Warehouse Automation

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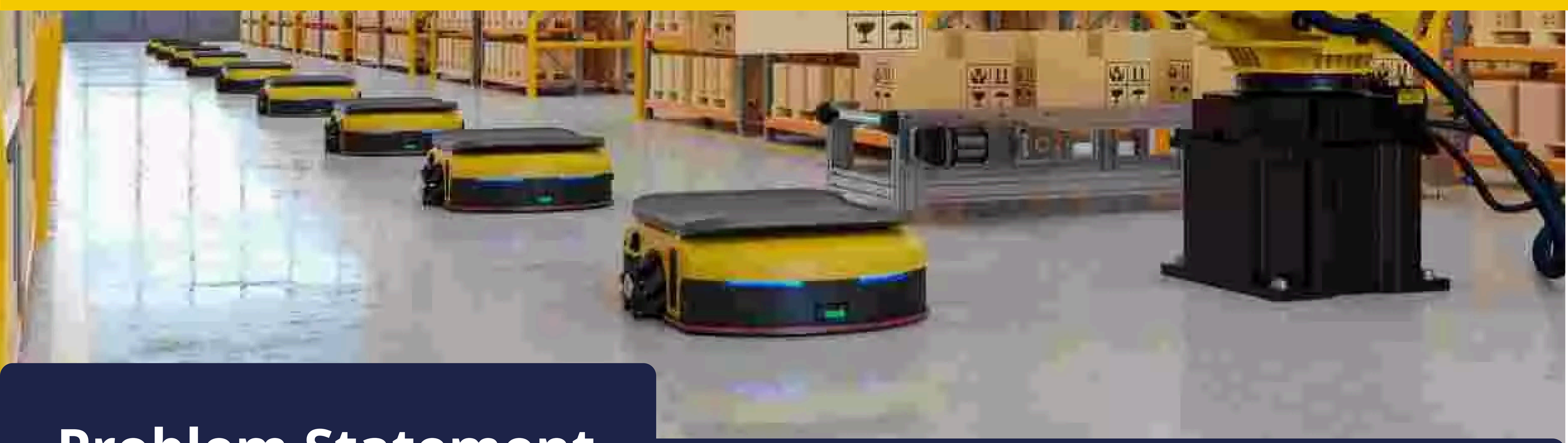
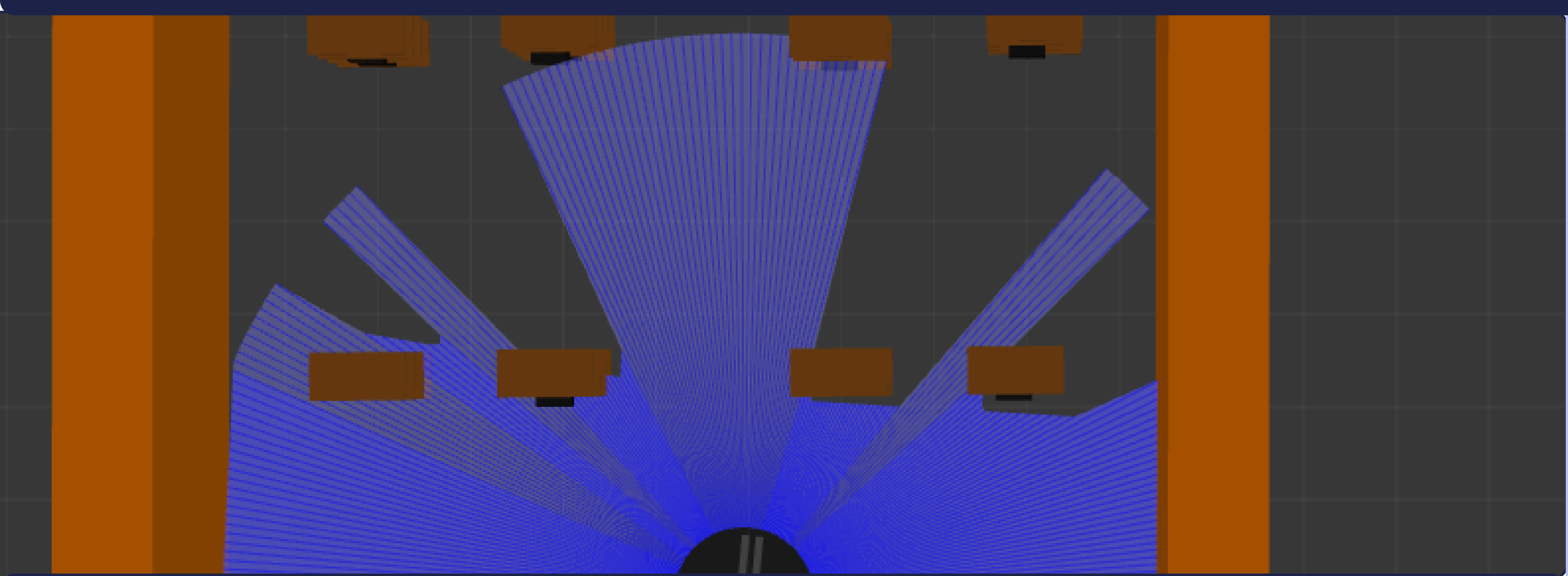


