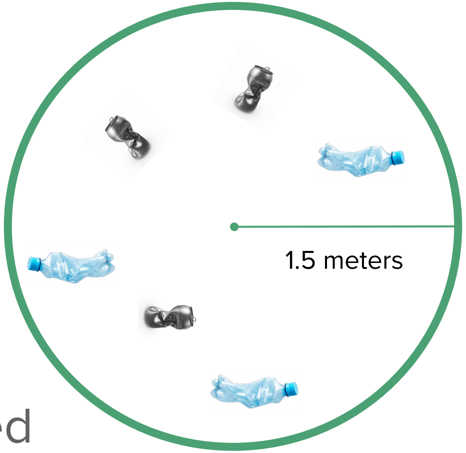
Use Case/Application

- RecycleBot will autonomously:
  - Detect, pick up and store littered bottles
  - **Avoid** potential non-bottle obstacles
- Key Task: locate and pick up **3 water bottles** within a 1.5 meter radius of the robot
- Changes:
  - Adding **non-bottle obstacles** for bot to avoid intaking
  - Pivot from building a full robot to mounting our intake mechanism on an **iRobot**
  - Reduced storage area— all tests now require picking up **3 bottles**

Photo credits: tinyurl.com/4438ebdd

Quantitative Use-Case Requirements

- Algorithm correctly identifies the following with less than 10% false positive rate:
    - 90% fixed-type water bottles
    - 80% varied-type water bottles
    - 80% obstacles
- Robot avoids obstacles with 80% success
- Picks up and stores detected bottles with 70% success
- Takes less than 1.25 minutes to pick up 3 items distributed within a 1.5 meter radius with no obstacles



