Team A4: RecycleBot

Meghana Keeta, Serena Ying, Mae Zhang

Introduction

- 22 billion plastic water bottles get littered every year in the US
- Even worse, only 12% of plastic bottles that are thrown away are recycled
- It takes resources and manpower to clean public areas and to make sure recyclable bottles are properly collected

Use Case and Project Scope

- RecycleBot will:
  - Autonomously detect littered water bottles
  - Pick up and store the littered bottles for proper recycling
  - Function in daylight on concrete/indoor terrain
- ECE areas:
  - Software systems:
    - machine learning, computer vision
  - Hardware systems:
    - robot parts, Jetson Nano integration
  - Signals and systems:
    - communications between commands and robot, motion control

Use Case Requirements

Target Terminology

Fixed-type

Varied-type

Conditions of Operation

- Fixed concrete background
- No obstacles that the robot needs to avoid
- Objects must be placed within 5 foot radius of the robot

Use Case Requirements con’t

Software

- Robot will be entirely autonomous in all states (searching and detecting)
- Accuracy over multiple trials
  - Detects fixed-type water bottles in a 5 foot radius with >= 90% success
  - Detects varied-type water bottles in a 5 foot radius with >= 70% success

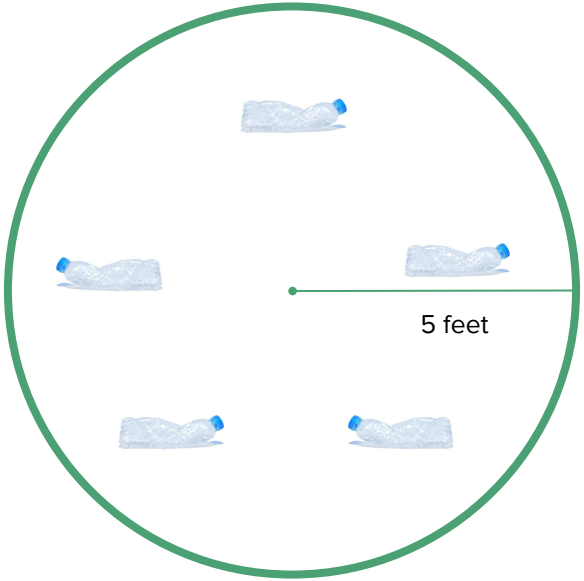
Hardware

- Picks up and securely stores detected bottles with 70% success

Use Case Requirements con’t

System

- Takes less than 2 minutes to pick up 5 items distributed within a 5 foot radius



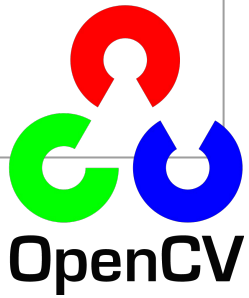
Technical Challenges

- Reaching projected accuracy of detection of fixed-type and varied-type bottles
  - Train object detection ML model on a supplemental dataset of images of the fixed-type bottle
  - Ensuring fixed parameters (environment light/clutter conditions)
- Building a robot to be able to navigate and pick up bottles
  - Design a bottle intake system with a rotating axle (vacuum cleaner) to collect all bottles
- Successfully locating and picking up 5 bottles within a 5 foot radius in under 2 minutes

