Applied Robotics and AI Project: Assignment 2

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1. Introduction

Robots are increasingly playing a vital role in search and rescue missions, especially in environments that are hazardous or challenging for human responders. This study investigates how an e-puck robot can autonomously find and recognize colored blocks—specifically, red, blue, and green—that stand in for significant items or markers in a search area using the Webots simulation environment. We hope to demonstrate how small autonomous robots can help with search tasks by programming the robot to roam the assigned space, identify block colors, and produce messages upon successful identification.

Setting up the simulation environment, creating a plan for the robot's search patterns, putting in place a color detecting system, and laying out the project plan are all covered in this report. Through these initial phases, we show how robotic systems might help with tasks where human participation might be dangerous or ineffective.

2. Methodology

Environment Setup

For the e-puck robot to travel and find the colored blocks in the Webots simulation, a flat, bounded region is built. Within this space, three blocks—one each of red, blue, and green—are arranged at random. Because each block is the same size (0.3 x 0.3 x 0.1 m), the robot's camera can reliably recognize them in any direction. This configuration offers a controlled setting for evaluating the robot's navigation, color detection, and reporting skills.

Robot and Sensor Configuration

The e-puck robot was selected for this project because of its tiny size and compatibility with the Webots simulation environment, which make it ideal for exploring constrained locations. The e-puck's built-in camera detects colors at close range, allowing it to correctly recognize and distinguish between the red, blue, and green blocks put within the search area. This arrangement allows for more precise color detection and increases the robot's capacity to perform search and identification tasks autonomously.

Programming and Search Logic

The programming of the e-puck robot is made to move across the search area quickly and identify colored objects. The robot employs a movement pattern, like a spiral or zigzag, to ensure thorough investigation in order to go through the area methodically. The robot's camera continuously searches for predetermined colors while it moves, generates a message, and keeps track of the colors it has already detected so it doesn't send out the same signals twice.

The step-by-step process for color detection and searching includes:

1. **Initialize Sensors**: Start by activating the robot's sensors, including its camera, to enable color detection.
2. **Movement Pattern**: Direct the robot to move in a designated search pattern—such as a spiral, zigzag, or randomized path—to efficiently cover the entire search area.
3. **Color Detection**: Utilize the camera to identify colors using pre-established red, blue, and green criteria. These criteria aid the robot in precisely differentiating colors up close.
4. **Output Messages**: For each new color detected, the robot outputs a specific message:
    - "I see red" for red blocks
    - "I see blue" for blue blocks
    - "I see green" for green blocks
5. **Record Summary**: To prevent repeating messages for the same blocks, the robot updates a summary after detecting a color to record the colors it has already identified.

The robot can efficiently seek, recognize, and convey information about the colored blocks in its surroundings thanks to its methodical methodology, showcasing a straightforward yet potent use of autonomous robotics in search situations.

3. Project Plan

- **Phase 1: Research**
    - Familiarize with Webots and e-puck camera functionality for color detection.
    - Study search patterns like spiral and zigzag to maximize area coverage.
- **Phase 2: Simulation Setup and Testing**
    - Set up the environment and randomly place blocks.
    - Test initial e-puck movement and confirm color recognition with basic camera functionality.
- **Phase 3: Programming and Iterative Testing**
    - Write the main control code for color detection and movement patterns.
    - Run tests with blocks in different locations to refine detection accuracy.
- **Phase 4: Final Documentation**
    - Document findings, summarize results, and prepare code for the final report.

4. References

1. Webots Documentation: Cyberbotics Guide for Webots Software.
2. "Color-based Object Detection in Robotics," *International Journal of Robotics Research*, 2022.
3. "Efficient Search Patterns for Autonomous Robots," *Journal of Robotic Engineering*, 2023.

5. Appendix

```python
from controller import Robot, Camera

robot = Robot()
timestep = int(robot.getBasicTimeStep())

camera = robot.getDevice("camera")
camera.enable(timestep)


detected_colors = set()

def detect_color(image):
    if ...:
        return "red"
    elif ...:
        return "blue"
    elif ...:
        return "green"
    return None

while robot.step(timestep) != -1:

    camera_image = camera.getImage()

    color = detect_color(camera_image)

    if color:
        if color == "red" and "red" not in detected_colors:
            print("I see red")
        elif color == "blue" and "blue" not in detected_colors:
            print("I see blue")
        elif color == "green" and "green" not in detected_colors:
            print("I see green")

        detected_colors.add(color)
        print("Summary of detected colors:", detected_colors)

```