Intelligent Beach Cleaning Robot

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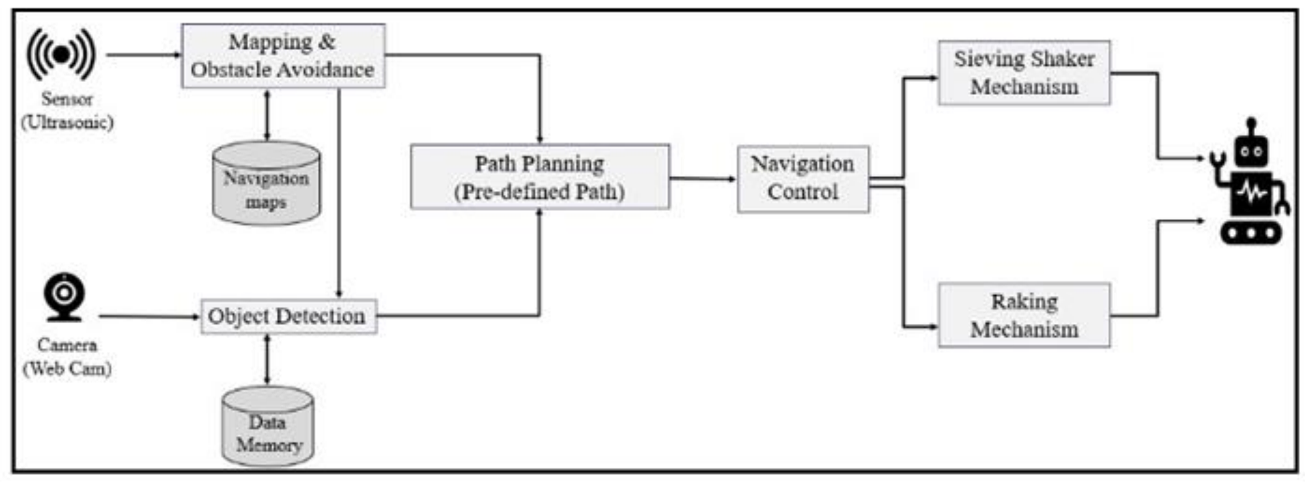
Introduction

- Coastal pollution, especially plastic and debris accumulation, threatens marine ecosystems.
- Manual cleaning is labor-intensive and insufficient, requiring advanced technological solutions.
- This research proposes intelligent beach cleaning robots with dual refuse collection mechanisms, object detection, autonomous navigation, and obstacle avoidance.
- These robots integrate cutting-edge technology with environmental stewardship, offering a promising solution to safeguard beaches and reduce human labor.
- Introducing the Intelligent Beach Cleaning Robot as a pioneering solution to combat coastal pollution and ensure sustainability

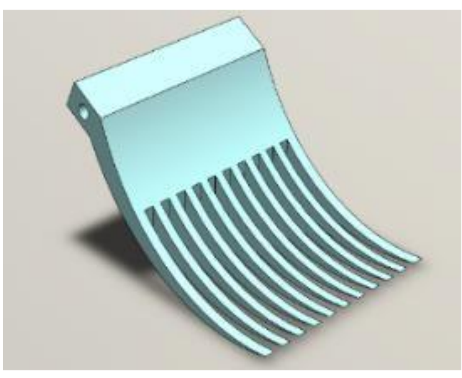
System Overview

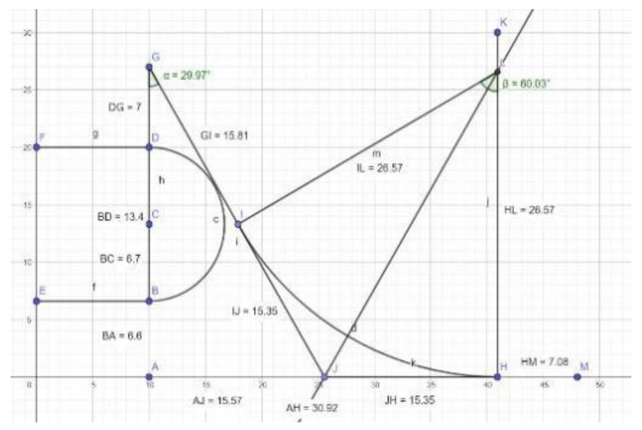


- Combines advanced technologies for efficient refuse collection.
- Features raking and sieving mechanisms for optimal waste gathering.
- Utilizes YOLO-based object detection for precise identification.
- Includes autonomous navigation with obstacle avoidance for safe movement.

