Team Syzygy Autonomous Mapping & Navigation Robot

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Mechatronics Engineering | Electrical & Electronics Engineering | Control & Instrumentation

Abstract

This paper introduces our custom-designed mapping and navigation robot, developed specifically for SLAM (Simultaneous Localization and Mapping) applications within a provided maze gamefield

By integrating advanced sensors and autonomous navigation capabilities, our robot enhances situational awareness and operational efficiency in challenging environments, crucial for search and rescue operations.
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Introduction

Objective: Our robot aims to provide efficient, reliable, and autonomous tools that improve operational outcomes through effective SLAM techniques.

Rising Demand: The need for advanced mapping and navigation solutions has surged, especially in search and rescue operations due to increasing natural disasters.

Methodology - II

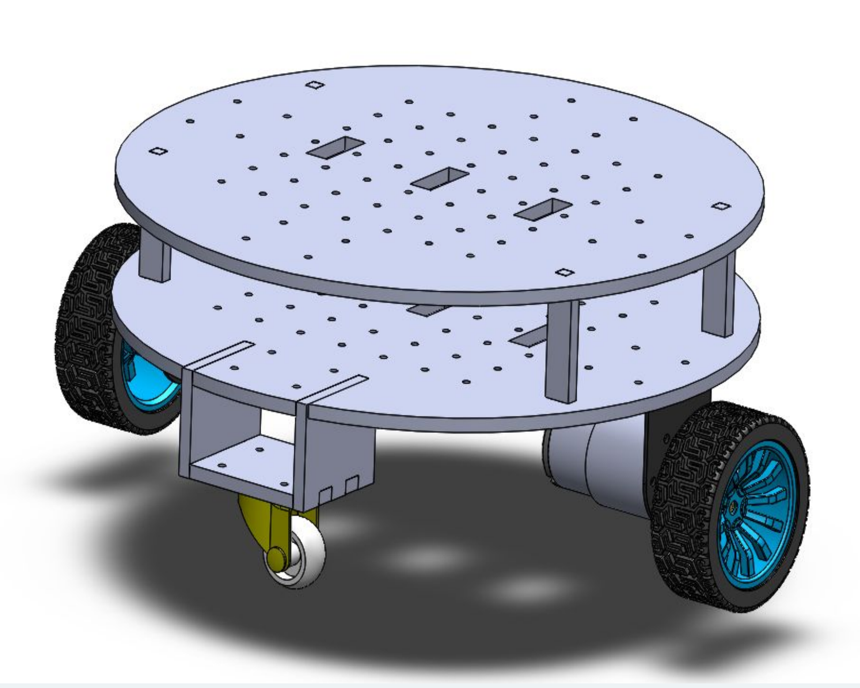

Fig. 2: Mobile Platform Chassis Design

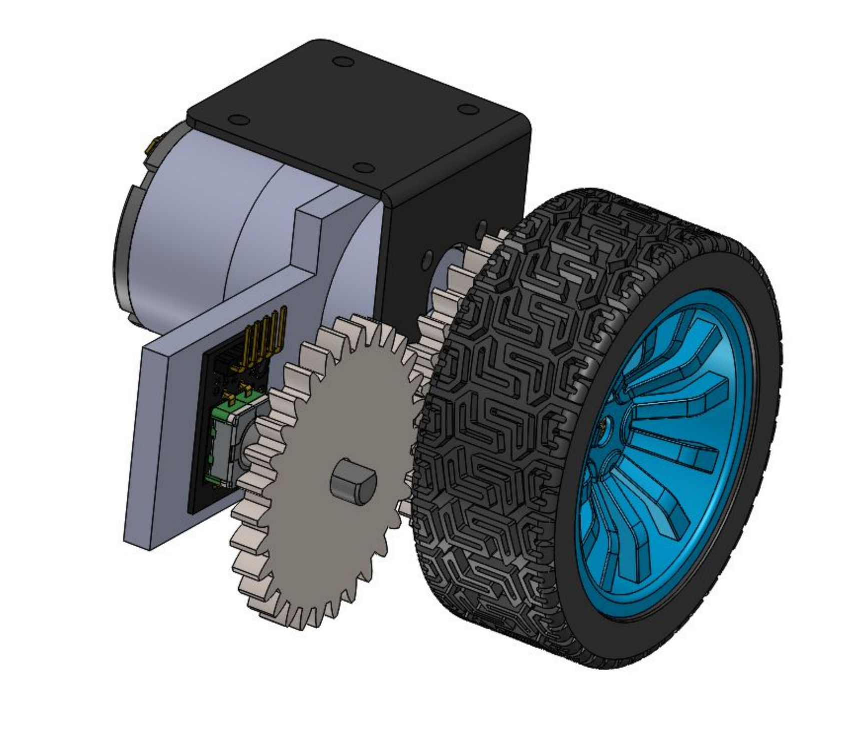

Fig. 3: Wheel-Encoder attachment

SLAM Implementation

ROS

Fig. 5: Robot Operating System (ROS)

