~Undergraduate Category~

PATH OPTIMIZATION ROBOT COMPETITION

COMPETITION OVERVIEW

OBJECTIVE

Participants must design and program a two-wheeled autonomous robot capable of learning a course on an initial run and then optimizing its path for speed and accuracy on a subsequent run. The challenge is divided into two stages with increasing difficulty. Machine Learning and Computer Vision will be central to the competition, but the complexity is limited to what an ESP32 or Raspberry Pi can handle.

The robot will be given 10 minutes to complete 5 laps starting from the start line(end line). If the robot stops(10s), the team will be able to reset the robot and start from where it stopped(two attempts), but the timer will not be stopped.

SPECIFICATIONS

- Must be a two-wheeled drive system
- Robot's dimensions : less than 20 cm x 20 cm x 20 cm
- Must be equipped with encoders, IMU, and a camera for vision
- No guided lines; navigation must rely on environmental features (walls, obstacles, key points)
- Must autonomously optimize its path using previously gathered data
- Obstacle size > 5 cm x 5 cm x 5 cm
- Path width : 40 cm - 100 cm
- Path wall height > 10 cm

Color code

- Floor : white
- Walls, obstacles : black
- Start/end line : red

COMPETITION STRUCTURE

Stage 1: Simulation Based Learning and Planning

- The robot will navigate a flat course in a simulated environment (Webots)
- The course will have walls, checkpoints, and obstacles
- The robot must learn the course and generate an optimized path
- Participants must submit:
    1. A video demonstrating their robot's learning process
    2. A logbook detailing algorithms, decision-making, and performance metrics
    3. A presentation explaining their approach, optimization strategy, and results

Stage 2: Physical Implementation and Path Execution

- The learned path from Stage 1 will be applied in a physical setting
- The course layout will be slightly modified (e.g., obstacles shifted, additional targets introduced
- The robot must autonomously execute the optimized path
- Participants must submit:
    1. A logbook of real-world implementation details
    2. A final report including hardware and software components used
    3. A presentation on challenges encountered and optimizations made

RULES AND REGULATIONS

General Rules:

1. **Hardware Restrictions:**
    - The robot must adhere to the provided hardware limitations (ESP32, Raspberry Pi, etc.)
    - No external computing assistance is allowed (e.g., off-board processing)
2. **Autonomy:**
    - The robot must be fully autonomous in both learning and execution phases
    - No external human intervention allowed after initialization
3. **Navigation & Path Optimization:**
    - The robot may use any strategy to optimize its path, including Machine Learning and Computer Vision
    - No predefined maps or external positioning systems (e.g., GPS) are allowed
4. **Course & Obstacles:**
    - The course will have walls, obstacles, and key targets
    - In Stage 2, the course may be slightly modified to test adaptability
5. **Safety:**
    - The robot must not damage the environment or itself
    - Any unsafe operation will lead to immediate disqualification
6. **Time Constraints:**
    - Each team has a fixed time to complete both stages
    - Exceeding the time limit results in penalties

Disqualification Criteria:

- External intervention during execution
- Robot fails to complete the course within the given time
- Violation of hardware or autonomy constraints

MARKING CRITERIA

Category	Stage 1 (Simulation)	Stage 2 (Physical)	Total Points
Navigation Accuracy	10	20	35
Speed Optimization	15	20	35
Obstacle Avoidance	10	15	25
Key Point Collection	10	15	25
Learning Adaptability	10	15	20
Technical Report	10	10	20
Presentation Clarity	10	10	20
Hardware Implementation	N/A	10	10
Aesthetics & Design	N/A	10	10
Total Points	80	125	205

MARKING CRITERIA

- **Navigation Accuracy:** How precisely the robot follows an optimal path
- **Speed Optimization:** The efficiency of the path relative to the learned map
- **Obstacle Avoidance:** The ability to navigate without collisions
- **Key Point Collection:** Ensuring required waypoints are visited
- **Learning Adaptability:** How well the robot adjusts to slight course modifications
- **Technical Report:** Clear documentation of approach and methodologies
- **Presentation Clarity:** Effectiveness of explaining the approach
- **Hardware Implementation:** Quality of assembly, stability, and efficiency
- **Aesthetics & Design:** Neatness, robustness, and overall build quality