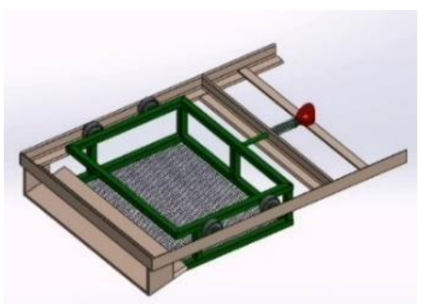
Raking Mechanism

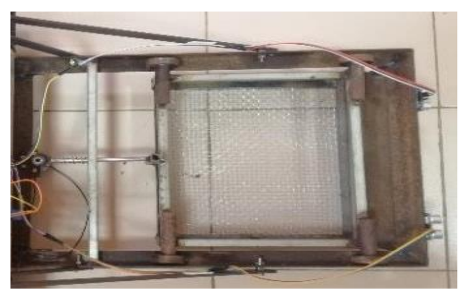
- Rake-like implement with a revolute joint arm for debris elevation into a dustbin.
- Rake branch - 30:31 dual curve bending and 1.6 cm spacing within the array.
- Dimensions: 32 cm width, 25 cm length, 20.4 cm height from the ground.
- Optimized for lifting surface-level debris, complemented by object detection for efficient operation.





Sieving Shaker Mechanism



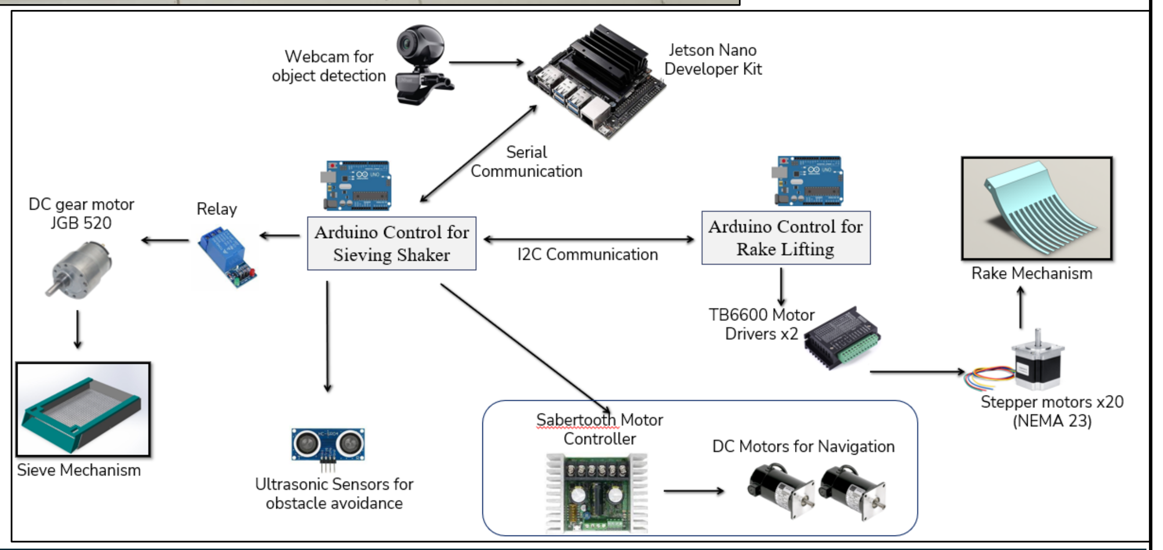


- Includes a sand director and vibrating mesh to sift through sand and retain solid waste.
- Fabricated using steel and sheet metal for robustness.
- Dimensions : Sieve Frame dimensions are 40 cm x 36.5 cm.
- Vibrating Mesh dimensions are 30 cm x 24.5 cm, each cell of the mesh measures 5 mm x 5 mm.
- Targets larger debris categories, allowing smaller sand particles to pass through.