tinyurl.com/4a25ju2y, tinyurl.com/4uhytvna

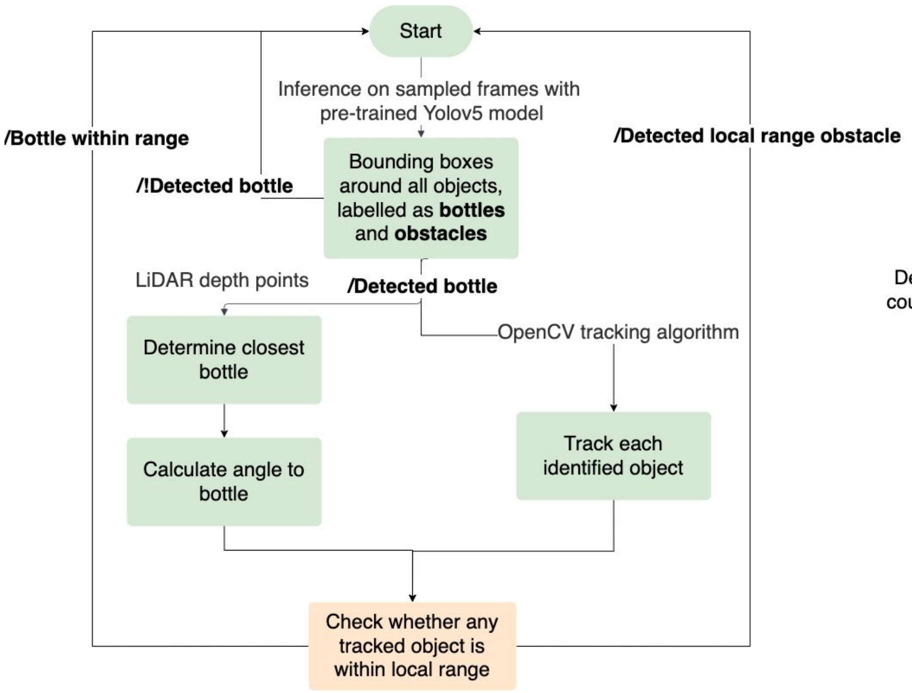
Solution Approach

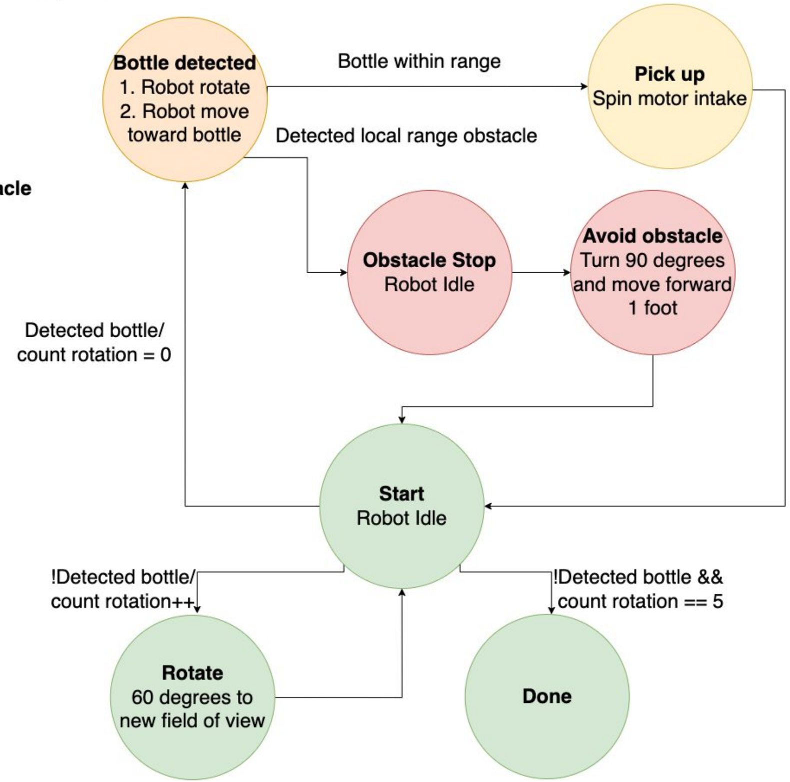
- **iRobot Augmentation**
  - Intake mechanism
- **Object Detection** - ML model
  - Pre-labeled bottle dataset and transfer learning to train model
  - Sets global path upon bottle detection
- **Navigation** - LiDAR and iRobot control
  - LiDAR for measuring distance between robot and target
  - Calculate angle between bot orientation and target
  - iRobot Open Interface for actuator command
- **Obstacle Avoidance** - LiDAR and object tracking
  - Continuously scan for whether tracked objects are in local range
  - Fixed local path avoidance when tracked obstacle is in local range

System Specification - Block Diagram

Software system diagram

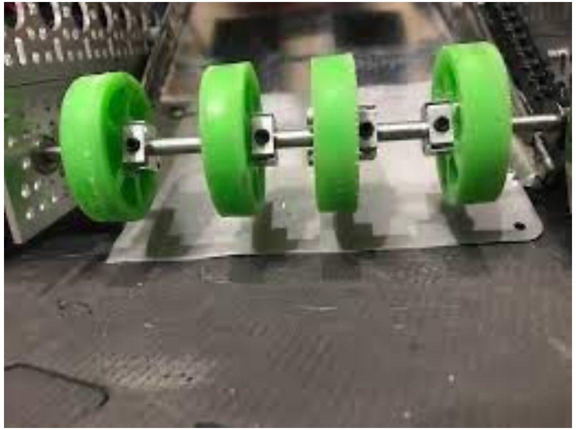
RecycleBot | October 2, 2022





System Specification- Robot

- Intake mechanism:
  - 5 rotating wheels on an axle
  - Wheel catches and pushes bottles underneath wheel axle and up a ramp to top of iRobot