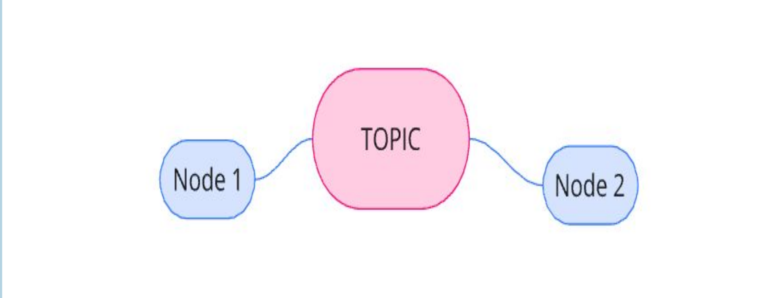

Fig. 6: ROS Nodes and Topics

NAV2
Powered By
OPEN NAVIGATION

Fig. 7: Navigation Stack 2 (Nav2)

Challenges

- Steep learning curve for ROS2 adoption (Robotics Dojo Community)
  - Providing training and guidance
  - Providing open-source resources e.g. code, simulation tooling, and docker image

Acknowledgements

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- Acknowledgment to Dr. Shohei Aoki, Ph.D., for guidance during research and development.

Future Work

- SLAM + Object Detection
- Visual Simultaneous Localization & Mapping (VSLAM)

Fig. 8: Intel Realsense D435i

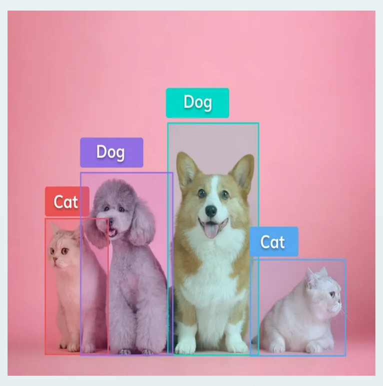

Fig. 9: Object Detection (cats and dogs)