Prototype Configuration Overview

Constructed Prototype of Beach Cleaning Robot

System Diagram with Components

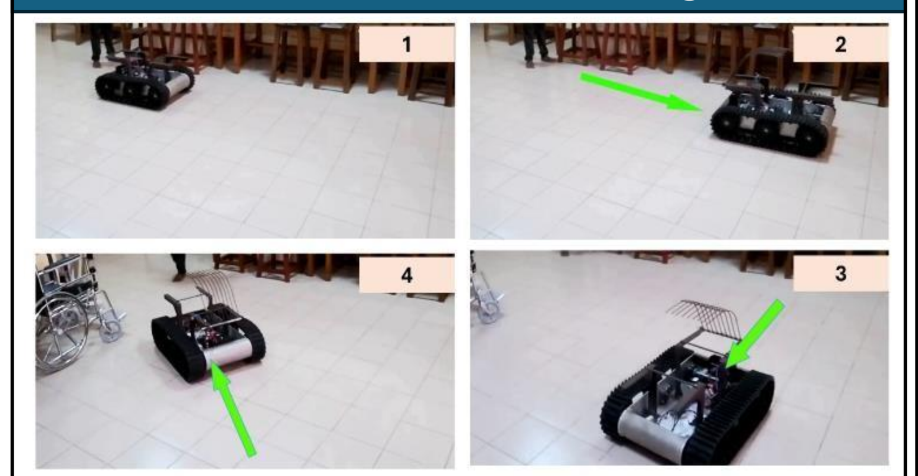


Object Recognition & Distance Estimation

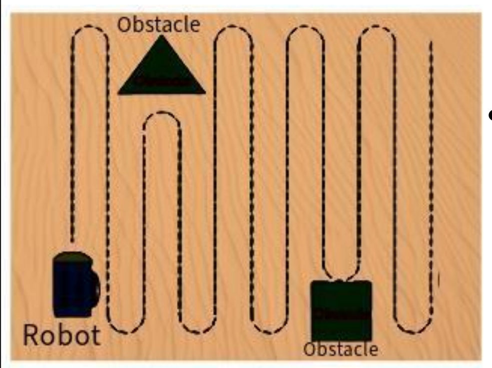
Real time recognition in sample environment

- Real-Time Detection using a simple web camera.
- Focal Length calculated using reference images of known object dimensions and Distance Estimation Function was Developed.
- Potential for Improvement: System shows potential for enhancing accuracy and efficiency in real-time scenarios.