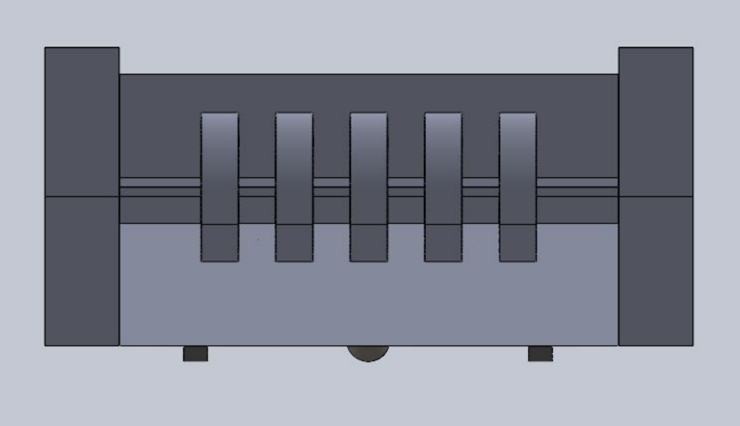
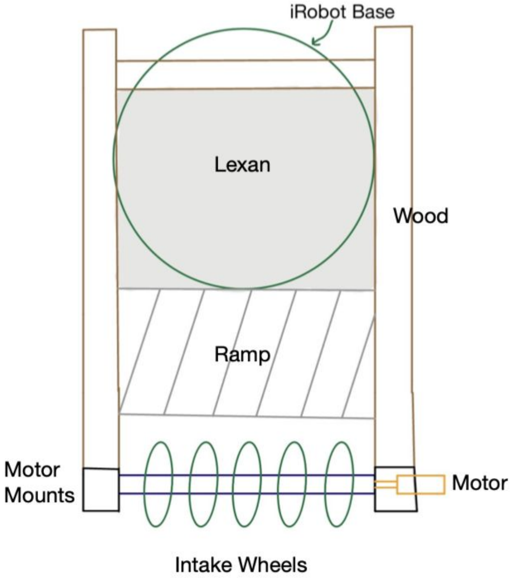
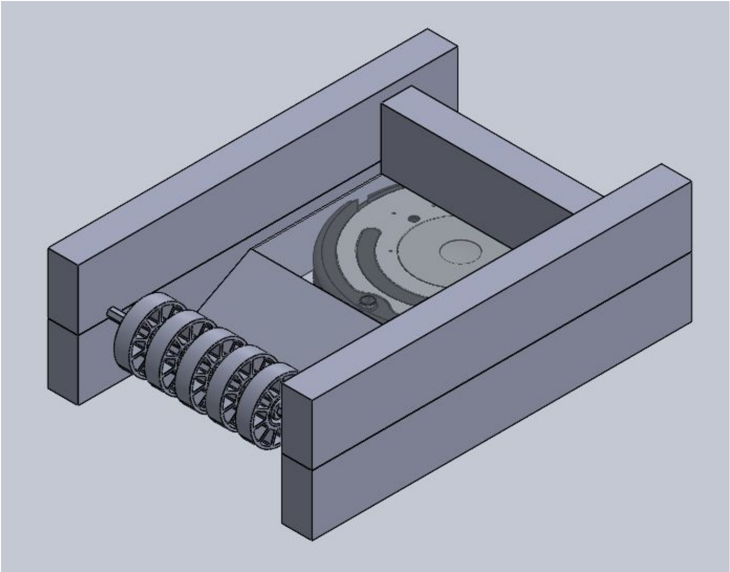


Photo Credit: tinyurl.com/zrsas5hc

System Specification- Robot

- Mounting the intake:
  - Drill into iRobot faceplate
  - No side mounting on iRobot— 2x4 middle beam will be attachment point



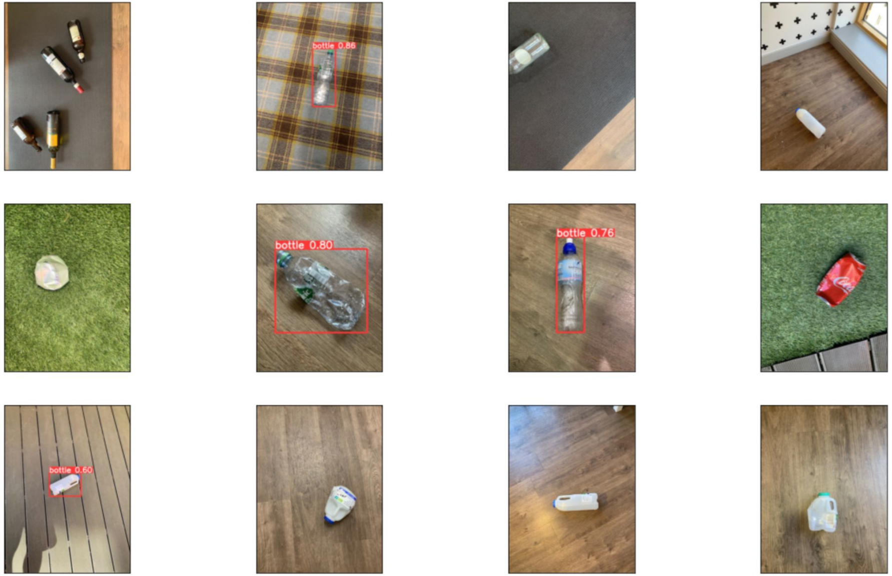


Implementation Plan

	Components to be integrated	Components to be developed
Robot hardware	iRobot 	Intake and storage mechanism on robot, and mounting those the iRobot faceplate
Object detection	Yolov5 model	Transfer learning on bottle and obstacle dataset
Navigation  	• Intel RealSense LIDAR Camera L515 for distance readings • OpenCV object tracking • Jetson Xavier	• Angle calculation to center robot to bottle • Communication with iRobot via Create 2 Open Interface • Software system logic