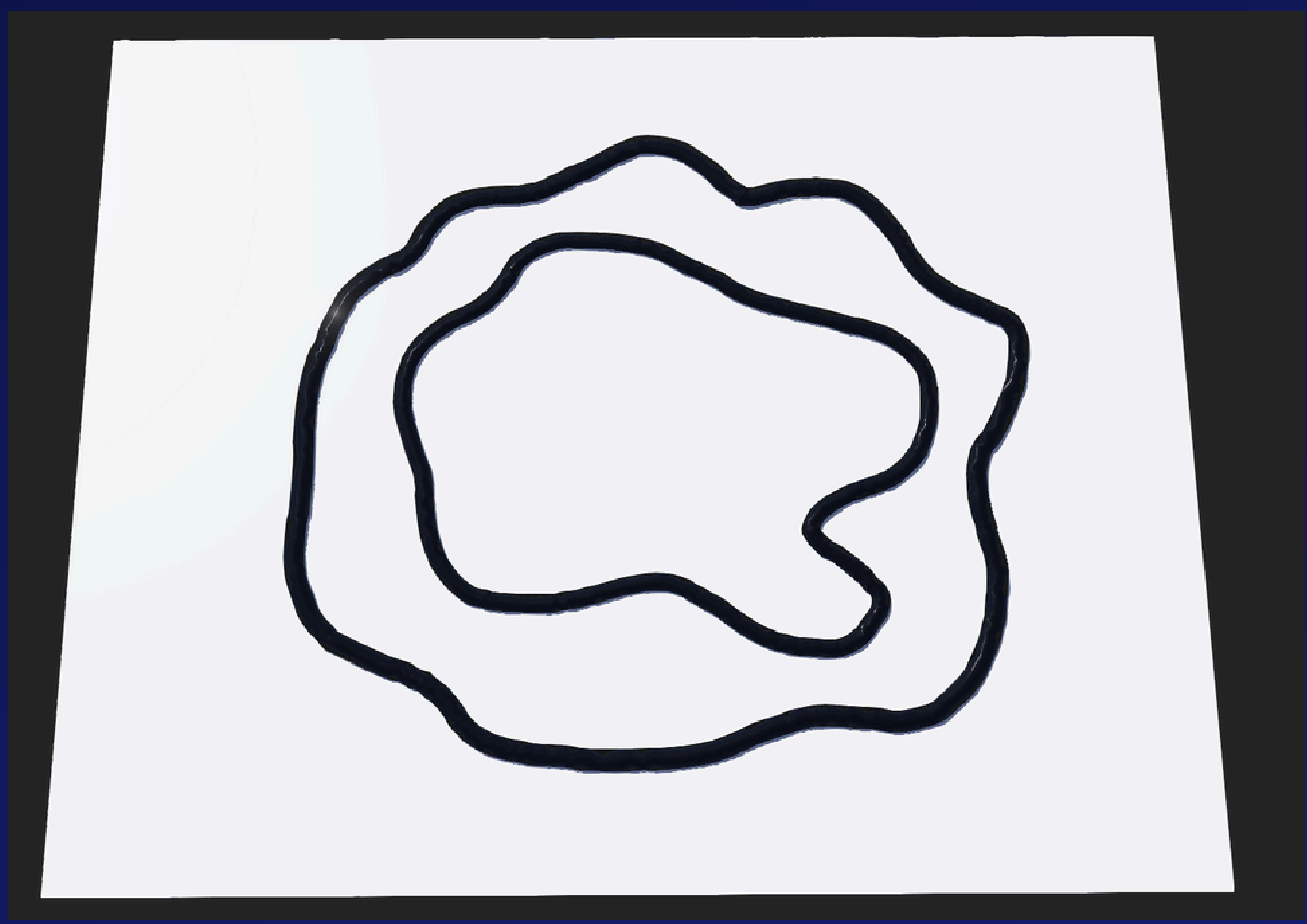
EXAMPLE COURSE DESIGN

Stage 1: Basic Navigation & Learning

- A flat surface with walls defining a path
- No obstacles; only waypoints to be collected in sequence
- The robot must learn the environment and determine the shortest path

Stage 2: Advanced Path Execution

- A slightly modified version of Stage 1
- Obstacles placed along the shortest paths
- New waypoints added in a specific order
- The robot must adapt and optimize its path accordingly



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