Robotics Dojo 2024
Autonomous Mobile Robot (AMR)

Joint Team 4

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Abstract

This research presents the **development of an AMR** capable of autonomously navigating through complex maze environment. Utilizing **ROS_2**, **SLAM**, and **LiDAR**, the robot successfully demonstrates

- Accurate mapping & localization,
- Path planning
- Obstacle avoidance.

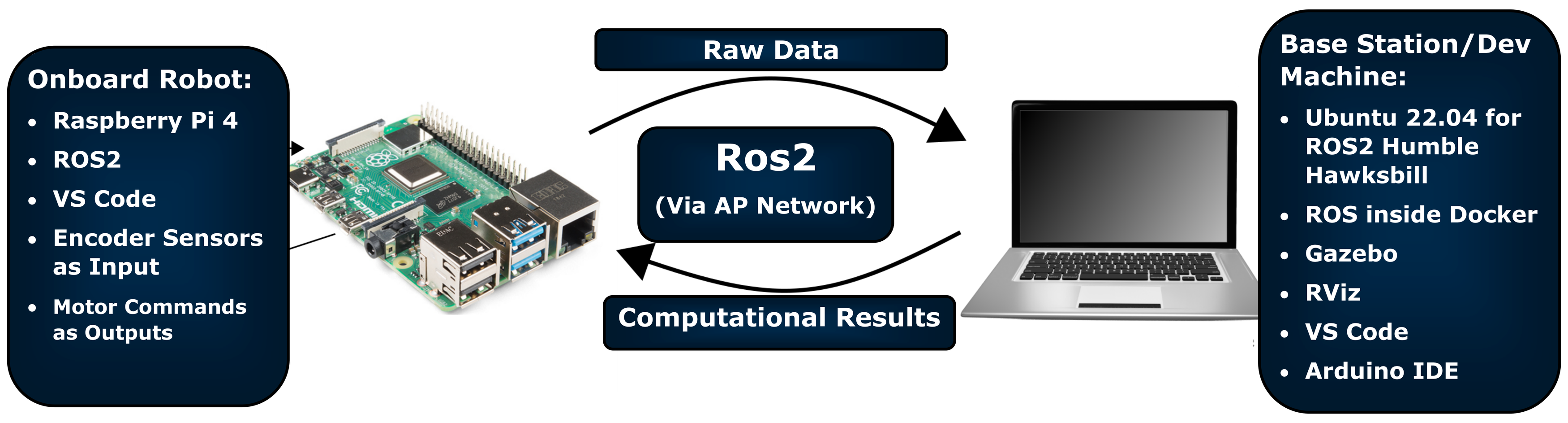
This research contributes to advancements in autonomous robotics and has potential applications in fields of **logistics**, **search and rescue,** and **industrial automation.**

1. Introduction

Objective: To deepen and share knowledge on Robotics by building an Autonomous Mobile Robot using **ROS2** for navigation.

Main Contributions:

1. Integrated real-world robotics with **ROS2, Gazebo** simulation, and hardware interfaces.
2. Developed robust **teleoperation** and **autonomous navigation**.
3. Designed and built a reliable hardware platform.



2. Design Strategy and Build Process

2.1 Robot Design

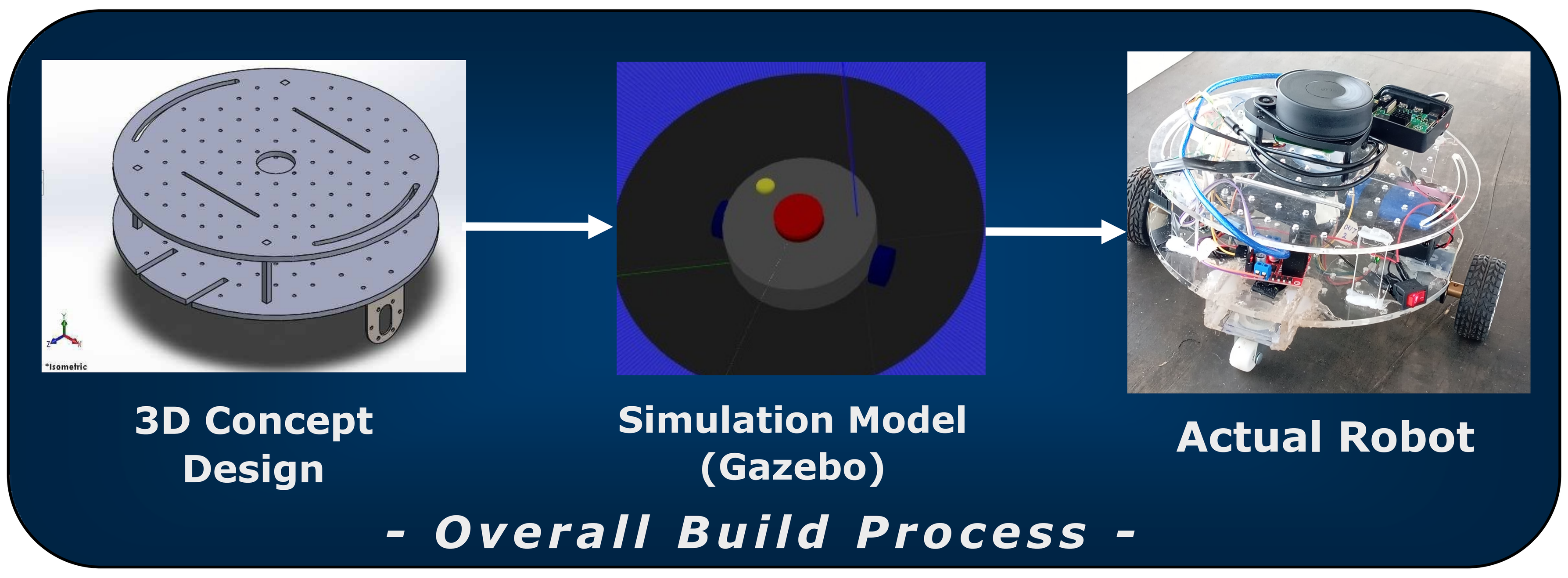
- **Modular Approach:** To facilitate easy assembly, testing, and modifications.
- **ROS 2 Framework:** Used for its flexibility, scalability, and extensive community support.
- **SLAM** and **Navigation**: Utilized the **SLAM Toolbox** and Nav2 packages for mapping and autonomous navigation.
- **LiDAR Integration:** Integrated a LiDAR sensor for accurate environment perception and obstacle avoidance.

