Towards an Error Tolerant Multi-Robot System for Roadside Trash Collection

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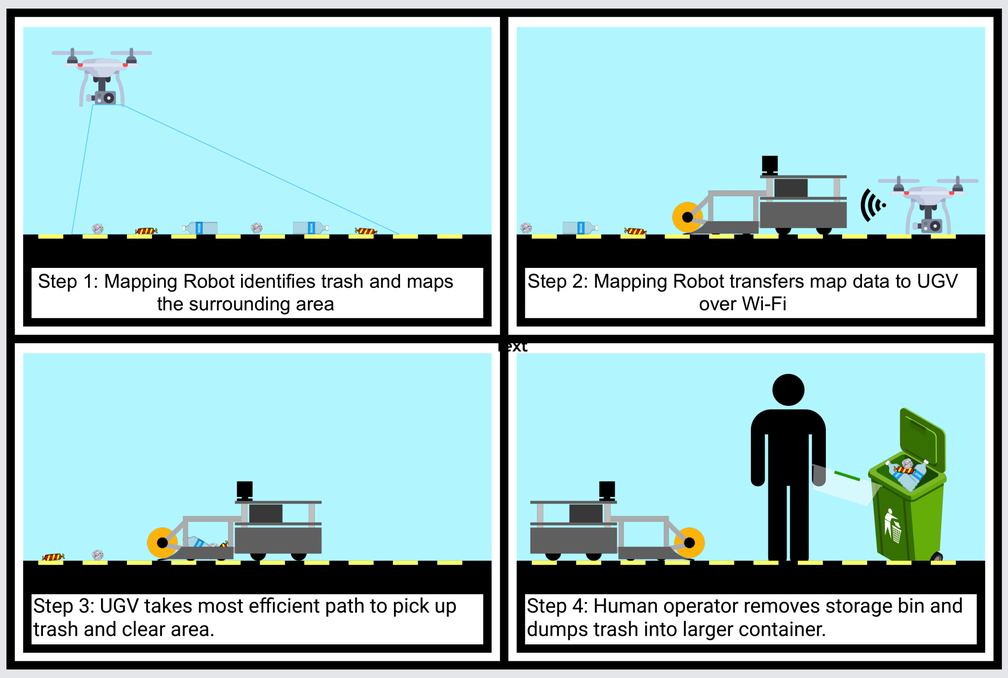
Objective

- **Autonomously collect litter**
  - Approximately 51.2 billion pieces of litter currently lie on roadways in the United States. The current solutions are expensive, labor-intensive and manual.
- **Proof of Concept for scalable and viable automative process**
  - A proposed three-stage approach to autonomously map, identify, and collect trash.
- **Preliminary analysis of repeatability and functionality**
  - Assessment of each of the three stages; mapping, identifying and collecting trash. In real world scenarios.

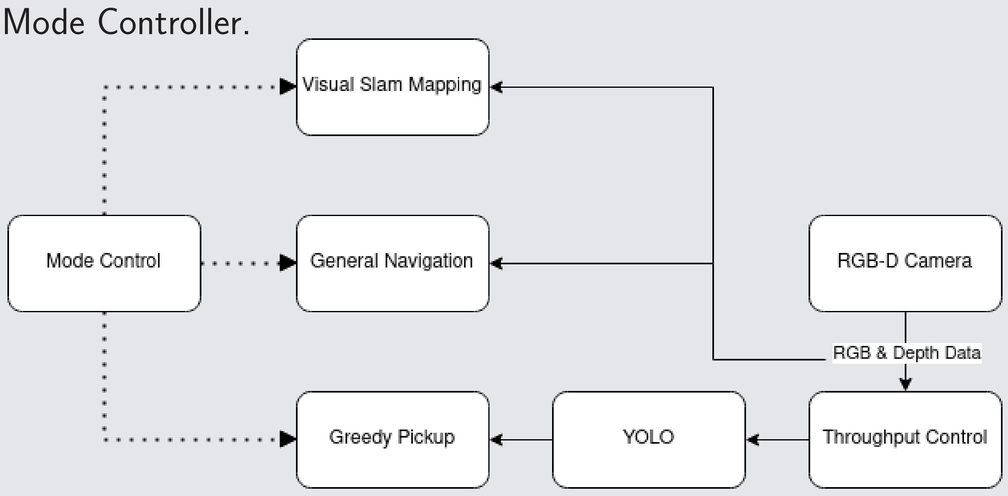
Proposed Framework

- We leveraged **Visual SLAM** to build a map of a given environment.
- We leveraged a **Convolutional Neural Network** to detect trash objects in the environment.
- We built a **Greedy Pickup Heuristic** to compensate for errors in mapping the environment and identifying trash.