Predefined Path Planning

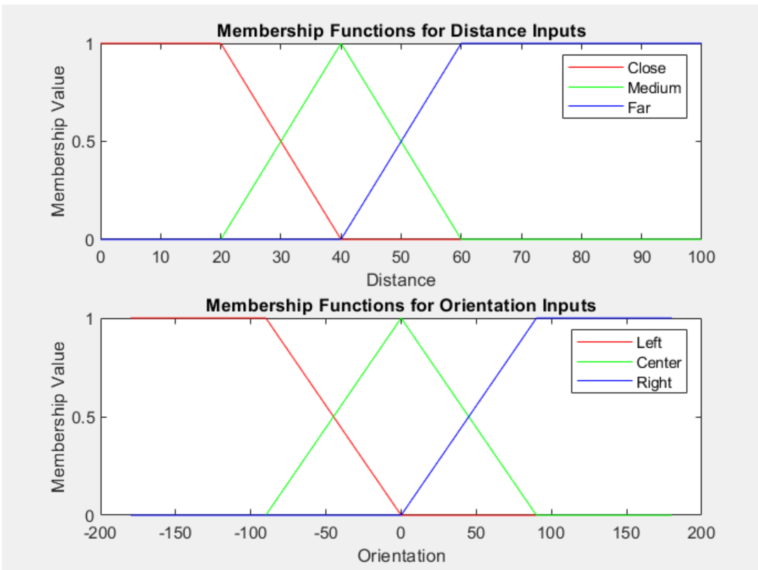


Navigation in Lab environment



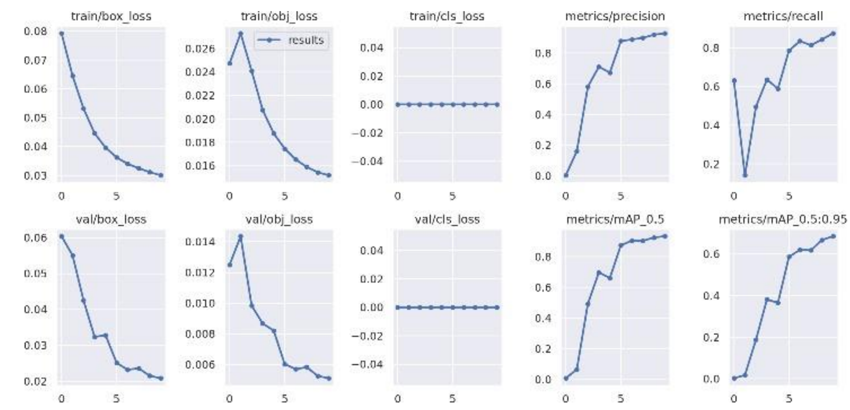
- Raking - Uses YOLOv5 for the plastic collection along the path.
- Sieving - Sensor inputs guide the robot for optimized sand filtration.

Obstacle Avoidance & Fuzzy Logic

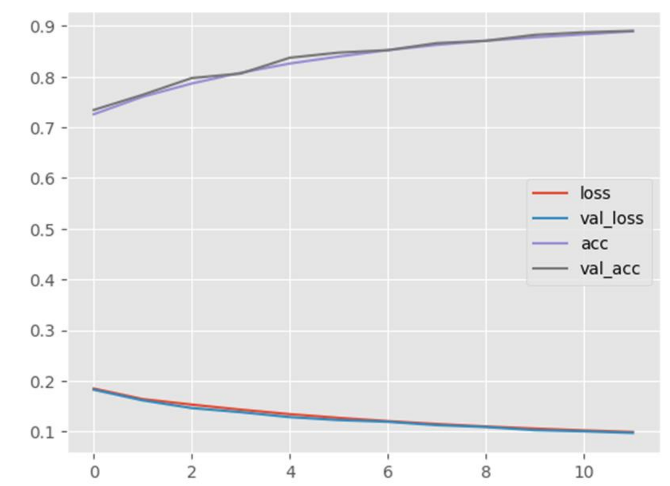


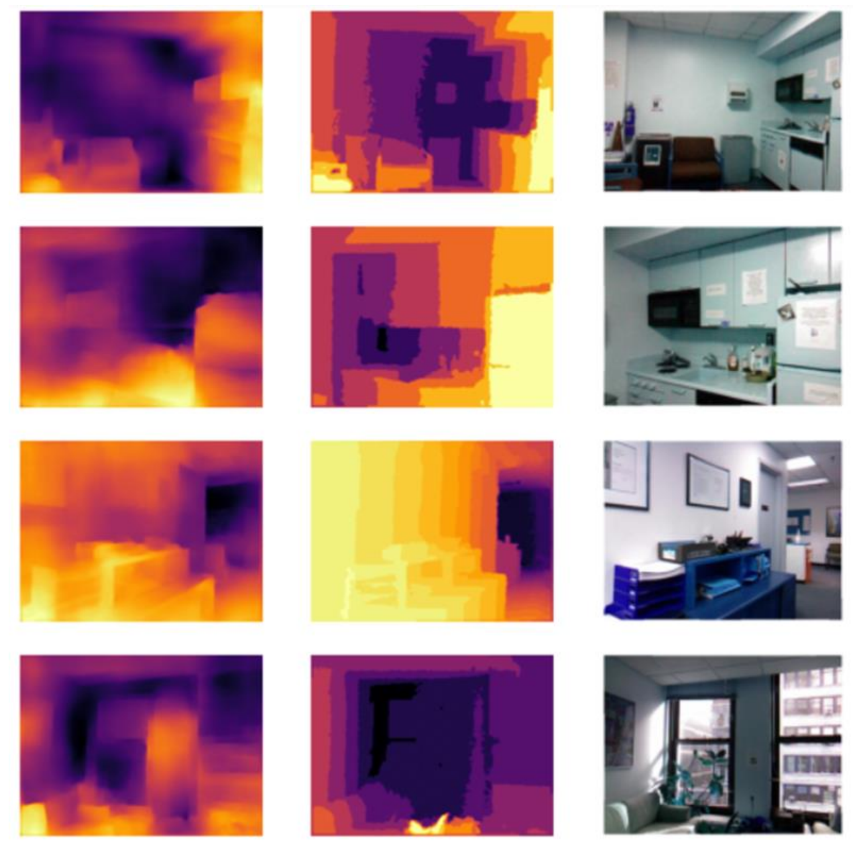
- Three ultrasonic sensors on each side detect obstacles.
- Fuzzy logic helps determine the robot's turning direction when obstacles are encountered.