2.2 Build Process

- **Hardware Selection:** Based on project requirements and budget constraints.
- **Chassis Construction:** Designed and built a custom chassis using **acrylic sheets** for a **lightweight** and durable structure.
- **Assembly**: Wired the components together, using proper power distribution and communication

2.3 Software Integration

- **Development** of **ROS 2 nodes** for control, navigation, and sensor processing.
- **ROS2 Setup**: Integration of ros2_control for motor control and diff_drive controller for navigation.
- **Simulation**: Utilized **Gazebo** for robot motion validation and **SLAM testing**
- **Autonomous Control**: Used **Nav2** stack for path planning and obstacle avoidance.



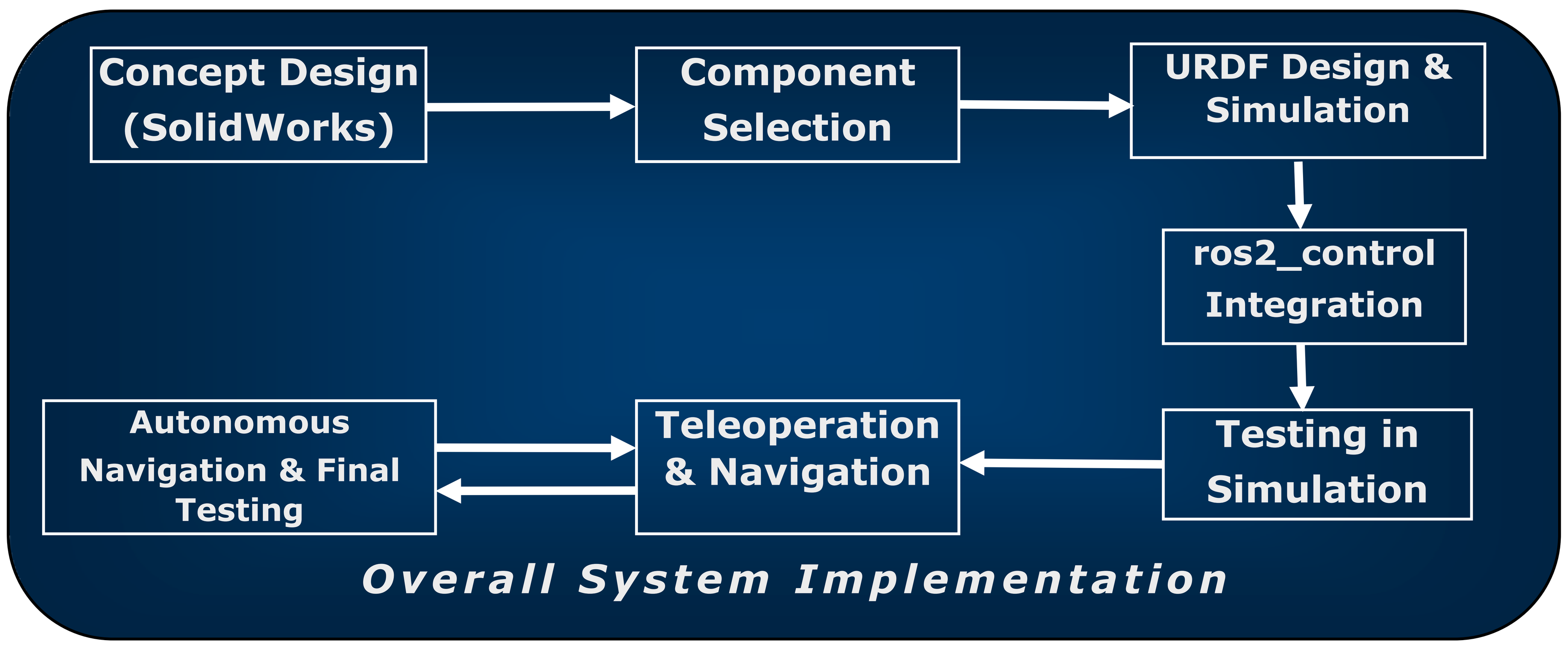
3. Control System Implementation

3.1 ROS2 Control Framework

- **Controller Manager**: Handles communication between ROS and the robot.
- **Diff Drive Controller:** Converts velocity commands into wheel speeds.
- **Hardware Interface:** Translates commands to the motor controller, receiving encoder feedback.

3.2 Teleoperation & Navigation

- **Teleoperation:** Utilized teleop_twist_keyboard for initial tests.
- **Autonomous Navigation:** Implemented SLAM for mapping and used Nav2 stack for path planning.



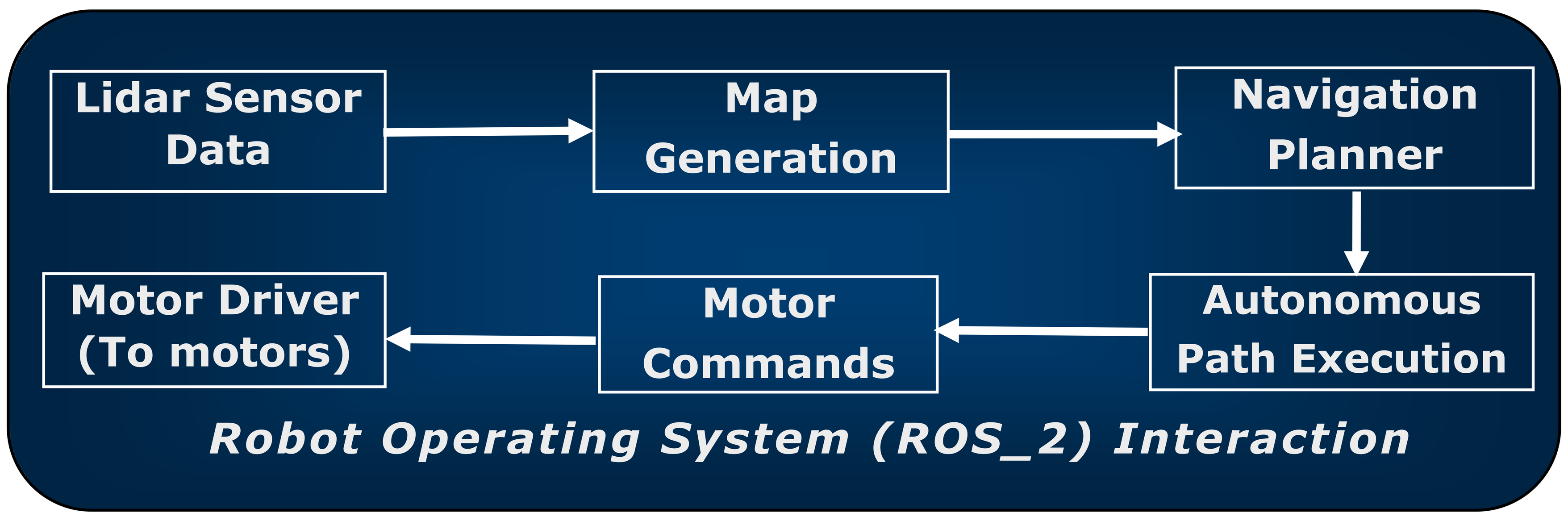
4. Testing and Perfomance Evaluation

4.1 Simulation Testing

- **Gazebo Simulation:** Verified robot motion and tested SLAM capabilities.
- **Virtual Environment:** Simulated real-world scenarios for collision detection and navigation.

4.2 Real-World Testing

- **Teleoperation Testing:** Conducted initial teleop tests using **ros2_control** and verified wheel velocities.
- **Autonomous Navigation:** Fine-tuned the Nav2 stack for smooth navigation and obstacle avoidance.



5. Results, Conclusion & Key Findings

(1) **ROS 2** proved to be a **valuable tool for robot control, communication,** and **integration** of various components.
(2) The robot demonstrated **robust obstacle avoidance** capabilities, successfully navigating around obstacles without collisions.
(3) The navigation algorithm via **SLAM efficiently planned and executed paths**, reaching the desired goal.

6. Future Works and Recommendations

- **Enhanced Environmental Perception:** Using additional sensors (cameras, depth sensors) for object recognition.
- **Advanced Navigation**: More complex navigation algorithms, such as **SLAMP** for dynamic environments.
- **Object Interaction**: Develop capabilities for interacting with objects, i.e. grasping, manipulating, or object tracking.
- **Human-Robot Interaction**: Implement features for human-robot interaction, i.e. voice commands or gesture control.

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