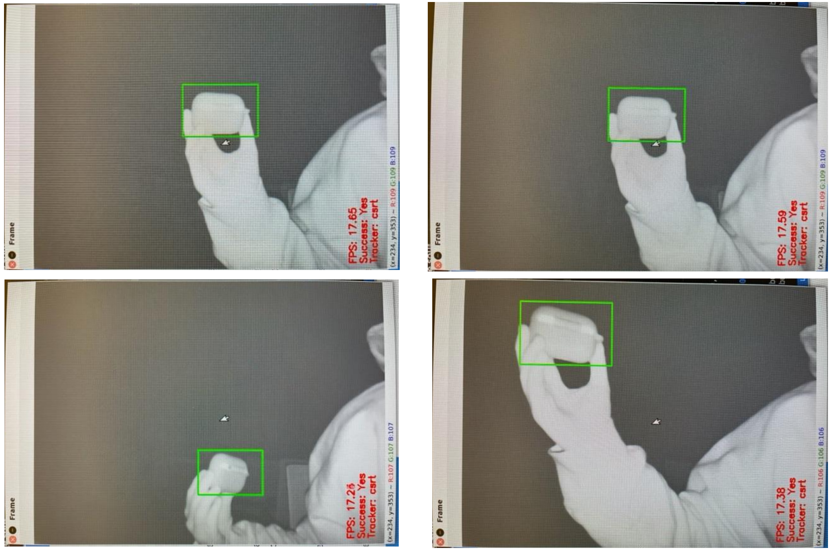
Photo credits: tinyurl.com/2vyw25kd, tinyurl.com/2huh768z, tinyurl.com/yhbuctue

Progress



Bottle Inference on Test Images

Dataset: aluminum cans, glass bottles, plastic bottles, milk bottles



OpenCV Tracking Algorithm (CSRT)

https://www.kaggle.com/datasets/arkadiyhacks/drinking-waste-classification

Testing and Metrics

- Environment
  - Objects randomly placed within a 1.25m radius
  - Objects at least .45m apart from each other
  - Concrete background
  - Fixed lighting
- Test cases
  - 3 fixed-type bottles
  - 3 variable-type bottles
  - 3 fixed-type bottles + 3 obstacles
- For each test case, we will compare the average of 10 runs (1 run = completion of one 1.25m radius) with our metrics

Testing and Metrics

Testing	Metrics
3 fixed-type bottles	- 90% detection accuracy - 70% pickup success - < 1.25 min
3 variable-type bottles	- 80% detection accuracy - 70% pickup success - < 1.25 min
3 fixed-type bottles + 3 obstacles	- 90% detection accuracy of bottles - 80% detection accuracy of obstacles - 80% obstacle avoidance success - 70% pickup success

Project Management

		Wk 4					Wk 5					Wk 6					Wk 7					Wk 8					Wk 9					Wk 10					Wk 11					Wk 12					Wk 13
TASKS	**TASK OWNER**	10/3	10/4	10/5	10/6	10/7	10/10	10/11	10/12	10/13	10/14	10/17	10/18	10/19	10/20	10/21	10/24	10/25	10/26	10/27	10/28	10/31	11/1	11/2	11/3	11/4	11/7	11/8	11/9	11/10	11/11	11/14	11/15	11/16	11/17	11/18	11/21	11/22	11/23	11/24	11/25	11/28	11/29	11/30	12/1	12/2	12/5
Deadlines																																															
Project proposal presentation	Serena																																														
Design presentation	Mae																																														
Final presentation	Meghana																																														
Object Detection and Identification																																															
Dataset generation	Mae																																														
Get model running with initial dataset	Mae																																														
Train model to 90% test accuracy	Mae																																														
Integrate ML model into Jetson/detection process	Mae/Serena																																														
Slack time	All																																														
Robot Construction and Software																																															
Research design implementations for using iRobot	Meghana																																														
Research and design intake and storage	Meghana																																														
Order Necessary Parts Materials	All																																														
Robot intake CAD and construction	Meghana																																														
Setting up Jetson to iRobot communication	Meghana																																														
Controls to allow robot to intake items	Meghana																																														
Robot driving and intake testing	All																																														
Slack time	All																																														
Navigation and Integration																																															
Set up Jetson and Intel Realsense	Serena																																														
Distance perception with LiDAR	Serena																																														
Object tracking algorithm	Serena																																														
Path and angle calculation to motor movement	Serena																																														
Write logic for entire software system	Mae																																														
Put entire software system together	Mae/Serena																																														
Completely merge software and hardware systems	All																																														
Slack time	All																																														
Final testing																																															
Whole system to detect and pick up 1 water bottle	All																																														
Test system logic for picking up multiple bottles	All																																														
Test fixed bottle environment	All																																														
Test varied bottle environment	All																																														
Slack time	All																																														

Conclusion

- Key changes
  - iRobot
  - Obstacle avoidance
- Key challenges
  - Intake design
  - Obstacle avoidance
  - Integration of entire software system