Problem Statement

- The warehouse automation systems currently in use are relatively very costly and can be only used by large corporations
- The use of sensors like LiDAR and technologies including computer vision make the system performance-intensive
- Through this project, we aim to build a robust, cost-effecient and performance-friendly warehouse automation system

Objectives

- To build a robust and scalable warehouse automation system
- To improve the cost efficiency of the system by using simple sensors like IR sensors
- To reduce the performance load required by each bot to the level of a microcontroller like ESP32



Concept Design

End Effectors

Sensors
Each bot utilizes only 3 IR sensors for localization

Acutators
Each bot consists of 2 wheels with DC servo motors connected using MD10C drivers along with a motor for end effector operation

Communications

Microcontroller
An ESP32 microcontroller is used for each bot to operate the actuators and sensors

Protocol
Communication happens over ROS2 using micro-ROS protocol

Main Processing Unit

- A Raspberry Pi is used as the main processing unit for the system
- It handles all path-planning algorithms as well as the localization data of each bot to ensure safe and optimized operation

Warehouse

- The warehouse needs to be maintained with demarcated paths for seamless operation of the bots.
- An interface website is available for the management to access the inventory and manipulate it.

Operation

- The bots are operated along predefined lines to define localization milestones for each bot.
- The localization milestones allow to define the function each bot needs to perform as well as avoid interactions with other bots.

Assumptions

Maintenance
Regular maintenance for the warehouse is performed to ensure the integrity of the paths

Inventory
A well-defined inventory is maintained by the warehouse management for streamlined operation

Docking Station
A docking station is built for the regular charging and docking of the bots

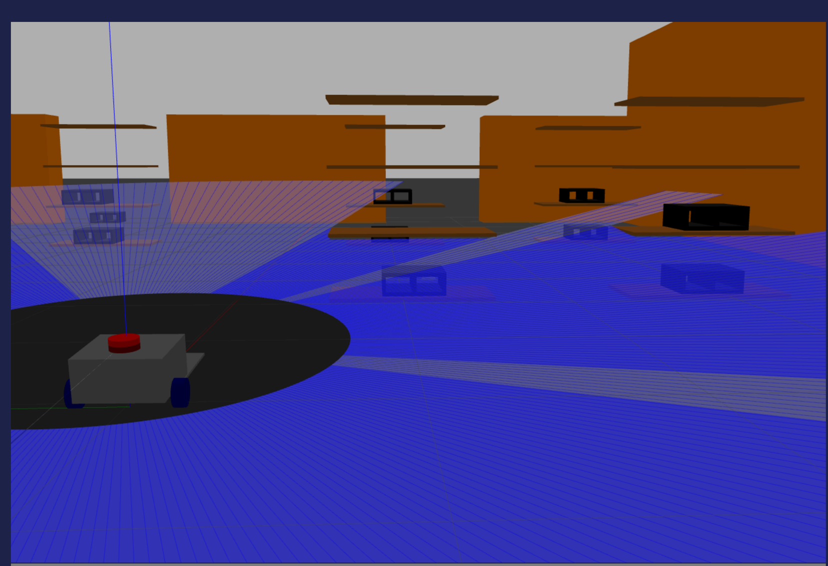
Supervision
The system can be supervised overall by management to ensure proper operation

