IST Project — TC / CITI

Autonomous Ping-Pong Ball Collection Car

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1. Context and Objective

Gymnasiums hosting table tennis training sessions face a recurring problem: ping-pong balls become scattered across the entire floor of the gym. Picking them up by hand is tedious and regularly interrupts practice sessions. This project aims to design and implement an autonomous mobile racing car capable of patrolling the gymnasium, detecting and capturing balls on the floor, and then depositing them in collection zones located in the four corners of the room.

The car must operate in safe coexistence with the players present, detecting human obstacles and stopping or backing away if necessary. Design simplicity is a core requirement: the system must be robust, require minimal maintenance, and carry an onboard power supply that is managed independently.

2. Functional Description

2.1 Movement and Navigation

The car moves continuously and slowly in a straight line along the perimeter of the gymnasium. It carries out successive rounds covering the length and width of the room. To orient itself, it uses simplified visual markers (such as ArUco tags or QR codes) placed at key points along its route, which it detects using an onboard camera.

When a player or any other obstacle is present on its path, the car gradually slows down and stops before making contact, maintaining a safety distance of at least one meter. It can also back away if the risk of contact becomes imminent.

2.2 Ball Detection and Capture

When the car identifies one or more balls along its path, it accelerates to pass over them and capture them in a trailing net located between its wheels, much like a fishing net. Once the balls are captured, it gradually slows down to prevent them from being thrown back out of the net by inertia.

The net is an easily replaceable wear part, in line with the system's minimalist design requirement.

2.3 Ball Deposit

Once the car has collected enough balls, it heads to a dedicated collection zone, for example located in one of the four corners of the gymnasium. There, it empties the contents of the net, then resumes its patrol route. Monitoring the net's fill level is handled by the onboard system.

3. Technical Architecture

The car is built on the Traxxas TRX-4 motorized base, controlled by a Raspberry Pi. Environmental perception is provided by an Intel RealSense camera, capable of supplying depth information for ball and obstacle detection. All processing (navigation, detection, mission logic) is run locally on the Raspberry Pi.

The embedded code must be deliverable on a USB drive and directly writable to the Raspberry Pi. The project will be managed via a GitHub repository, including architecture documentation and source code.

4. Validation Scenarios

The project will be evaluated according to the following progressive test scenarios:

1. Autonomous travel of the car along the borders of a defined 2D space.
2. Detection of an obstacle and immediate stop.
3. Detection of an obstacle and stop at least one meter before contact.
4. Identification of balls along the car's path.
5. Controlled acceleration toward detected balls.
6. Gradual deceleration without losing balls.
7. Deposit of a single ball in a collection zone.
8. Deposit of a full net in a collection zone.

5. Expected Deliverables

The project's GitHub repository must contain:

- Technical documentation describing the software and hardware architecture, design choices, and the algorithms implemented.
- The complete source code structured and commented, ready to be flashed onto a Raspberry Pi.
- A car commissioning and maintenance guide.

https://docs.ros.org/en/rolling/Releases.html
https://github.com/fictionlab/ros_aruco_opencv
https://www.rcteam.com/products/traxxas-trx-4-chassis-kit-clipless-82216-4