the GPS over certain lengths it was determined that the GPS was approximately 93% accurate. The average speed of the boat to be approximately 0.1m/s. The device drove for a distance of 3.5 meters while time was recorded.

The GPS was adequately accurate, although this was in a limited testing environment. The results would have been more representative of real-world use had the device been tested over a larger distance. The speed of the device was disappointing, however there are many points of failure that could be in a future iteration of this project. The main loss of energy in the system was the extremely inefficient propellers which did not properly convert rotational kinetic energy into translational kinetic energy because they were not able to to exert much force against the water. In a future version, premade propellers could be used, instead of making custom propellers, The other main point of failure were the underpowered motors which simply could not produce enough speed and torque to move the device.

With all the trash currently in the oceans and the lack of other solutions, the project has the potential to be used to help clean large bodies of water. There are many other features that can be improve or redesign to maximize the efficiency of the device.

Background Research

Currently, there are 5 trillion pieces of trash, weighing 322 million tons of garbage in the ocean. This garbage pollutes the water and sea animals ingesting the trash, thinking that is is food. The project aims to help remove trash from oceans. Not many companies have tried to solve this problem. Although there are many concept designs, only a handful have worked and even less have made it to the market. Currently, the best design is the Waste Shark robot which has many issues that make it not very reliable.

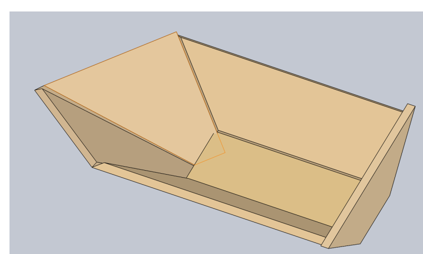
The design of this boat is tailored specifically to collect solid debris from any body of water. With a pontoon-type build, this design takes advantage of the open undercarriage of the ship to allow for a compact and streamlined way to collect trash. In addition to this design, the material of the boat will be made out of plastic for ease of fabrication and less water resistance. The body of the boat contains the electronics and will have a protective, waterproof covering to keep the electronics from experiencing any possible water damage. Propellers at the end of the boat will be used to propel the boat forward as it collects garbage. Additionally, the boat may be able to release its payload of trash at a specified location such that it can continue to collect garbage.

The main part of the electronics will be a Raspberry Pi. This part will be in charge of processing the code and also for communications to other devices via WiFi. An issue with the Raspberry pie is that it cannot pass strong electrical currents through it to power the motors. To solve this, motor controllers will be used. These will let the high voltage motors be controlled by the Raspberry Pi. The motors will be around 12 volt DC motors and the motor controller must be able to power those. Although the Raspberry can be controlled by a human operator over WiFi, the robot should be moving autonomously most of the time.

The software to be developed will help the robot move and detect trash around it. The code will be written using Java and Python. The Java code will consist of drive code, which will instruct the motors to move at certain times. The more complex and interesting part of the software in the machine learning and artificial intelligence (AI), the code written in Python. The purpose of the AI is to let the robot look for trash, and pick up the trash all by itself. To do this a convolutional neural network (CNN) will be used. The test images can be found on GitHub pages and there are others provided by universities.

This project will be based on the latest technology to help save our oceans. This technology helps make our life easier while also helping our environment. The vision for this project is to see a product that may be viable for use in oceans and other aquatic areas and make an impact on our world.

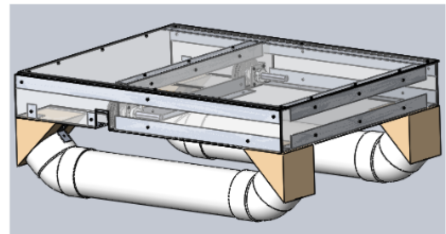
Mechanical Design

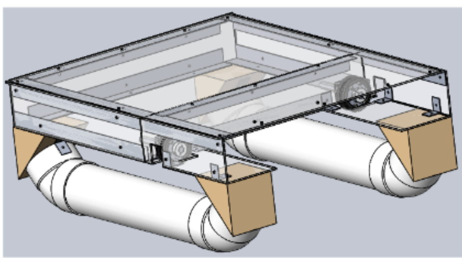


The first design was a wooden hull with motors attached to the hull. The idea was to make two of these hulls and attach a net in between to collect trash. The first design was very water dynamic, this made space for less powerful motors to move the device, also increasing the efficiency of the robot. This design was very lightweight and contained a large volume. By performing buoyancy calculations, I determined that the large inner volume let it hold the most mass in water. However, there were large drawbacks with this design. When a scaled down prototype was created, the building process was very difficult to

