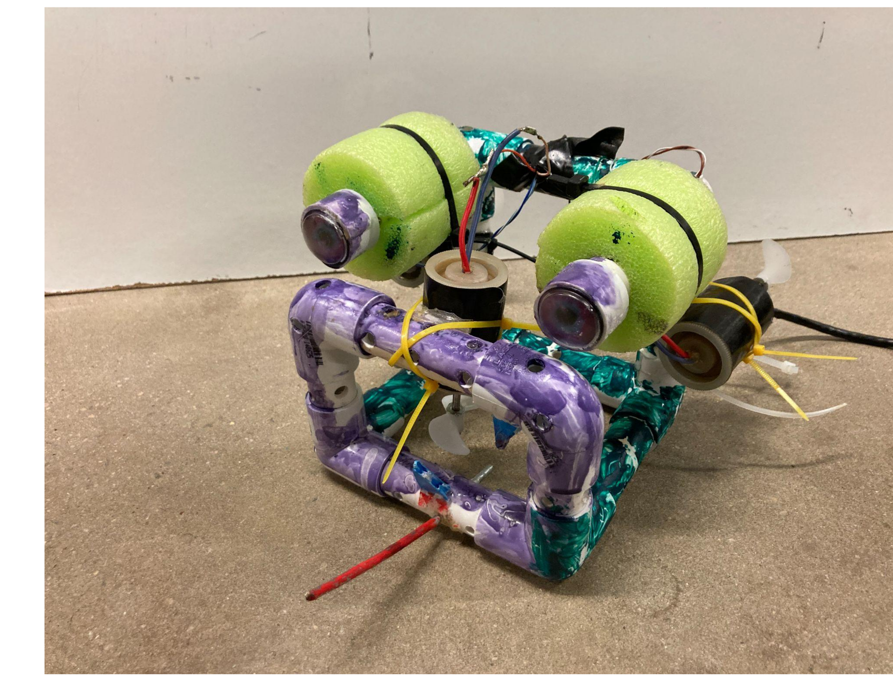
Ideaventions Academy for Mathematics and Science

The Piranha: Tackling the Microplastics Issue



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1. Introduction

- Our ROV, the Piranha, was designed to efficiently tackle issues regarding coral reefs such as ocean pollution, ocean acidification, and coral bleaching through reef monitoring and transport of marine samples with a focus on microplastics and the potential use of PlanktoScope technology.
- It was built using the engineering design process: brainstorm, design, build, test, and revise.
- For our build, we focused on the aspects of hydrodynamics, neutral buoyancy, efficiency in carrying objects, and solid maneuverability and control.
- The Piranha is a unique ROV with features-such as a hook-to make it extra effective underwater.

2. Motivation and Background

- "The living world can't operate without a healthy ocean, and neither can we." -Sir David Attenborough
- The issue we focused on specifically during our build was microplastics in our oceans and how they negatively affect the reef ecosystem.
- The theme for the 2025 SeaPerch competition, coral restoration, impacted our design process.
- At EPA's coral research facility located in Gulf Breeze, Florida, they found that long-time exposure to microplastics impeded corals' growth (*Tiny Plastics, Big Threat: How are Microplastics Impacting our Coral Reefs?*, 2025).
- A PlanktoScope could be adapted to study and monitor microplastics around reefs. It is an affordable, compact device using Raspberry-Pi 4, Pi camera, pumps, and multiple lenses to study micro-plankton communities. An AI model is then used to identify the species (*PlanktoScope,* n.d.).
- Also, plankton help absorb 30-50% of the world's carbon dioxide and they provide the foundation of a global food chain. Monitoring micro-plankton communities using this technology could also benefit the fight against climate change around reefs.

References:

Tiny Plastics, Big Threat: How are Microplastics Impacting our Coral Reefs? | US EPA. (2025, February 4). US EPA. https://www.epa.gov/sciencematters/tiny-plastics-big-threat-how-are-microplastics-impacting-our-coral-reefs

PlanktoScope. (n.d.). https://www.planktoscope.org/discover

3. Methodology

Brainstorm/Design:

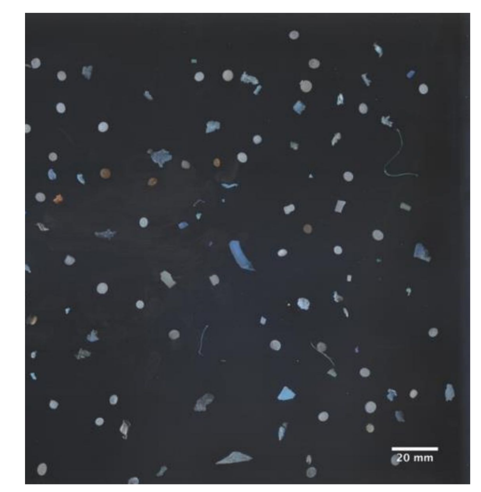
- List pros and cons of each proposed design
- Decide on ROV model
- Prototype v0: conceptual design idea
- Prototype v1: physical design
  - Research optimization of PlanktoScope on our ROV

