DASE7503 Robotic Systems Integration

Group Project – A Smart Wheel-driven Robot for Logistics Applications

(40% of Total Course Mark)

Objectives

This group project is aimed at providing a hands-on experience for students to apply their knowledge and skills, such as robotic systems design, control, ROS programming, etc., to design and develop a smart wheel-driven robot for logistics applications with integration of ESP32 & Raspberry Pi boards, lidar, camera, etc.

A group of around 8 students designs and builds a smart wheel-driven robot with a lifting device for locating a cargo rack and then delivering it to a specific zone.

Each group is required to submit the following:

- SolidWorks CAD assembly models of a smart wheel-driven robot
- All computer programs
- A physical robot assembly
- A PowerPoint

Major equipment, software and materials

- Equipment
  - 3D printers
  - Laser material processing equipment
- Software
  - SolidWorks
  - Arduino IDE
  - ROS 2 Jazzy
  - Python
- Materials
  - Acrylic board
  - 3D printing materials
  - ESP32 and Raspberry Pi development boards
  - Lidar, motors, cameras

Procedures

1. Design and create a 3D assembly model of a smart wheel-driven robot using SolidWorks CAD software.
2. Adopt 3D printers and laser material processing equipment to fabricate the required mechanical/housing parts of the robot
3. Assemble the required parts, a lidar, and a camera to form a complete robot.
4. Write the required control programs (micro-ROS) on ESP32 to control the movement of the robot and the movement of the lifting device on the robot.
5. Write the required programs on Raspberry Pi (ROS2 Jazzy) to do the following:
    a. control a robot's camera to scan a QR code and store the decoded QR code data.
    b. control a robot's lidar for localisation and navigation
    c. communicate with the ESP32 via a USB serial port
6. Write a program on either a Raspberry Pi or a PC to achieve a robot's autonomous navigation.
7. Test the robot.

Tasks for each group

Each group should complete the following:

1. Design and fabricate a smart wheel-driven robot with integration of a lifting device.
2. Develop all required programs for achieving the robot's functionalities, including lifting, QR scanning, localisation and navigation, and the robot's autonomous navigation, etc.
3. Participate in a robot (game) demonstration. Within 3 minutes, the robot needs to navigate in the game field to locate and collect the cargo rack at different points of the game field and transfer each cargo rack to the destination point.

Project requirements

Each group should pay attention to the following:

- The overall size of a smart robot (physical robot) should not be larger than 30cm x 30cm x 18cm.
- Only one set of required components will be provided for each group.
- Return all group project components, tooling, and materials (not assembled in the physical robot) on Nov 26, 2026.

Details of the game

i) Game field

- The field size is around 300cm x 200cm.
- All points on the field, including the start point, destination point and cargos, have their own QR codes for route marking, as shown in Figure 1.
- Cargo racks' locations are fixed on the field. All participants also know their locations (x, y) in advance.

ii) Game rules

1. The game is based on groups. Each group is considered as one participant.
2. Each group's robot should use its camera to scan a QR code of the start point, and the robot should start identifying and picking a cargo rack in an automatic way. At the same time, the game's timer starts counting.
3. Using a lidar, the robot should automatically navigate to a zone with a cargo rack and use its camera to scan a QR label assigned to the rack to locate the rack and lifting and delivering it to the destination area.
4. Within 3 minutes, Step 3 is repeated until all racks are delivered to the destination area.
5. The rack cannot touch any floor during delivery.
6. If either a robot or a rack collides with a wall, 2 points will be deducted for each collision.
7. At the end of 3 minutes' game time, the number of cargo racks that lay in the destination area will be recorded. 5 points will be awarded for each shipment, and the final score will be tied to the ranking of all groups.

