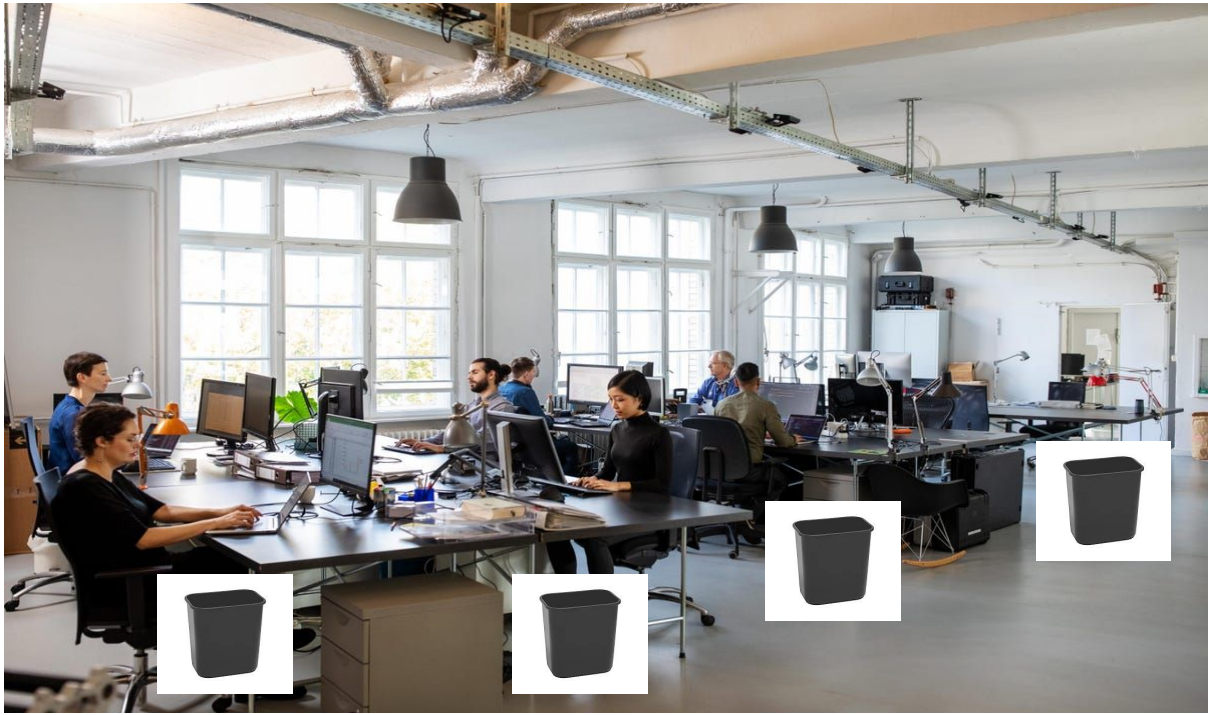
Robotic Trash Concierge

B4 - George Gao, Jack Girel-Mats, Zachary Mason

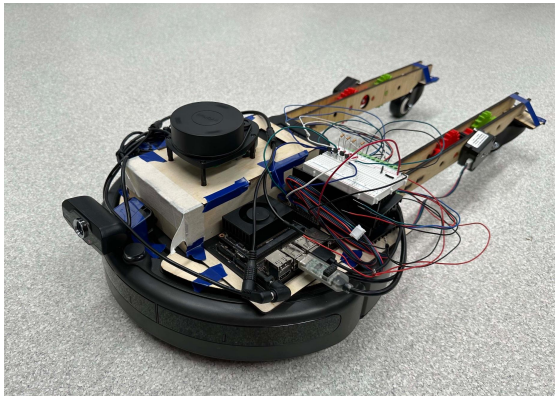
Use-Case / Application



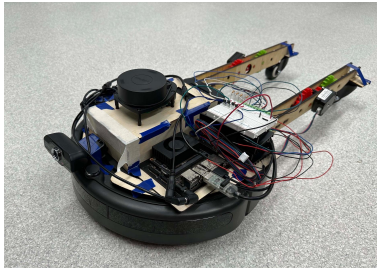
Requirements Reminder

Requirement	Use-case Specification	Design Requirement
Work Area	META Open Office Work Section	Robot Height <30in, Robot Width: <3ft Flexible Mapping Technology
Health & Safety	Minimize human collisions and trash spills.	Obstacle avoidance system, easily identifiable
Movement	Room Setup: 19m x 23m, 90 People, ~90 bins 5 Hour Work Period: 7 PM - 12 PM	Robot Battery >5 Hr, Movement Speed: >.21 m/s
Task Completion	Lift 10 lb bins, navigate the office space efficiently	Localization <.5m to get cameras in range for bin ID and alignment