Build:

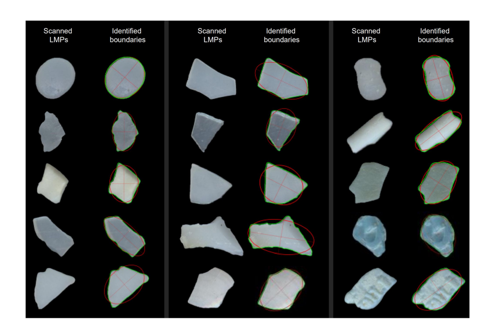
- Split work among team members
- Build frame, assemble controller, and waterproof motors
  - Integrate PlanktoScope with ROV.
  - Design considerations:
    - Larger frame
    - Stronger vertical motors
    - Weight balance
    - Should operate with 12V source
    - Should be able to go 5m deep
    - Save data on SD card

Testing:

- Test model in pool
- Record results and make improvements
  - Integrate PlanktoScope and test more. Make revisions as needed.
  - Larger scaled testing–select test location (VA Beach)
    - Analyze real-world data
    - Apply AI model to monitor microplastics
    - Construct multiple ROVs and deploy to worldwide coral reefs



Scanned images of large microplastics collected in a quadrat (Gauci, 2019).



Scanned LMPs, identified boundaries (in green) and the corresponding fitted ellipsoids (in red). (Gauci, 2019).

Image Credit: Gauci, 2019

Gauci, A., Deidun, A., Montebello, J., Abela, J., & Galgani, F. (2019). Automating the characterisation of beach microplastics through the application of image analyses. *Ocean & Coastal Management*, *182*, 104950.

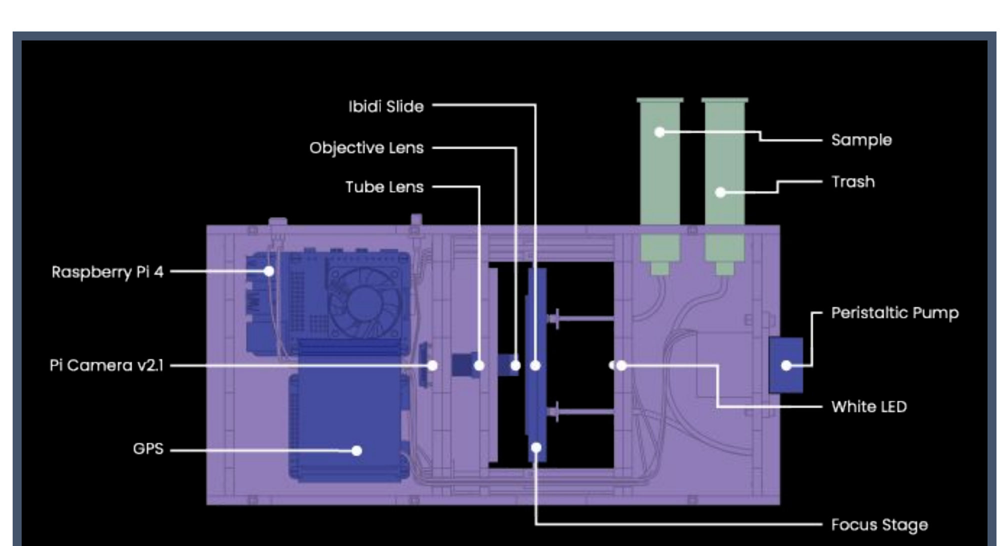
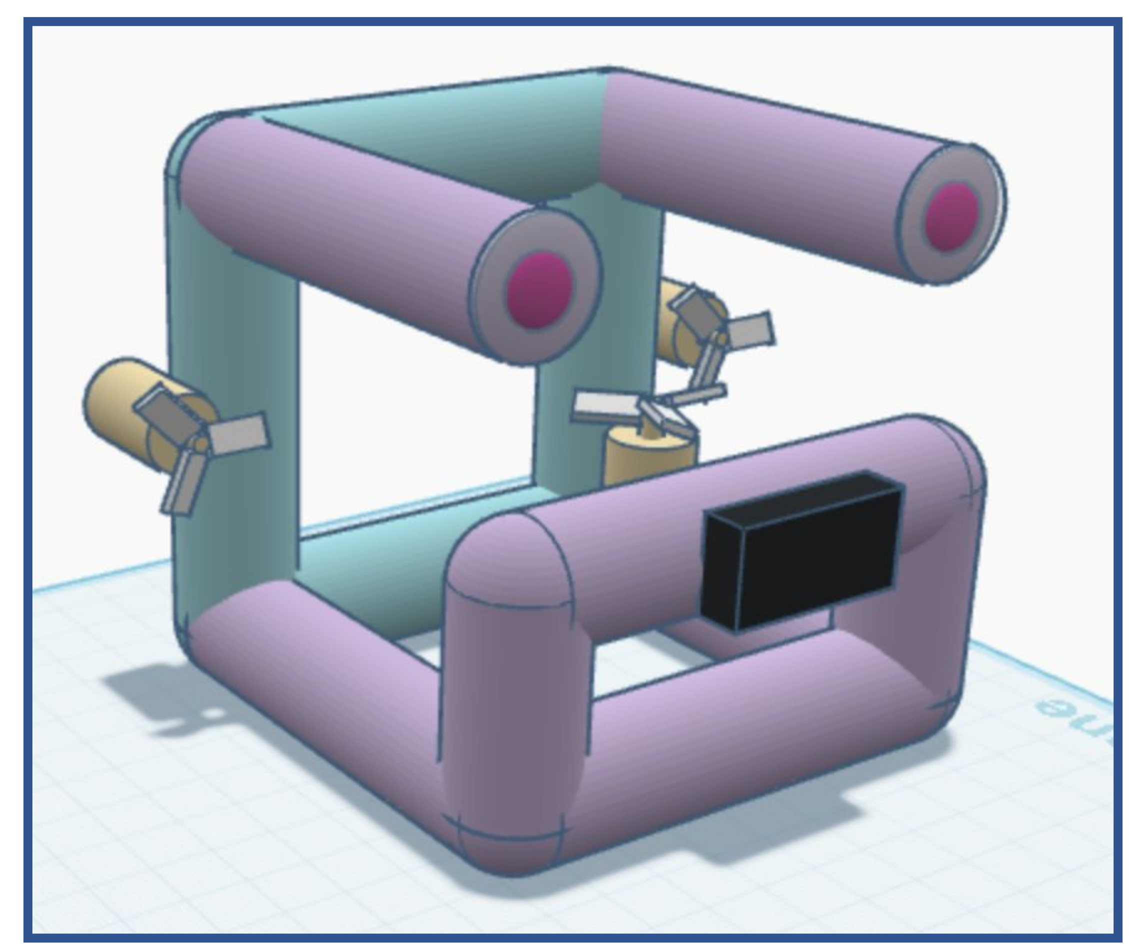