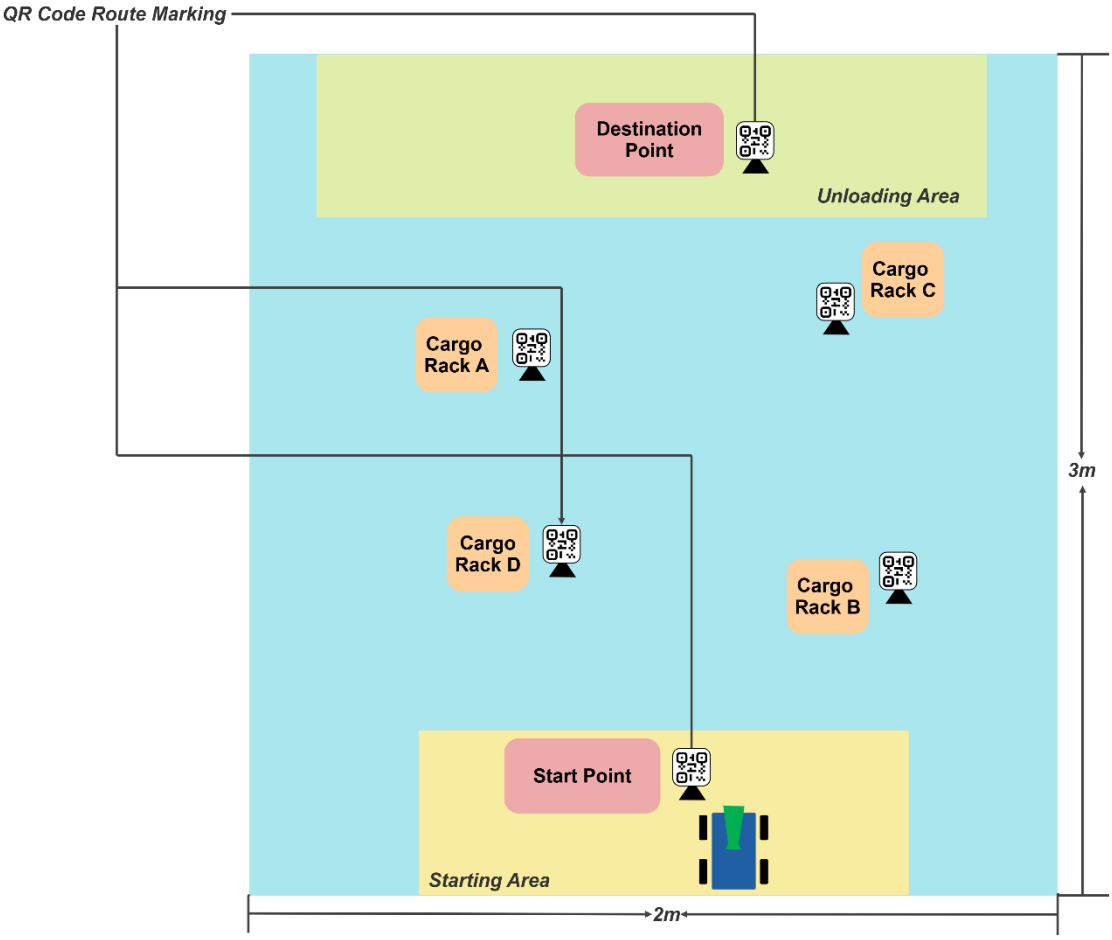


Figure 1. Game field

Assessment

The group project assesses the overall performance of each student based on his/her participation in and contributions to the project. The assessment consists of two main parts:

I. Overall Group Assessment **(25% of Total Course Mark)**

II. Game Demonstration **(10% of Total Course Mark)**

III. Peer Assessment (5% of Total Course Mark)

I. Overall Group Assessment (25% of Total Course Mark)

The teacher will be responsible for this overall group assessment. The performance of each group is based on the following criteria:

(a) Design concept and innovation
- *Creativity*
- *Originality*

(b) Robot product details
- *Aesthetics (visual appearance)*
- *Functionality*
- *Easiness of assembly*

(c) Programs
- *Performance*
- *Easiness of code reading*
- *User- friendliness*

II. Game Demonstration (10% of Total Course Mark)

Each group is assessed by the performance of each robot's demonstration with the following criteria:

- Achieve automatic navigation and complete all the operations within a specific time (A range)
- Achieve manual control and complete all the operations within a specific time (B range)

III. Peer Assessment (5% of Total Course Mark)

Each group member is assessed by other group members to award each group member's contributions to the group project.

Submission

Each group is required to submit the following items:

1. A completed and tested Smart Wheel-driven Robot;
2. All CAD models and files, including a SolidWorks design zip file created by the "pack-and-go" function;
3. All control programs, including ROS2 Jazzy files and micro-ROS files; and
4. Group Project tooling and materials, including plastic box, display cables, Raspberry Pi 5 27W power supply, USB 3.2 card readers, battery charger, power adaptor, unused parts;

Items 1 and 4 should be submitted to **Mr. Derek Tong** or **Mr. Mark Wan** in the Laboratory **HW 103A** by **17:00 on Nov 26, 2026 (Thursday)**.

Besides, items 2-3 should be submitted to the Moodle by **23:59 on Nov 26, 2026**.