Prototyping and Testing in Warehouse Automation

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February 28, 2025

1 Introduction

Warehouse automation has become a crucial aspect of modern logistics, aiming to enhance operational efficiency and minimize human intervention. The primary focus is to streamline material handling, inventory management, and navigation to ensure a more robust and adaptable system. Our approach emphasizes the use of easy-to-replicate methodologies, making automation accessible and scalable. The project incorporates a combination of hardware and software techniques to enhance navigation, control, and performance of automated warehouse robots.

2 Motivation

The complexity of existing warehouse automation systems often leads to high costs and computational resource constraints. Many solutions require sophisticated autonomy algorithms and expensive sensors, limiting their feasibility for small-scale applications. The objective of this project is to develop an efficient, cost-effective system that simplifies warehouse automation using widely available components and optimized control strategies. By focusing on practical implementation, the project aims to improve usability without compromising reliability.

3 Literature Survey

Previous research highlights various methodologies for warehouse automation:

- **PID Control:** Kumar
  Verma (2018) - Proportional-Integral-Derivative control enables real-time correction of deviations, ensuring smoother movement and precise trajectory tracking.
- **IR Sensors:** Patel
  Patel (2017) - Infrared sensors help robots detect contrast differences between the path and surroundings, allowing accurate course correction and improved alignment.

- **Fixed Path Systems:** Gupta
  Khurana (2015) - Predefined paths enhance navigation reliability, reducing the complexity of free-space path planning.

4 Objectives

The primary objectives of this project include:

- Development of an IR sensor-based autonomous warehouse bot.
- Implementation of a PID control algorithm for accurate path tracking.
- Simulation and analysis using Gazebo to identify potential hazards and optimize navigation strategies.
- Ensuring seamless integration of hardware and software components for a robust system.

5 Methodology

The methodology involves the following key components:

5.1 Hardware Design

- **Chassis:** A two-wheel drive robot with a caster wheel for stability.
- **Sensors:** Infrared sensors for path detection and obstacle avoidance.
- **Microcontroller:** ESP32-WROOM for processing sensor data and executing control algorithms.
- **Motor Driver:** L298N module for precise motor control.
- **Power System:** Rechargeable battery for sustained operation.

5.2 Software Implementation

- **Core Framework:** ROS2 for modular and scalable robotics programming.
- **Simulation Tools:** Gazebo and Rviz for realistic testing and analysis.
- **Control Algorithm:** PID-based path-following logic for smooth and stable navigation.
- **Navigation Strategy:** Fixed-path navigation using pre-determined markers and sensor feedback.

6 Deliverables

6.1 Hardware Implementation

- Fully assembled and functional warehouse bot.
- Integrated IR sensor array for line detection and navigation.
- Motorized movement controlled via PID-based corrections.

6.2 Software Development

- PID algorithm implementation for real-time speed adjustments.
- Obstacle detection and path correction mechanism.
- Integration of a monitoring system for remote supervision.

6.3 System Integration and Testing

- Warehouse setup with predefined black lines for navigation.
- Evaluation of robot movement efficiency and accuracy.
- Testing in simulated environments using Gazebo.

7 Future Upgrades

- Multi-bot coordination for efficient warehouse operations.
- Development of a cloud-based interface for real-time monitoring and control.
- Enhanced navigation algorithms for dynamic obstacle avoidance.

8 Conclusion

This project presents a practical approach to warehouse automation by integrating hardware and software solutions for efficient and reliable operation. The use of IR sensors, PID control, and ROS2 framework provides a scalable and adaptable solution. Future enhancements will focus on multi-bot collaboration and real-time cloud-based control for advanced automation.

Thank You

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