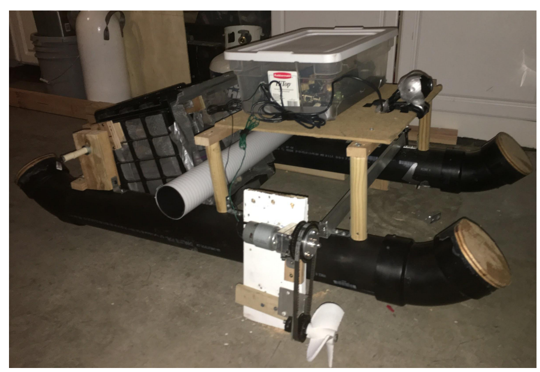
build a large scale model of this design. In addition to that, the general shape made it difficult to mount other objects to it in a way that does not capsize the device.

The second design used two large PVC pipes and curved end pipes, using this, a floating base can be made. On top of this, it is very easy to mount a covered board with motors and electronics that can be protected inside the polycarbonate shelter. This design is quite a bit easy to build with straight and simple cuts to assemble the frame. The extra space in the design allows for more powerful components to be added and other special mechanisms. As seen in the images of the CAD models provided, this design extensively uses special materials such as polycarbonate plastic that is not cheap and not always necessary.



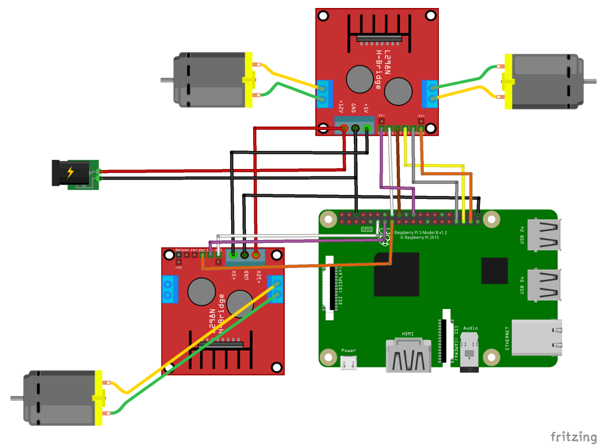


Based on all the earlier design, unnecessary parts that did not directly help in collecting trash were taken off of the robot. Larger pipes were used, changed the gearing ratio of the belts in a simpler transmission system, and added caulking to places that were vulnerable. This design was much easier to build and not very expensive. The final design sufficiently protects the sensitive electronics, is able to carry 36 kilograms of weight, and has ample space to expand. However, this frame is not as sturdy as it should be.



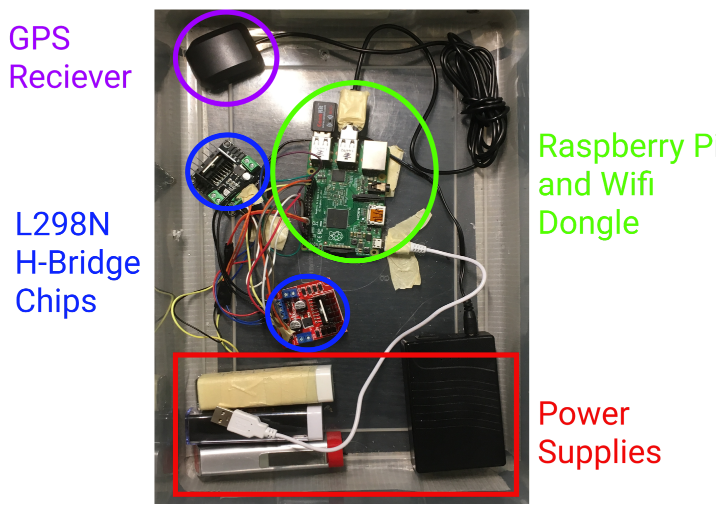
Electronic Design

The main components to drive the motors are:



- L298N motor controllers
- 12v Battery
- Raspberry Pi

The motor controllers can support up to two DC motors and run enough voltage and current for them. The motor controllers are connected to the Raspberry Pi. This is the module that will communicate with the computer and control the motors.



The other sensors on the robot are for vision and location tracking. These modules include a GPS sensor, and a camera. All of these modules are connected via USB to the Raspberry Pi.