Results & Discussion



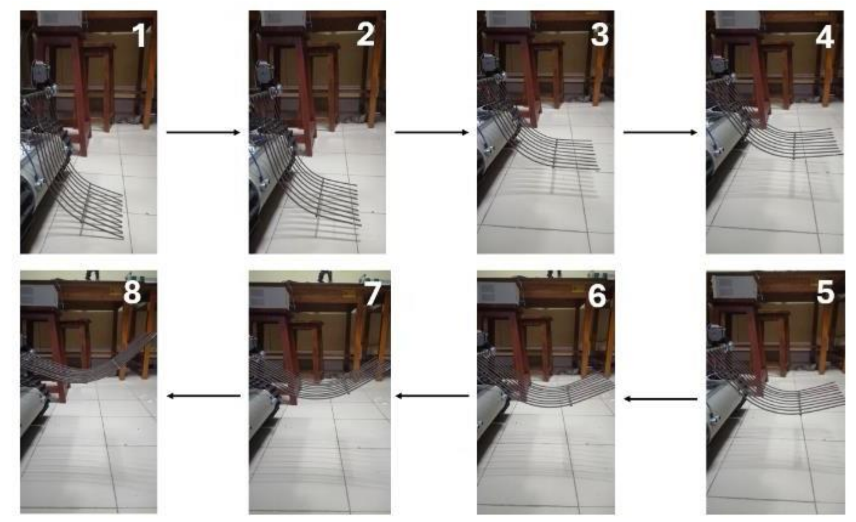
High Detection Accuracy of 93% for plastics using the YOLOv5 model trained on 16,000 images.



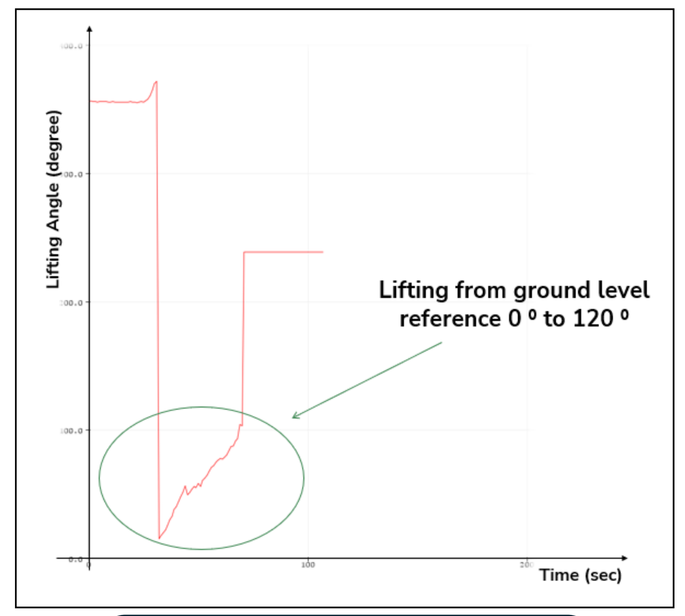


NYU Depth V2 dataset after the process of depth

Our real time depth map creation estimation



Lifting phases of Rake



Lifting Angle vs Time - from IMU sensor

Conclusion

Our prototype fills a crucial gap in beach cleaning robotics, addresses coastal pollution challenges, providing a robust and sustainable solution for effective beach maintenance. The key highlights and impacts include,

- **Effective Cleanup Operations -** Demonstrates significant efficiency in beach cleanup.
- **Plastic Pollution Mitigation -** Contributes to reducing beach plastic waste.
- **Sustainable Beach Management -** Promises a sustainable future for beach maintenance.

References

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