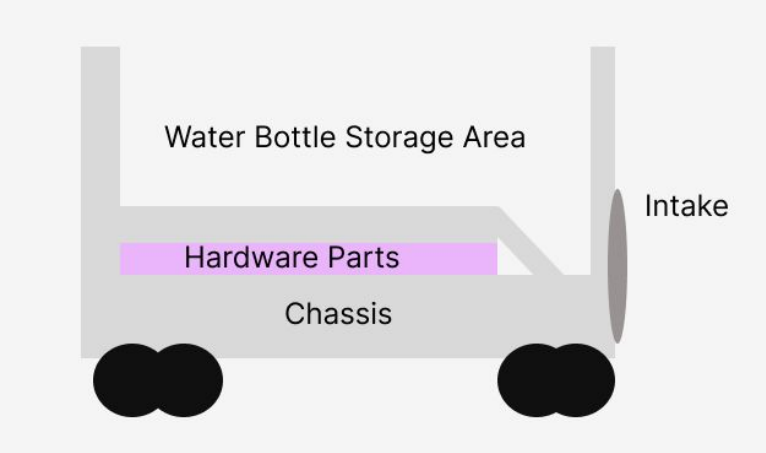
Solution Approach

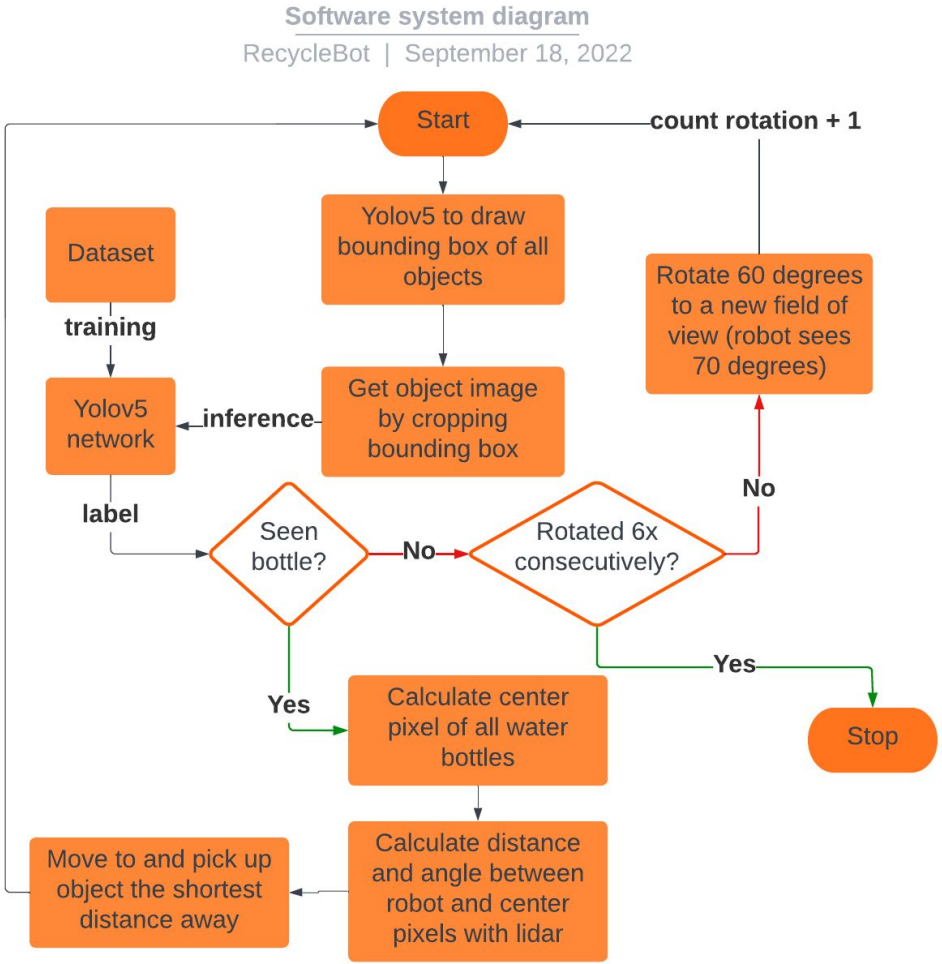
Tools Required:

Nvidia Jetson Nano	Intel RealSense LIDAR Camera L515	OpenCV and Yolov5 (Python)
Low power draw (5W) Powerful GPU for machine learning 	Low power draw (3.5W) Fast LiDAR depth readings (1024x768 pixels at 30 fps and 23 million depth points)	OpenCV: Powerful library optimized for real-time operation, pre-installed on Nano Yolov5: contains pretrained models that we will use as a base model