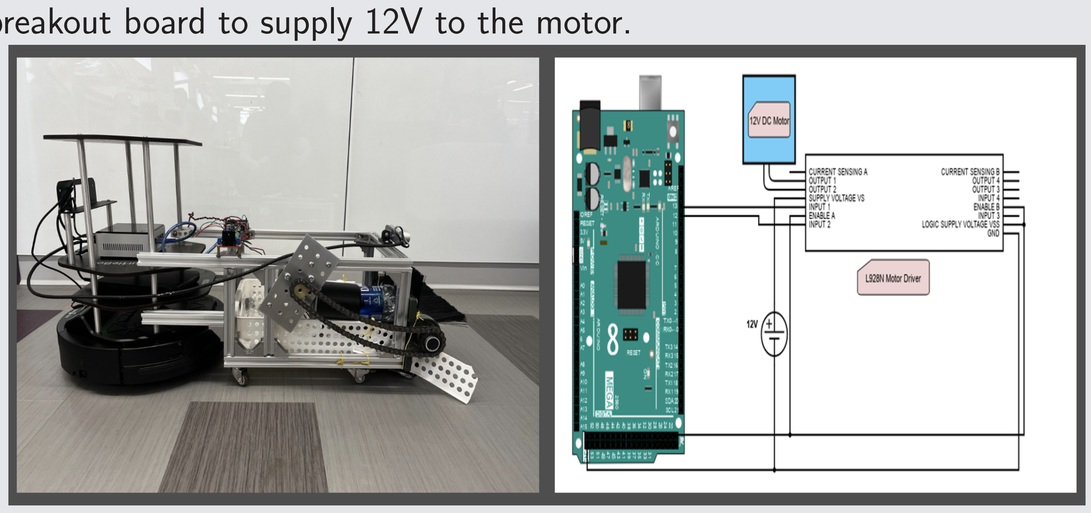


Design Overview

1. **Software Overview:** The software stack networks with ROS. An Intel Realsense D435 camera collects external data and each ROS node processes that data. The framework switches between the three stage approach using the Mode Controller.



2. **Hardware Overview:** The hardware design consists of a Kobuki Mobile Base, an x86 Intel NUC computer, an Intel Realsense D435 RGB-D Camera, and a custom designed trasb collection mechanism. The collection mechanism uses a custom designed rotary brush friven by a motor and controlled by an Arduino Mega over USB, using a L298N Motor Driver breakout board to supply 12V to the motor.

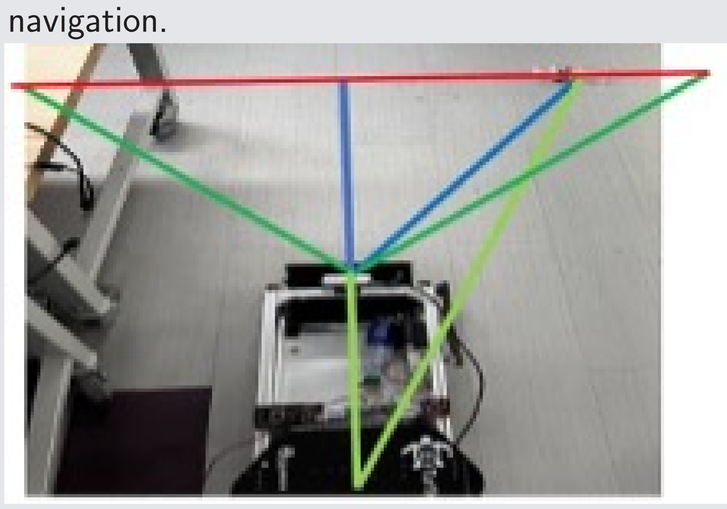


Three Stage Trash Collection Process

1. **Stage 1: Mapping** Using ORB-SLAM2 (visual SLAM) the robot maps its environment. It saves the trajectory and the map. Trash is detected by YOLOv4 and placed in the map.

   - Clustering trash detections ⇒ eliminates redundancy and filters noise.
2. **Stage 2: General Navigation** The robot localizes itself in the map using Adaptive Monte Carlo Localization, then path plans to trash clusters using the Dynamic Window Approach.

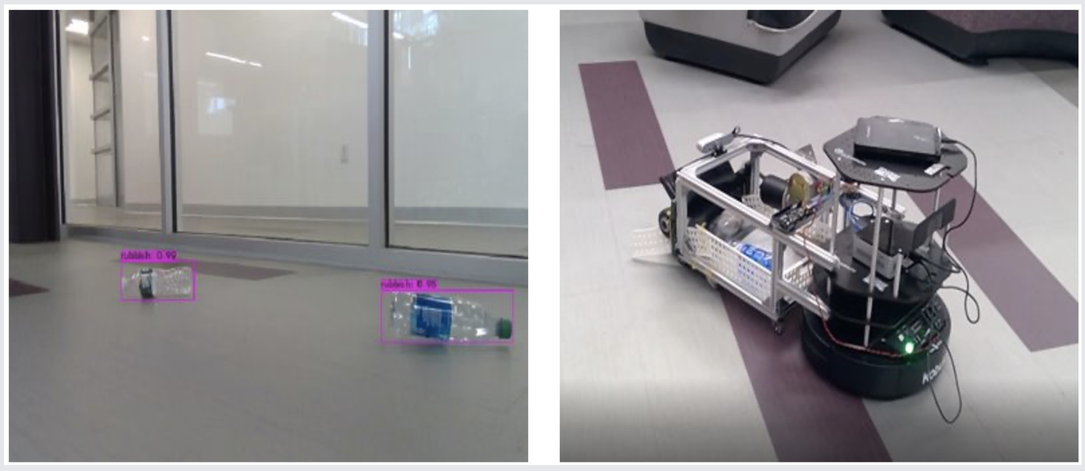
   - Navigates to within 2 meters of identified piece of trash.
3. **Stage 3: Greedy Pickup** The robot scans around until it confirms the trash location using its camera and trigonometry. This corrects for errors in mapping and navigation.



   - Runs asynchronously ignoring all navigation and map factors.
   - Accounts for latency in processing, once receiving a detection it turns back to the rotation is saw the trash at.
   - After receiving a detection, turns the motor on and moves 0.2m past the trash's location.

Conclusions

- Custom-trained YOLOv4 can detect trash objects with 95% confidence.
- During map creation the proposed framework can identify and plot trash points within the map.
- Greedy pickup succeeds in picking up trash 70% of the time over 30 trials using water bottles and paper balls.



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