Solution Approach

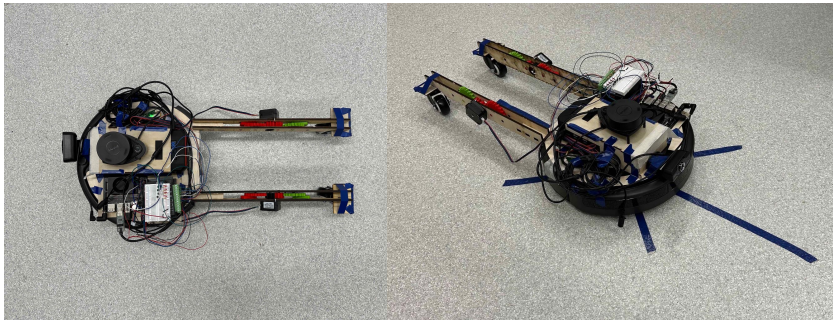


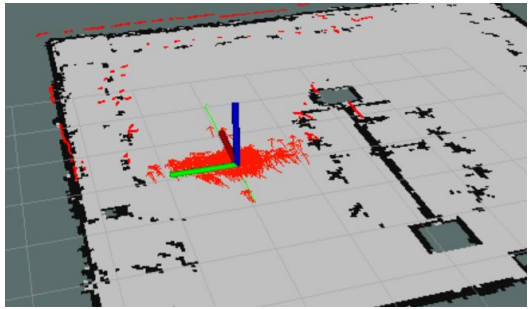
1. General Welfare: Maximize engineer happiness
2. Health and Safety: Eliminate leftover/overfilled trash bins
3. Economic Consideration: Reduce custodial workload

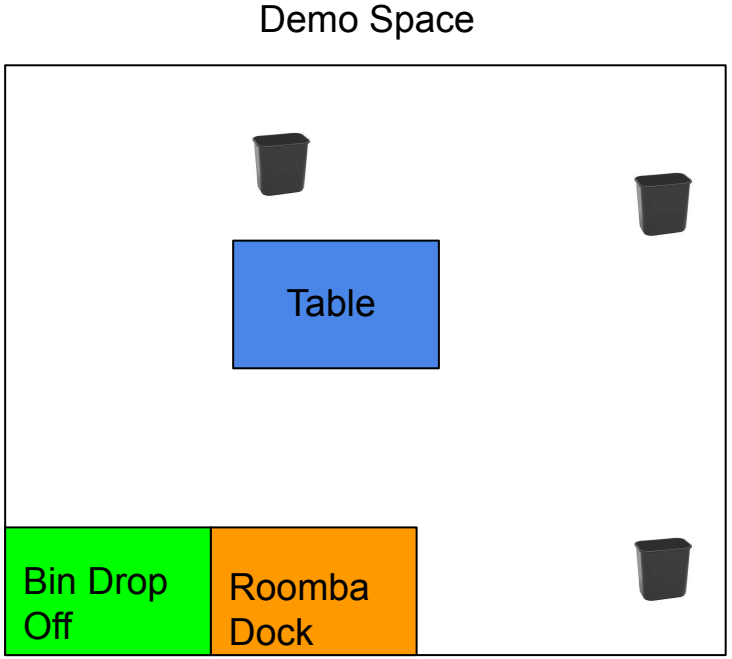


ECE Inventory Components
Purchased Components
Custom-made Components
Open-Source Library
HW Components
SW Modules
Power
Data
MOS GPIO Interface
TB6600 Stepper Driver
NEMA 17 Stepper Motors (x2)
Docking Mechanism
Trash Bin
CV Processing
Bin Database
Jetson XAVIER NX
SLAMTec LiDAR
Front Camera
USB Data
Central Coordinator
GPIO
SLAM
Path Planning
Drive System
Serial
5V via USB
iRobot Create 2
12V DC
Battery Bank
12V DC

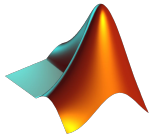
Demo Time



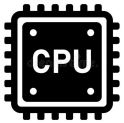




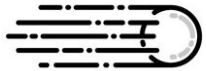
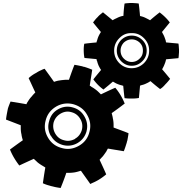
Software / Hardware Changes

