Introduction

Problem with Roombas:

Cleaning robots path inefficiently and are unable to adapt to changes in their environment, getting stuck or colliding into obstacles.

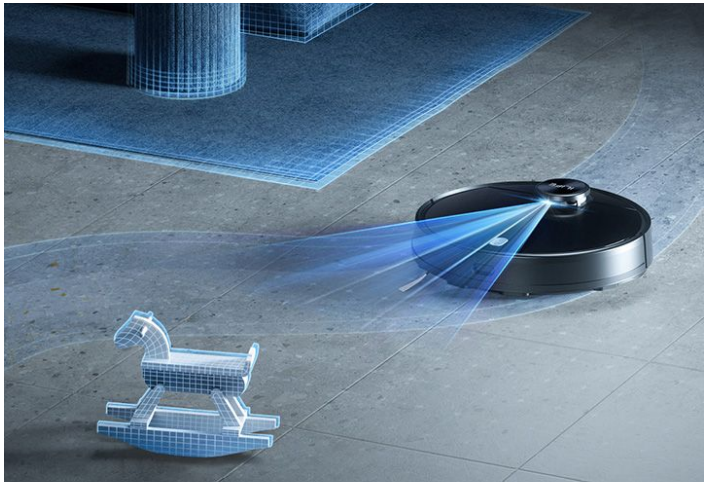
Our Proposed Solution:

A Roomba equipped with 2D LIDAR that can react dynamically to its surroundings while efficiently navigating its surroundings.

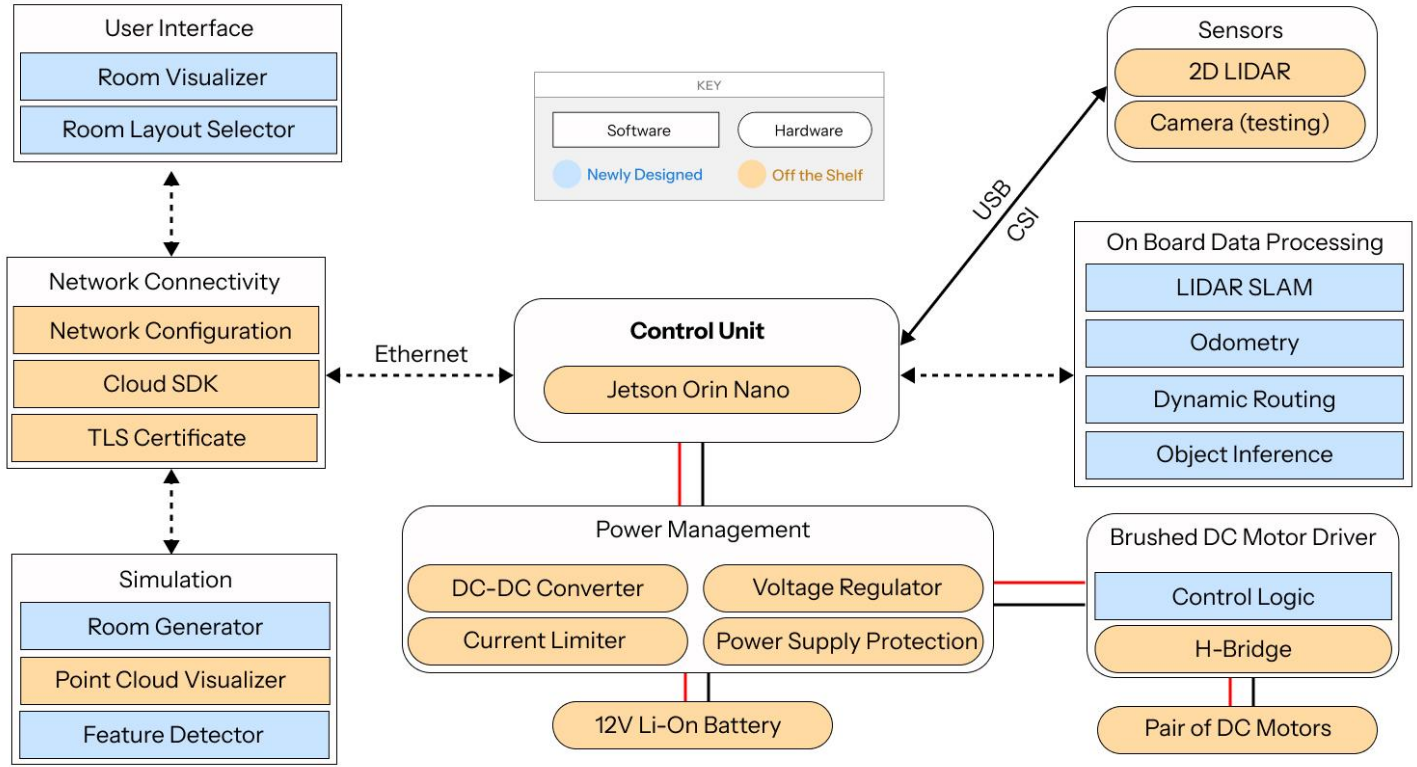
Use Case Requirements

Our robot must be able to:

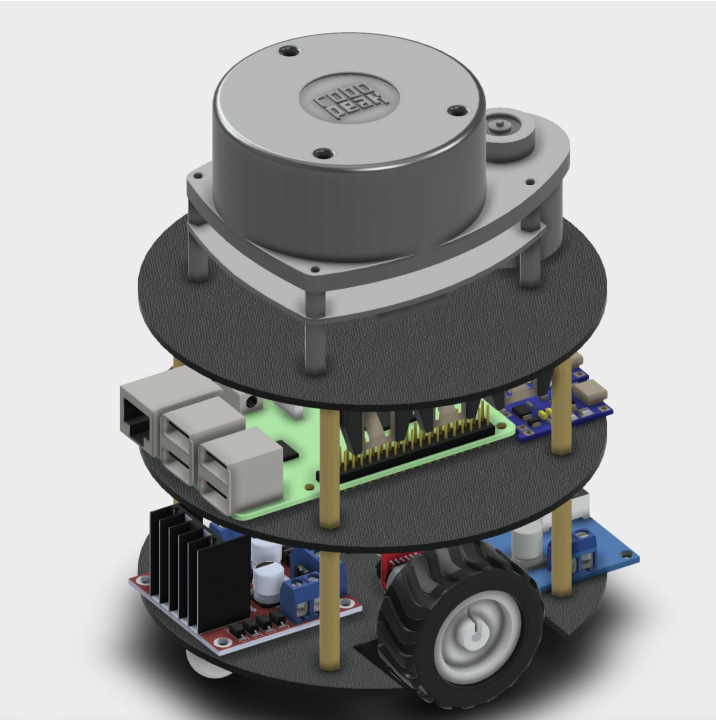
1) Map its surroundings
2) Plan the fastest cleaning path
3) Detect objects in real-time



Block Diagram



CAD Model



Quantitative Design Requirements

Use Cases	Technical Requirement
Room Mapping: Accuracy and Precision	- By surface area, robot will cover >95% of a 100m^2 space
Robot Path-Planning and Navigation	- Robot will complete cleaning a 100m^2 space within 15 minutes - Robot will cover within 0.05m of all stationary obstacles.
Real-time Obstacle Detection and Avoidance	- Within the room cleaning time frame, the robot will not collide with any obstacles moving slower than itself

Solution Approach: Hardware and Robotics

1. **Locomotion:** Brushed DC motors with encoders
2. **Power Supply:** 12V Li-On battery pack
3. **Microcontroller:** Jetson Orin Nano
4. **Sensing:** 2D LIDAR module

Solution Approach: Software Systems

1. **Mapping:** Use SLAM algorithms with LIDAR PCD data
2. **Visualization:** Create room diagrams with SLAM results
3. **Routing:** Run adaptive pathfinding algos on room map
4. **User Input:** Custom interface to select cleaning areas

System Implementation

Hardware Systems:

Robot model will be 3D modeled in fusion 360 and fabricated from techspark materials. Hardware components will be fitted to chassis.

Software Systems:

SLAM algorithm for pruning data points, calculating odometry, and generating mapping will be written in C.

User interface will be written with python (open3d, laspy) and javascript (D3.js).

Design Trade Study

	2D Lidar	2D Lidar + Camera	3D Lidar
Design	Mount to front	2 mounting angles	Mount to front
Cost	$70	$110	$450
Horizontal FOV	360°	360° / 50°	360°
Vertical FOV	1°	1° / 30°	360°
Data Volume	4000 pts/s	(4000 pts + 9M pix)/s	43200 pts/s

Testing, Verification, Metrics

Requirement	Testing
Mapping Accuracy: 95% coverage of the given testing space	Manual measurement of the room compared to the 3D mapping with measuring tape. Room size: 8m x 12m, Table size: 2m x 1m , 4 chairs or random arrangement
Precision: Be able to reach within a distance of 0.05m to every obstacle and wall at the closest point	Taping a perimeter 0.05m off all the objects in the testing area and making sure it reaches these points
Minimal Collision: 0 Collisions	Visually inspect and count all collisions.

Project Management

			Initial Creation															Integration															Optimization															DONE				
Task Number	TASK TITLE	DURATION	WEEK 1					WEEK 2					WEEK 3					WEEK 4					WEEK 5					WEEK 6					WEEK 7					WEEK 8					WEEK 9					WEEK 10				
			M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F
1	Hardware Selection & Purchase	5																																																		
2	LiDAR Mapping Research	2																																																		
2.1	LiDAR Data Acquisition Implementation	3																																																	
2.2	LiDAR Room Mapping Algorithm	5																																																	
3	Robot Design	4																																																	
3.1	Robot Base Assembly	2																																																	
3.2	Motor and Sensor Mounting	2																																																	
3.3	Microcontroller & Wiring	3																																																	
4	LiDAR Integration with Robot	7																																																	
5	Robot Odometry Fine Tuning	6																																																	
6	Path Planning Design	4																																																	
6.1	Initial Robot Navigation Integration	5																																																	
6.2	Obstacle Detection & Collision Avoidance	5																																																	
7	Testing & Optimization	7																																																	
8	Final Debugging & Documentation	3																																																	

Matthew will be responsible for hardware components**, Nick** will be responsible for mapping algorithms + user interface creation, **Kevin** will be responsible for path-planning algorithms

Bill of Materials

Product	Cost	Model #/Manufacturer
Jetson Orin Nano	-	NVIDIA
2D Lidar	-	Slamtec RPILidar A1M8
Brushed DC Motors (x2)	$48	FIT0186/DFRobot
12V 5200mAh Li-On Battery	$43	KBT Battery
H Bridge	$15	L298N/ST
DC-DC Converter	$15	12V to 5V DC Converter