Image Credit: PlanktoScope. (n.d.). https://www.planktoscope.org/discover

Our design is based on adapting the Planktoscope to image and classify microplastics. The modified device would be mounted to the SeaPerch ROV and water would be sampled.

4. Experimental Design

- For our ROV, we decided to make it smaller than last year, so that it would be able to move faster through the water and also be able to navigate throughout the coral reefs easier.
- In order to identify the different microplastics of coral reefs, we would mount a microscope and camera–the PlanktoScope–to the front of the ROV, that would be capable of sampling water and image any microplastics present.
- This camera would take in information from the outside world and send it to an AI model on a Raspberry Pi onboard the PlanktoScope that would be able to identify the coral and monitor the microplastic and how it's affecting reef health.



5. Results

- During tests it performed well, although it had a few problems: the motors were waterlogged and wax-logged, and controls were reversed.
- By our run at SeaPerch Regionals, we had fully fixed the motors, and the driver had already gotten used to the controls, so it was better to leave the controls the way they were
- During our run at the regional competition, we completed the obstacle course with a time of 1 minute 21 seconds, and we scored 40 points on the mission course.
- The upward motor was in the front of the ROV, which made it tilt whenever we tried to use it. This made it harder to control; however it also allowed us to move the ROV faster when it was going up without carrying anything.

6. Discussion

- Our ROV was efficient and accomplished the tasks quite well as discussed in the Results section.
- Prototype v0 meets design considerations. Prototype v1 would require a modified ROV controller (button to trigger data collection) and frame.
- Strengths:
  - Low-cost
  - Easy to repair
  - Uses data and unsupervised study of microplastics
- Weaknesses:
  - Waterproofing extra electrical components
  - Retaining good maneuverability despite extra bulk

7. Conclusions and Caveats

- Our ROV performed quite well overall during the tests, which is why we were able to make it to the International Competition.
- Prototype v0 provides a reliable model to study microplastics efficiently in reef ecosystems using a proven imaging system.
  - It could be used to sample and quantify microplastics
  - It is low-cost so this idea could scale into something bigger and be applied worldwide.
  - It could act as a precedent for other ROV models to collect scientific data.

8. Next Steps

- Our first step would be to build and test a full prototype while integrating the Planktoscope into the ROV frame. We would also reduce unnecessary weight, and evaluate more powerful motors in order to make the ROV maneuverable with the added mass of the microscope and camera. In order to control the ROV, we would rebalance the motors to have the vertical motor in the center, make the center of mass in the center of the ROV, and update the controls to remotely operate the camera and sampling. Lastly, we would try different variants of our ROV prototypes and train and evaluate the AI model for detecting microplastics.