Task	Original	New
Lidar Slam / Path Planning		ROS
Positioning for bin docking	 	 
Lift arm height	Low profile (~2in bin standoff)	High clearance (~4in bin standoff)
Lift system	Worm gear driving a rotating cam, 2x steppers	Two-stage spur gear with fixed cam, 2x steppers

Trade-offs

Area	Choice 1	Choice 2	
	Faster Jetson Xavier AGX	Slower Jetson Xavier NX	AGX had poor ssh performance, and NX had enough power for our use case
	2 web cameras	1 web cameras	Bin identification needs only 1 webcam, swapped to LiDAR-based alignment for improved distance accuracy
	Fast rotation during bin search	Slow rotation during bin search	Slow rotation drastically increased bin ID performance, at the expense of speed

Trade-offs (cont.)

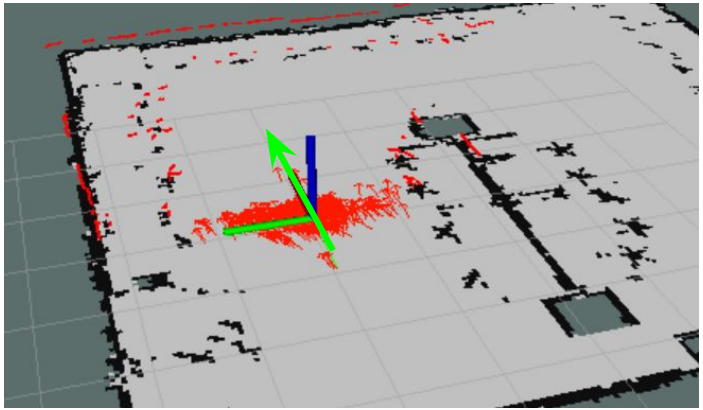
Area	Choice 1	Choice 2	
	Slow (0.15 m/s)	Fast (0.28 m/s)	Slower movement speed means better localization tracking and less odometry slip
	Worm gears	Traditional spur gears	Worm gears do not fit well in the limited arm form-factor; spur gears have lower ratio but can be chained easily

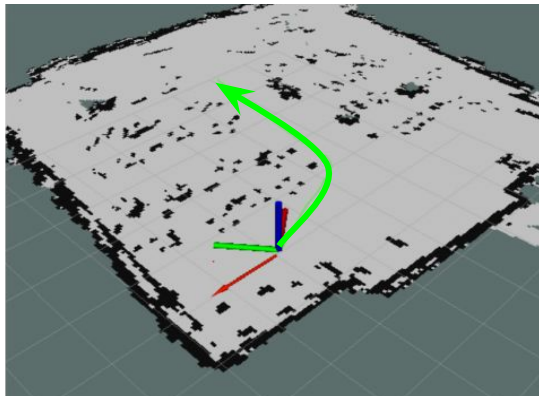
Testing / Verification

Measurement	Input	Output / Goal	Results
Bin Identification	ARUCO tag on bin	Successful identification	Success (100% up to 2 meters)
Bin Docking	ARUCO tag on bin	Successful localization and docking	WIP
Bin Lift & Tow	10 lb trash can	Successful lift, <0.2m positioning	WIP
Movement Speed	Goal Destination	0.21m/s	Success (0.23 m/s)
Form Factor with Bin	Robot measurement	Height <30in, width: <3ft	Verified

Testing / Verification

Measurement	Input	Output / Goal	Result
Battery Life	Continuous goals	5 hrs	WIP (interpolated for failure currently)
SLAM Room Mapping	HH 1307 & HH A101	General accuracy	Success
Path Finding	Multiple bin locations + obstacles	.5 m accuracy	Success (Average 0.21 m)
Obstacle Avoidance	Person walking around	< 95% collision rate	Success (95%)
Integration Test	HH 1307 two bin rotation	Runtime, 85% overall success	WIP