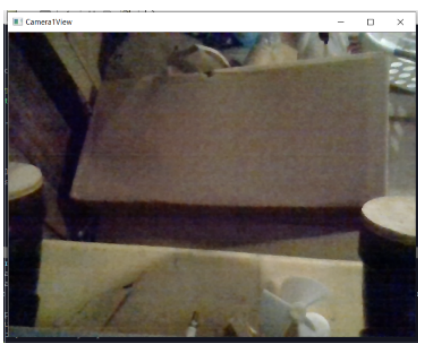
Software Design

To move the device the Python code uses the Rpi_Motor_Library and a library to use the GPIO pins on the raspberry pi. This allows the DC motors we put on the robot to be controlled as a stepper motor by using a square wave and changing the frequency to change the speed at which the motors turn. When used manually, the device is controlled using the arrow keys where each button click executes a separate function for the motors. The basic autonomas code works on the same principle, using either a pre-programmed circular path, or vision code to identify objects in the water.

The GPS code runs of the linux GPSD client, which is a seperate program that is able to use the GPS receiver. On the right, a small python script is shown which uses the GPSD client to retrieve data on what one’s coordinates are. During actual use, the robot is able to calculate how to travel to certain GPS coordinates using the Haversine formula, which can determine the distance and angle to travel.

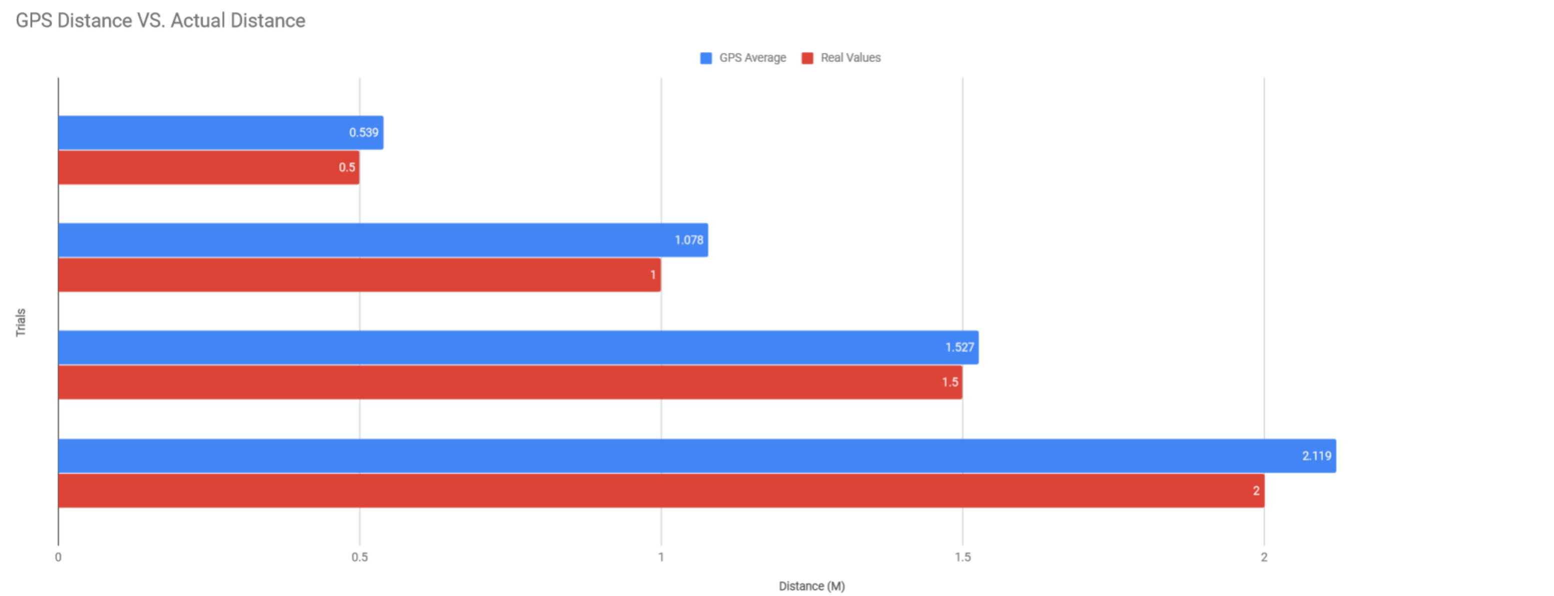
```
import gpsd

# Connect to the local GPS
gpsd.connect()

# Get GPS position
packet = gpsd.get_current()

print(packet.position())
```

The vision system implemented lets the robot identify pieces of trash. The vision code operates on a general purpose webcam and lets the view see where the robot is. (To the right is the basic Python script to relay video input from a camera to the user’s computer.) The vision operates on the OpenCV library, which can run the image through multiple filters to help identify the object.

