Senior Capstone Design Project

Mechanical Engineering
Carnegie Mellon University

Perry : Autonomous Aquatic Debris Cleanup

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Problem Description:

The world's aquatic ecosystems are i**ncreasingly becoming dumping ground** for countries To leave waste, much of which **damages the environment. This project explores electromechanical aquatic cleanup processes and aims to design a low-cost system to remove trash from the water's surface.**

Customer Needs and Specs:

Survey Takeaways

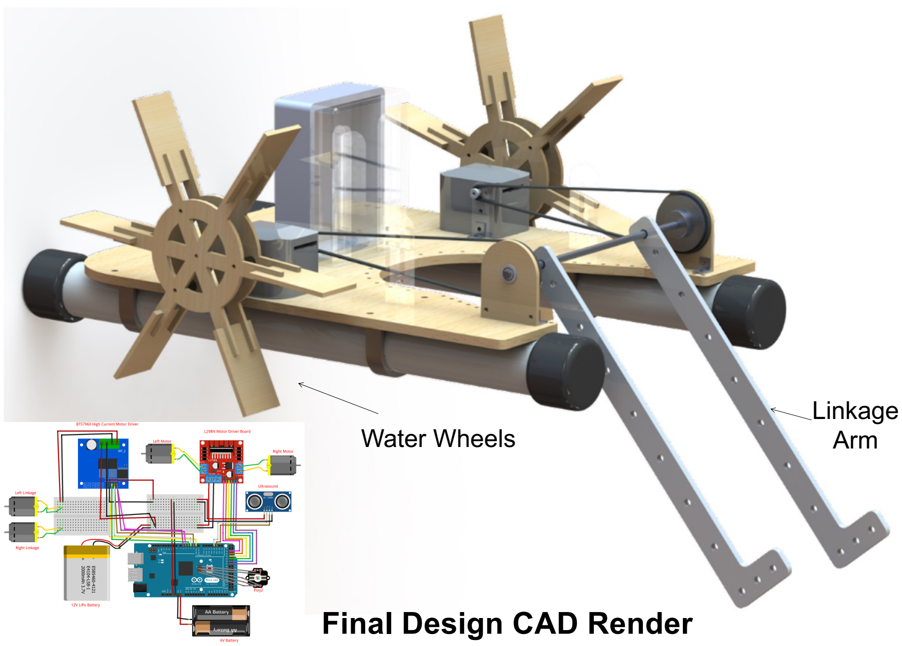
1. **High cleaning accuracy**
2. **Ease of use**
3. **Covers large aquatic surface area**

Note: Surveyed conservation NGO leaders & workers, professors, & students. Approx. 15 responses.

90% Detection Accuracy At least 9/10 objects considered to be trash placed in the field view must be detected.	**90% Intake Accuracy** Once the trash is detected the product must move towards the object and the intake mechanism must place the object into storage.	**3m Range** Can accurately detect debris that is within a 3m range form the camera.
25s Intake Time From time of detection to storing the debris, the service should last 25 seconds.	**1.5 m/s Propeller Speed** Drives at walking speed which is ~1.5 m/s to ensure effective surface area coverage. This may seem slow, but the customer prioritizes accuracy over speed.	**Waterproof Capabilities** Prototype is built to be robust so that it can withstand various environmental conditions.

Concept Description:

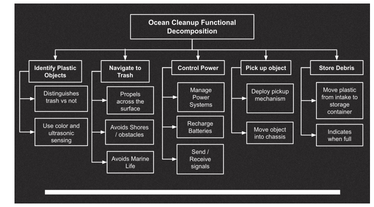
A successful prototype will include a sensor package that can accurately detect floating trash and lever arm with netting that will center on the object, pick it up, and transfer it to storage where it will be removed at the end of each power cycle. The final prototype will bring these functionalities together to be able to demonstrate an autonomous floating device that can locate and pick up water surface debris.



Final Design CAD Render

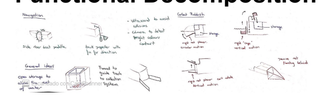
Concept Selection Criteria:

- **Item Identification**
  - Color sensor, ultrasonic, depth sensor
  - Waterproof electronic setup
- **Navigation**
  - Paddle wheel propeller on a pontoon/ catamaran style hull
- **Collecting Debris**
  - Fixed net that rotates and scoops debris
- **Storing Plastic**
  - Passive storage that is netted and open at the bottom



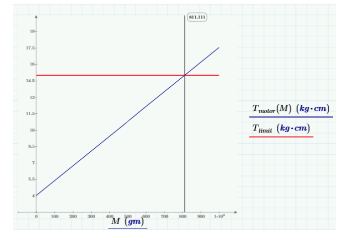
Functional Decomposition

Concept Sketches



Analysis:

- Power limit: we can actuate the linkage at a speed of w = 1.4rad/s (13 rpm) our optimum was making ¼ of a revolution in 25 s (0.6rpm)
- The combination of both motors in the linkage offers 1.6 Kg of lift (assuming no drag)

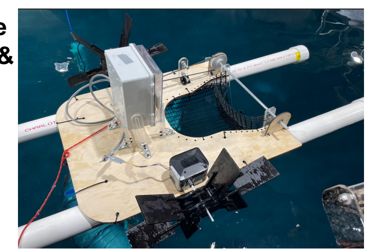


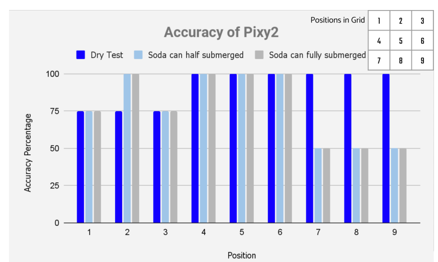
Linkage Arm Torque Calcs

Testing:

- Pixy2 camera testing proved effective for navigation
- Ultrasonic distance sensing is used to determine when to enter "Lift" state

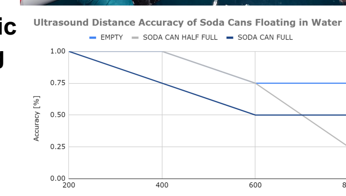
Testing The Navigation & Detection Software





Pixy2 Sensing Data Recap

Ultrasonic Sensing Data Recap



Conclusions:

The prototype achieves all 6 customer needs and fulfills the problem description. In order to create a product from this, we would create a design that can be mass manufactured. Our trash-cleaning robot has an advantage against competing concepts due to its low cost, light weight, and autonomous ability.

QR Code to Final Aquatic Demo Video