Methodology - I

Agile Methodology

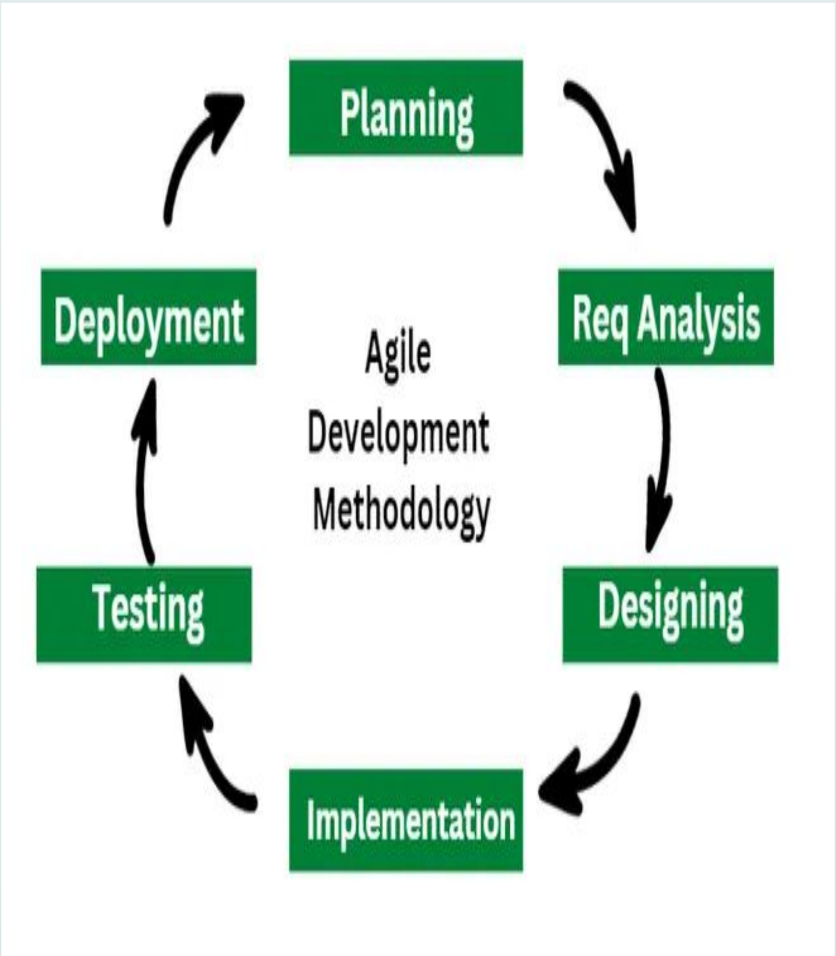

Fig. 1: Agile Methodology Chart

Vehicle Design

- **Design Requirements:**
  - **Short fabrication time - Laser Cutting vs 3D Printing**
  - **Simple physical model - Circular Chassis**
  - **Competition Guidelines**

SLAM Implementation

- **Key Components:**
  - RPLiDAR A1 (LiDAR sensor) for accurate mapping.
  - Wheel encoders for precise localization.
  - L298N motor driver.
  - Raspberry Pi 4 and Arduino Mega 2560 for processing.

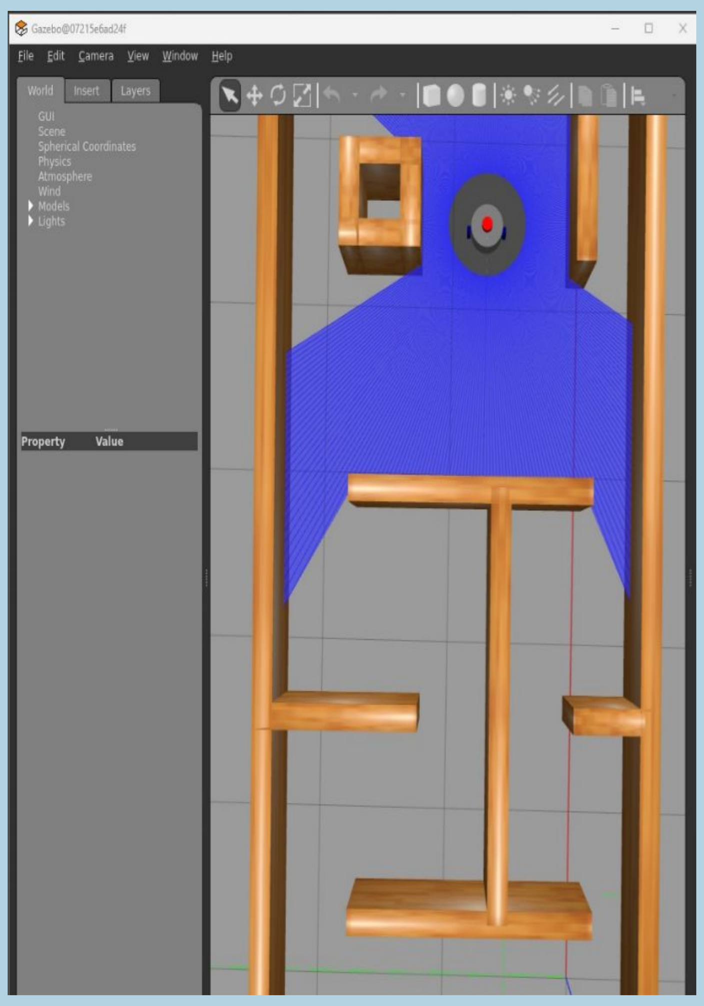

Fig. 4: Gazebo Simulation Environment

Experimental Results

- **Modular Development Approach:**
  - Individual units developed first e.g. individual motors programmed
  - Individual functional units next e.g. motor control in all 4 directions
  - Individual subsystems e.g. driving motors via tele-operation nodes
- **Testing Approach:**
  - Unit testing of individual nodes (e.g., LiDAR data visualization).
  - Integration testing of the entire robot (e.g., teleoperation within the maze).
- **Mapping Integration:** Final integration of SLAM functionality tested on the maze gamefield to ensure effective navigation and mapping.
- A custom simulation environment was built on Gazebo and RViz and this enabled the rapid testing of ROS2 mapping and navigation packages.

Contact Information

For further inquiries or collaboration opportunities, please reach out to our team via the details below (or scan the QR code to get all contact details)

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Fig. 10: Team Syzygy Contact Information