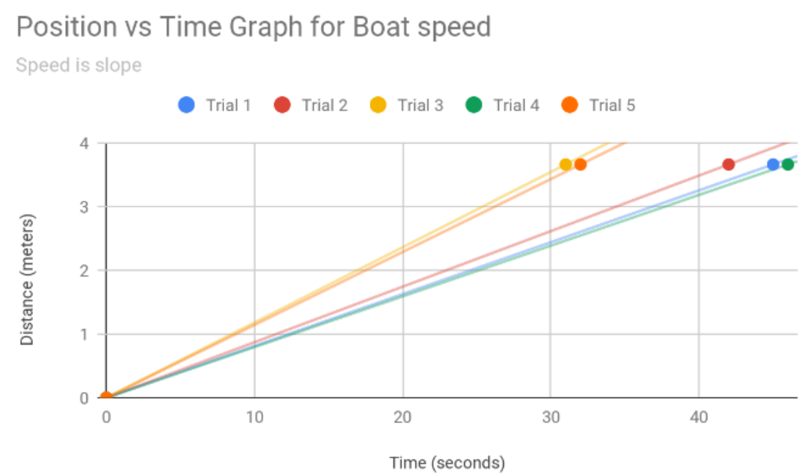


```
import numpy as np
import cv2 as cv


cap = cv.VideoCapture(0)

while True:
    ret, Camera1View = cap.read()

    cv.imshow('Camera2View', Camera1View)

    if cv.waitKey(20) & 0xFF == ord('q'):
        break

cap.release()
cap.destoryAllWindows()


```

Testing and Results



Trial, per distance	GPS Distance (m)	Actual distance (m)	Percent Error
1	0.534	0.5	6.80%
2	0.541	0.5	8.20%
3	0.541	0.5	8.20%
Ave	**0.539**	**0.5**	***7.70%***
1	1.079	1	7.90%
2	1.083	1	8.40%
3	1.072	1	.7.20%
Ave	**1.078**	**1**	***7.80%***
1	1.559	1.5	4.93%
2	1.472	1.5	1.90%
3	1.623	1.5	8.20%
Ave	**1.527**	**1.5**	***5.01%***
1	2.085	2	4.25%
2	2.172	2	8.60%
3	2.101	2	5.05%
Ave	**2.119**	**2**	***6.00%***



The GPS accuracy is around 93% accurate. The tests were performed by measuring different lengths, and then moving the GPS sensor that certain length. The python script would then calculate the distance that the GPS receiver moved. The GPS sensing is at proper standards.

The speed graph was made by measuring out a certain distance for the device to cover, and timing the device as it travels. These are the most disappointing results. The boat travels very slowly, at around 0.1 meters per second.

Conclusion

The vessel created can retrieve free floating debris and solid waste-from the surface of the water. The watercraft is semi-autonomous and has an onboard GPS system that is used to track its path traveled. Through extensive testing data on the catamaran identifies its GPS accuracy, speed, and carrying capacity. These tests were carried out in controlled environments, and in residential property. With the known data and fully constructed pontoon trash collection is done without extensive human supervision. With the addition of the GPS system the watercraft can trace its path and return to a specified area to dispense of the collected waste. One of the primary fallacies in the tests were, all of the tests were performed in controlled residential environments. This insinuates that external wind, current, or other natural obstacles on the water have not been accounted for during testing.

With all the trash currently in the oceans and the lack of other solutions, this project has the potential to be used to help clean large bodies of water. There are many other features that can be improve or redesign to maximize the efficiency of the boat. In order for the design to make a lasting impact upon the marine environment many modifications could be made to streamline and optimize M.A.L.C. For the future of this device, future research utilized to delve into the optimization of M.A.L.C should regard the following: a) A more compact and efficient way to store and dispose of collected pollutants, b) An efficient system for turning both the propellers and garbage dump, c) The effectiveness of M.A.L.C in polluted waters for a real-life representation.

Bibliography

- Yang, Mindy, and Gary Thung. *Classification of Trash for Recyclability Status*, cs229.stanford.edu/proj2016/report/ThungYang-ClassificationOfTrashForRecyclabilityStatus-report.pdf.
- Rojas, Juan. *Plastic Waste Is Exponentially Filling Our Oceans, but Where Are the Robots?* Cornell University, 6 June 2018, arxiv.org/pdf/1809.00798.pdf.
- “How Do Convolutional Neural Networks Work?” *Brandon Rohrer*, brohrer.github.io/how_convolutional_neural_networks_work.html.
- Mishra, Gopal. “Waterproofing in Buildings - Methods and Types of Waterproofing.” *The Constructor*, 1 Sept. 2018, theconstructor.org/concrete/types-waterproofing-methods-buildings/10856/.