Group Course Project: Design and Control of an Omnidirectional Mobile Robot

General Notes

1. Submission Deadline: 09-January-2024.
2. Group Composition Requirements:

   Each group must consist of a minimum of three students and a maximum of five students. This range is designed to promote effective teamwork while ensuring that each member can significantly contribute to the project.
3. Refund Policy for Project Materials:

   Groups are eligible for reimbursement for the costs incurred in purchasing project materials. To qualify for a refund, the following criteria must be met:
   - The project must be fully functional and meet all specified objectives.
   - The group must provide a valid, itemized bill detailing all expenses related to the project.

   This policy aims to encourage careful budgeting and responsible expenditure by the groups while also providing financial support for successful project completion.

Project Description

In this project, students will design and implement an omnidirectional mobile robot, choosing between a four Mecanum wheel configuration or a three Swedish 90-degree wheel configuration. The project aims to provide hands-on experience in kinematic analysis, robot operating system (ROS2) integration, and real-world control of mobile robots.

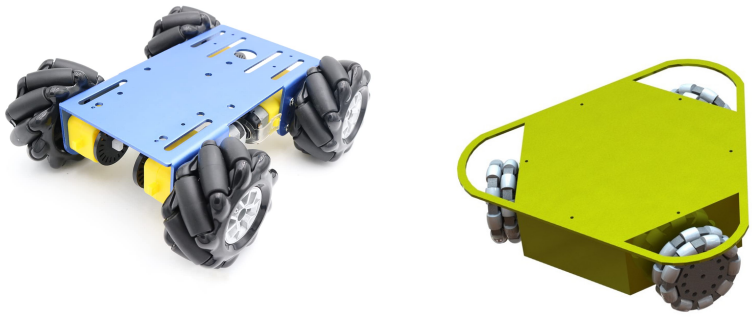

Figure 1 Omnidirectional robot platforms

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Objectives

1. **Kinematic Analysis:** Perform a comprehensive kinematic analysis of the chosen wheel configuration.
2. **URDF Creation:** Build a Unified Robot Description Format (URDF) file for the robot, facilitating its simulation and control in ROS2.
3. **Control System Development**: Develop a control system that interfaces with the robot via a USB cable, sending motor commands to an Arduino Uno.
4. **ROS2 and Python Integration:** Implement the control logic using ROS2 and the Python Serial library for communication with the hardware.

Hardware Requirements

1. Four Mecanum wheels or Three Swedish 90-degree wheels
2. Chassis to mount the wheels
3. Motors compatible with the chosen wheel type
4. Arduino Uno for motor control
5. A long USB cable for communication between the laptop and Arduino
6. Battery and power management system
7. Optional sensors for advanced applications (e.g., encoders, IMU)

Project Phases

Phase 1 - Design and Kinematic Analysis

- Choose the wheel configuration.
- Perform kinematic analysis for the chosen configuration.
- Design the mechanical structure of the robot.

Phase 2 - Building the Robot

- Assemble the mechanical components.
- Integrate motors and control electronics.
- Establish the USB communication setup.

Phase 3 - Software Development

- Develop the URDF file for the robot.
- Implement the control logic in ROS2 using Python where the input to the code on the PC will be the speed required for the robot as a ROS geometry_msgs/Twist.
- Test communication between the laptop, Arduino Uno, and motors.

Phase 4 - Testing and Calibration

- Conduct initial tests to validate the mechanical assembly.
- Fine-tune the control system for smooth operation.
- Calibrate sensors (if used) for accurate performance.

Phase 5 - Final Integration and Demonstration

- Integrate all components into a cohesive system.
- Demonstrate basic maneuvers (forward, backward, rotation, etc.).
- Optionally, implement advanced control strategies.

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Deliverables

1. A fully assembled and functional omnidirectional mobile robot.
2. A comprehensive report detailing:
   - Kinematic analysis
   - Design choices and mechanical layout
   - Software implementation and challenges

- Testing and calibration procedures

3. A ROS2 package containing all the developed software, including the URDF file and control scripts.

Evaluation Criteria

- Quality and completeness of the kinematic analysis.
- Mechanical robustness and functionality of the robot.
- Efficacy and reliability of the control system.
- Quality of documentation and adherence to project deliverables.
- Oral demonstration of the project.