Solution Approach





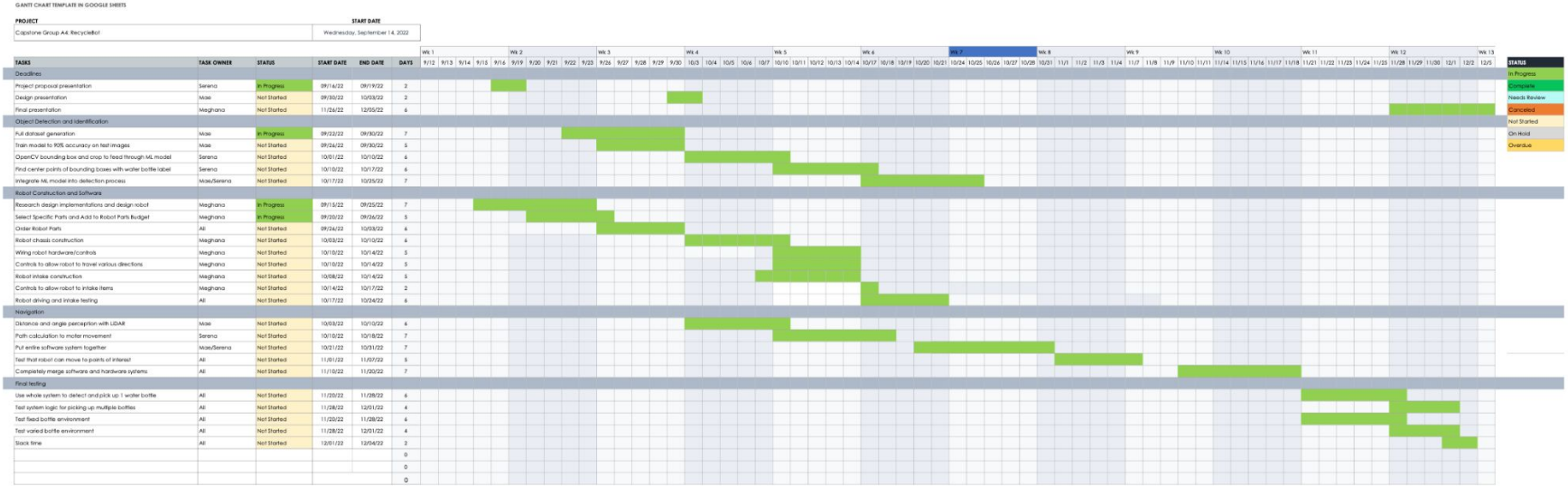
Testing, Verification and Metrics

Testing	Metrics
Image processing accuracy for water bottle detection	Algorithm correctly identifies 90% fixed-type water bottles and 70% varied-type water bottles, with a false positive rate of less than 10% for both types
Speed of completion for entire run	Completion of 1 5x5 (5 bottles, 5 foot radius) test in under 2 min, where 70% of all detected bottles will be picked up successfully
Battery life of system	Run 4 5x5 bottle tests on same charge or until failure
Robot system success repeatability	Overall, robot will maintain success rate at or above metrics over 5 trials

Tasks and Division of Labor

- Meghana
  - Robot Chassis and Intake
  - Motors/Wheels/Intake/Robot Travel
- Serena
  - Path calculation to motor movement
  - Object detection and bounding box retrieval
- Mae
  - Dataset generation and model training
  - Path calculation using LiDAR readings

Schedule



GANTT CHART TEMPLATE IN GOOGLE SHEETS

PROJECT	START DATE
Capstone Group A4: Recyclebot	Wednesday, September 14, 2022

TASKS	TASK OWNER	STATUS	START DATE	END DATE	DAYS
Deadlines					
Project proposal presentation	Serena	In Progress	09/14/22	09/19/22	2
Design presentation	Mae	Not Started	09/30/22	10/03/22	2
Final presentation	Meghana	Not Started	11/28/22	12/05/22	6
Object Detection and Identification					
Full dataset generation	Mae	In Progress	09/22/22	09/30/22	7
Train model to 90% accuracy on test images	Mae	Not Started	09/24/22	09/30/22	5
OpenCV bounding box and crop to feed through ML model	Serena	Not Started	10/01/22	10/10/22	6
Find center points of bounding boxes with water bottle label	Serena	Not Started	10/10/22	10/17/22	6
Integrate ML model into detection process	Mae/Serena	Not Started	10/17/22	10/25/22	7
Robot Construction and Software					
Research design implementations and design robot	Meghana	In Progress	09/15/22	09/25/22	7
Select Specific Parts and Add to Robot Parts Budget	Meghana	In Progress	09/20/22	09/26/22	5
Order Robot Parts	All	Not Started	09/26/22	10/03/22	6
Robot chassis construction	Meghana	Not Started	10/03/22	10/10/22	6
Wiring robot hardware/controls	Meghana	Not Started	10/10/22	10/14/22	5
Controls to allow robot to travel various directions	Meghana	Not Started	10/10/22	10/14/22	5
Robot intake construction	Meghana	Not Started	10/08/22	10/14/22	5
Controls to allow robot to intake items	Meghana	Not Started	10/14/22	10/17/22	2
Robot driving and intake testing	All	Not Started	10/17/22	10/24/22	6
Navigation					
Distance and angle perception with LIDAR	Mae	Not Started	10/03/22	10/10/22	6
Path calculation to motor movement	Serena	Not Started	10/10/22	10/18/22	7
Put entire software system together	Mae/Serena	Not Started	10/21/22	10/31/22	7
Test that robot can move to points of interest	All	Not Started	11/01/22	11/07/22	5
Completely merge software and hardware systems	All	Not Started	11/10/22	11/20/22	7
Final testing					
Use whole system to detect and pick up 1 water bottle	All	Not Started	11/20/22	11/28/22	6
Test system logic for picking up multiple bottles	All	Not Started	11/28/22	12/01/22	4
Test fixed bottle environment	All	Not Started	11/20/22	11/28/22	6
Test varied bottle environment	All	Not Started	11/28/22	12/01/22	4
Slack time	All	Not Started	12/01/22	12/04/22	2
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STATUS
In Progress
Complete
Needs Review
Canceled
Not Started
On Hold
Overdue