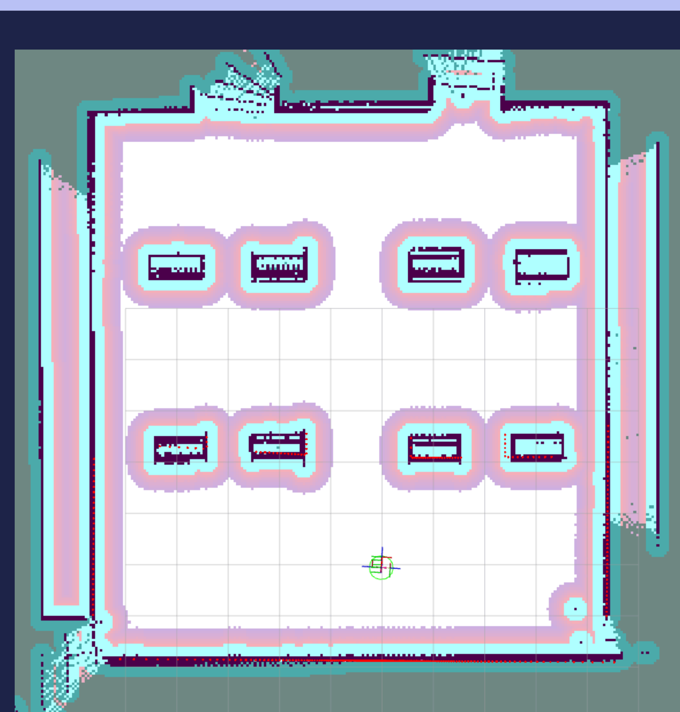
Prototype Overview

The prototype is a compact, IR-based line-following robot designed for warehouse automation. It uses a PID control algorithm for precise navigation along a predefined path. The system is powered by an ESP32 microcontroller and includes standard components like an IR sensor array, motor driver (L298N), and Li-ion battery pack.

An optional LiDAR module enhances the robot's capabilities by enabling obstacle detection and basic environment awareness. When integrated with ROS 2, LiDAR allows the robot to pause or reroute in response to dynamic obstacles, improving safety and adaptability in shared or semi-dynamic warehouse spaces.

This modular design supports future upgrades like SLAM navigation, multi-bot coordination, and cloud-based control.





Outcome and Inferences

- Implemented a custom warehouse automation simulation successfully using Gazebo
- Implemented the solution in real-world using custom built environment and bots

Bill of Materials

Processing Units
- Raspberry Pi
- ESP32: 1 (For each bot)

Sensors
- IR Sensors: 3 (For each bot)
- LiDAR Sensor: 1 (Advancement opportunity, for each bot)

Actuators
- MD10C Motor Drivers: 3 (For each bot)
- DC Servo Motors: 3 (For each bot)

Power
- 12V DC Battery (For each bot)

References

- Kumar, S., & Verma, R. (2018). PID controller for line follower bot. In 2018 IEEE International Conference on Computing, Power and Communication Technologies (GUCON) (pp. 186–190). IEEE. Rimberio. (2022). Principles of Language Learning and Teaching Journal
- Patel, M., & Patel, A. (2017). Line following robot for warehouse automation. In 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS). IEEE

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