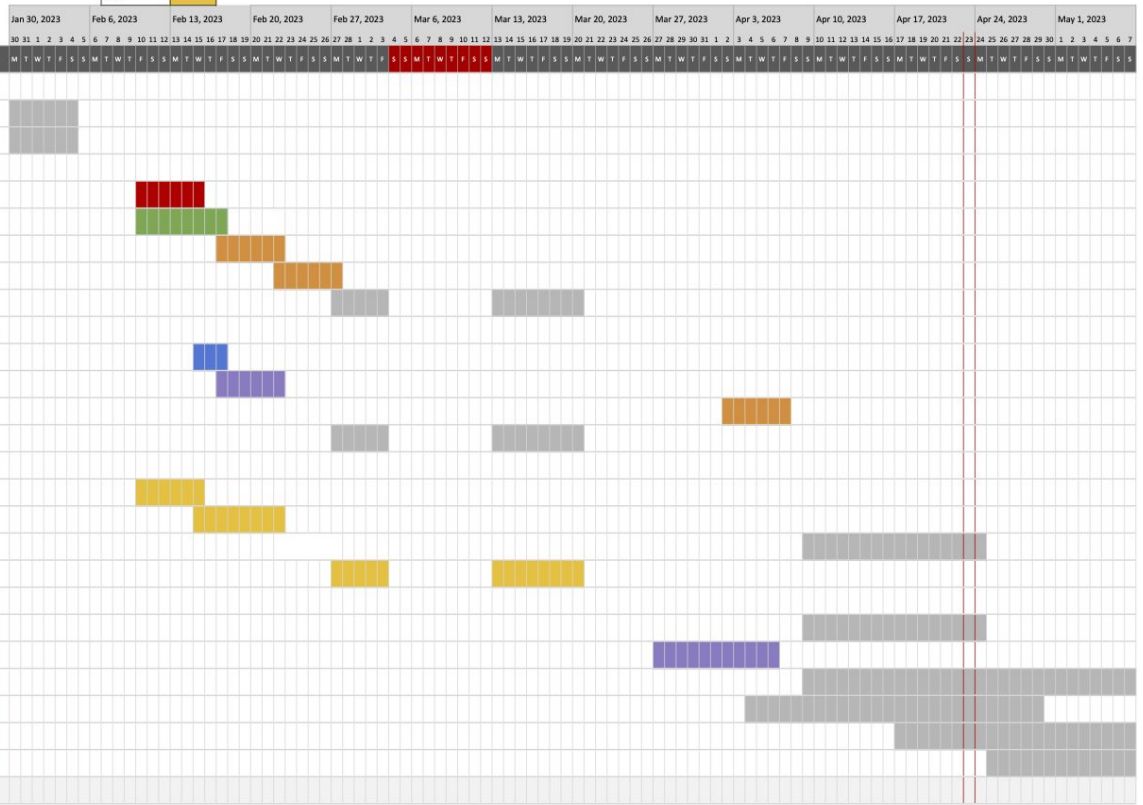


Team B4: Trash Concierge

18-500, Spring 2023
George Gao, Jack
Girel-Mats, Zach
Mason

Project Start: Mon, 1/30/2023
Project End: Sun, 4/30/2023

George
Jack
Zach



TASK	ASSIGNED TO	PROGRESS	START	END
Initial documentation				
Project Proposal	Zach, George, Jack	DONE	1/30/23	2/4/23
Website Setup	Zach, George, Jack	DONE	2/3/23	2/4/23
Pathfinding and database				
Database setup	George	DONE	2/10/23	2/15/23
SLAM/LIDAR bringup	George, Jack	DONE	2/17/23	2/22/23
Data capture testing	George, Zach, Jack	DONE	2/22/23	2/27/23
Simulate pathfinding	George, Zach	REMOVED	2/12/23	2/17/23
SLACK		0%	2/27/23	3/20/23
Movement and local bin detection				
Roomba movement	Jack	DONE	2/13/23	2/17/23
Local bin identification	George, Jack	DONE	2/17/23	2/20/23
Movement towards bin	George, Jack	70%	2/22/23	2/27/23
SLACK		0%	2/27/23	3/20/23
Bin/robot hardware				
Bin attachment design	Zach	DONE	2/10/23	2/15/23
Roomba fixture design	Zach	DONE	2/15/23	2/22/23
Docking system test	Zach, George, Jack	0%	2/22/23	2/27/23
SLACK		0%	2/24/23	3/20/23
System integration				
Automatic bin docking	Zach, George, Jack	0%	3/20/23	3/27/23
Movement with SLAM	Jack, George, Zach	DONE	3/20/23	3/27/23
Bin pickup w/ database	George, Jack, Zach	0%	3/27/23	4/3/23
Multi-bin pickup	George, Jack, Zach	0%	4/3/23	4/10/23
Bin replacement	George, Jack, Zach	0%	4/10/23	4/17/23
SLACK			4/17/23	4/28/23