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CDA 4621 Control of Mobile Robots

Lab 2

**Task 1 Plots**

Figure 1: Plot showing the values reported by the front, left, and right distance sensors for a starting robot orientation of 0 rad (facing directly forward) and kp = 1. Note that the left and right sensors reported almost identical values.

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

**Task 2 Plot**

Figure 7: Plot showing the robot’s distance from the cylinder (measured using the front sensor), alignment with the cylinder (measured with get\_position\_on\_image()), and blob size of the cylinder. Note that it took approximately four seconds before the robot finished turning to detect the obstacle.

**Mathematical Computations**

Task 1

This task required the robot to utilize PID control to move towards the goal while keeping its distance from the side walls. The robot starts at a distance of 50 inches from the end wall and must move forward 40 inches, stopping exactly 10 inches from the end wall. This motion must be completed in 30 seconds. To complete the motion within this time, the robot measures its distance from the goal (using the front distance sensor), and it keeps track of how much time has elapsed since the simulation began. Dividing the remaining distance by the remaining time yields the desired linear velocity V.

PID control is used to keep the robot centered in its path. Let y(t) be the distance from each side wall as measured by the distance sensors. Let r(t) = 3.624 in., the optimal distance from each wall. When both side distance sensors report this value, the robot is directly in between the walls. The error e(t) is given by the equation below:

(1)

The error is positive when the robot is too close to the wall, and it is negative when the robot is too far from the wall.

The motor velocity control function is as follows:

(2)

The constant Kp was determined through experimentation. After testing different starting orientations (in the range of -30 to 30 degrees, inclusive), using 2.5 for the Kp value yielded the best results. This value caused the robot to stabilize its motion and center itself in the corridor fastest, even when starting at an orientation of 30 degrees.

After determining the error for each motor, the two errors are compared to determine which is larger. If the absolute value of the left sensor’s error is larger, the robot is closer to the wall to its left. In this case, the robot’s left motor should be sped up to move it away from the left wall. The new velocity will be the sum of V and the left motor velocity control value. The right motor’s velocity is determined by solving the following equation for vr:

(3)

A similar procedure is used when the right sensor’s error is larger.

Task 2

This task can be divided into two parts. First, the robot must rotate in place until it detects the yellow cylinder with its camera. As was determined in the previous lab, setting one motor to a speed of 2.92 and another motor to -2.92 results in the fastest possible rotation. For this task, the robot is rotated at a speed equal to 1/3 of this. The goal is to turn the robot so that the cylinder is near the center of its field of view, and turning too quickly could lead to an inaccurate rotation. The robot will turn counterclockwise until the cylinder is within five pixels of the center of the camera view.

Once the robot has turned to face the cylinder, the next step begins. As with the previous task, the robot’s linear velocity is equal to the distance remaining (measured using the front distance sensor) divided by the remaining time. The robot moves towards the cylinder, using PID control to keep itself aligned with the cylinder. For this task, rather than using the left and right distance sensors to calculate the error, a better approach involves tracking the position of the cylinder in the image taken by the camera. This error will be zero when the cylinder is exactly in the center of the image, which is the case when its X position value is 40. Positive error indicates that the robot is facing too far to the right, while negative error indicates that the robot is facing too far to the left. The error is given by the equation below:

error = camera\_center\_x - position / (camera\_center\_x / 8) (4)

When the error is positive, the left motor should be sped up to realign the robot with the cylinder. The new velocity of the left motor will be as follows:

left\_motor\_velocity = (linear\_velocity + error) \* Kp (5)

A similar procedure if the error is negative. The right motor will be sped up to compensate.

Task 3 - Corridor

This task required the robot to implement wall-following behavior. The robot maintains a distance of 7 inches from the wall it is following as best it can. The PID techniques from previous tasks were used to keep the robot away from the walls. Whenever the robot detects a wall in front of itself, it will attempt to turn left or right, depending on which controller is currently active. If the left turn controller is active, and the robot detects a wall to its left and in front, it will perform a 180 degree turn. If the right turn controller is active, and the robot to detects a wall to its right and in front, it also turns 180 degrees.

The task is finished after the robot traverses the entire path, which is about 220 inches. Whenever the robot performs a 180 degree turn, it adds twice the number of inches it has travelled up to that point to this value. For example, if the robot has travelled 30 inches in total before it turns 180 degrees, the total length of the path increases to 280 inches.

Task 3 - Maze

The maze component of Task 3 requires some changes to be made to the robot’s controller. In particular, if the robot only makes left turns or right turns, it will be impossible to complete the task from some starting positions. To compensate for this, the robot will switch from the kinds of turns it is performing (left turns become right turns and right turns become left turns) after performing two 180 degree turns. This prevents the robot from getting stuck and allows it to make progress in the maze. The task ends at the top left corner of the maze, which is reached when all three distance sensors report values less than or equal to the stopping distance (8.4 inches).

Task 4

**Conclusions**