Universidade de Aveiro
Departamento de Eletrónica, Telecomunicações e Informática

Perceção e Controlo / Perception and Control

(Academic year of 2024-2025)

Assignment 2

Corridor Runner
using the CiberRato simulation environment

December, 2024

1 Objectives

In this assignment, each group should develop 2 robotic agents to command a simulated mobile robot. The objective of this challenge is to control the movement of a robot through an unknown closed path defined by walls. The robot should follow the corridor as fast as possible. There is a central line on horizontal corridors that may be sensed by the line sensor. The robot can only use the obstacle, line and ground sensors for perception.

Each group should develop 2 versions of an agent that fulfills this task. One version based on a more classical control approach and another one using either Machine Learning or Fuzzy Control.

2 The CiberRato environment

The CiberRato simulation environment will be used to assess the developed agent. The simulated robot (see figure 1) is equipped with 2 motors (actuating in the left and right wheels) and 3 leds (visiting, returning and finish). In terms of sensors, it includes a GPS, a compass, four obstacle sensors, a beacon sensor, a ground sensor, a collision sensor, and a line sensor.

The simulated robot navigates in a delimited rectangular arena, 14-units tall and 28-units wide, being the diameter of the robot the unit of measure. This navigable area can be seen as a bi-dimensional array of fixed size cells, each cell being a square with side length equal to twice the diameter of the robot (2-units). So, the maximum size of the competing arena is 7-cells tall and 14-cells wide. A maze is defined by placing thin walls on the boundaries of cells, which can be detected using the obstacle sensors. The target spots are detectable by the ground sensor.

3 Challenge description

As stated before, the objective of this challenge is to develop an agent suitable to control the movement of a robot through through an unknown closed path defined by walls. The robot should follow the corridor as fast as possible. There is a central line on horizontal corridors that may be sensed by the line sensor. The robot can only use the obstacle, line and ground sensors for perception. Figure 2 shows an example of a maze suitable for this challenge, which will be available during development. On start, the robot will be aligned with the X (horizontal) axis, pointing to the right, which corresponds to the North direction. The idea behind this challenge is to use the obstacle and line sensors to control the movement of the robot in the maze. There

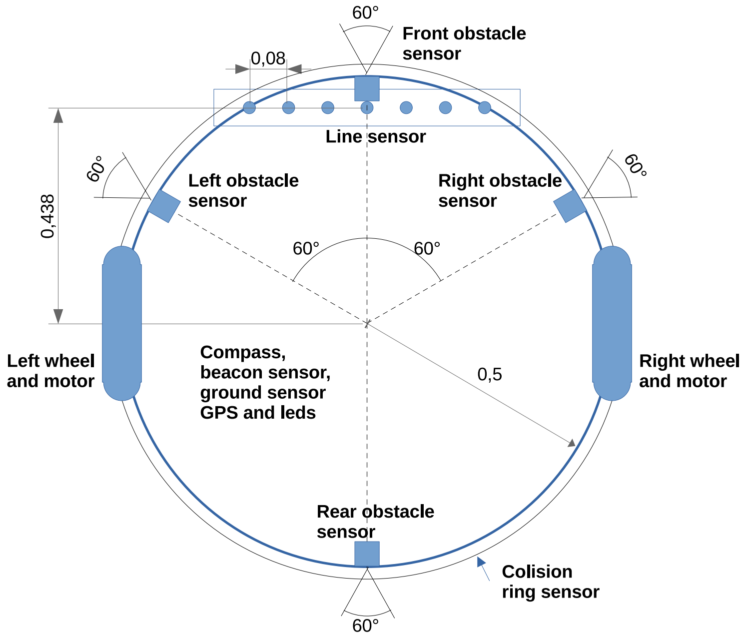

Figure 1: The simulated robot.

are checkpoints along the closed path, which can be used to determine whether the robot is traveling along the track in the correct direction or to check the progress and number of laps. These checkpoints are sensed by the ground sensor, and therefore they can be verified by the agent.

The robot must complete as many laps as possible on an unknown path during a given period of time. Scoring (and also grading) will be based on the number of cells covered along the closed path in the given time.

Each group should develop 2 versions of an agent that fulfills this task. One version based on a more classical control approach and another one using either Machine Learning or Fuzzy Control.

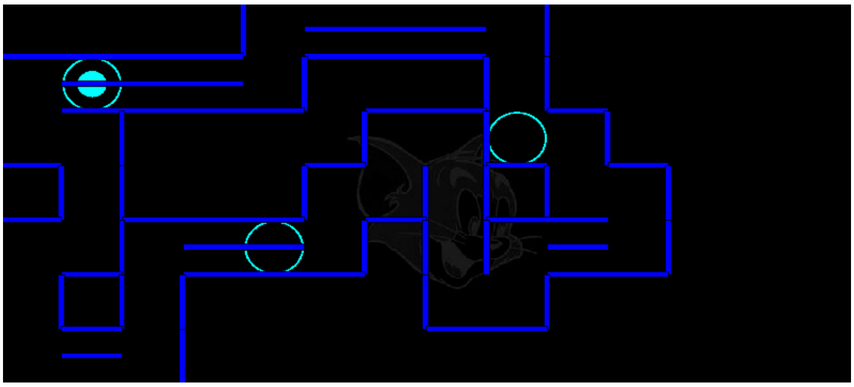

Figure 2: Example of a maze.

The agent should accept the following command line options:

- `-h` or `--host`: specifies the ip/hostname of computer running simulator
- `-p` or `--pos`: specifies the starting position (if starting grid has several options)
- `-r` or `--robname`: specifies the name of the robot

To start the simulator and viewer in the configuration of this assignment use:

./start_PC_C1

4 Movement model

Consider that the robot's pose is given by (x, y, θ), where x and y define the robot position and θ specifies the robot orientation. When the command sent to the simulator at step t is `DriveMotors(`in_t^l, in_t^r`)`, then the following equations determine the new robot pose.

An IIR filter is applied to each of the powers provided by the agent (in_t^l and in_t^r) that models the inertial characteristics of the motors and generates the effective powers that will be applied to the motors, corresponding to

$$out_t = \frac{in_i + out_{t-1}}{2} * \mathcal{N}(1, \sigma^2) \tag{1}$$

where out_t is the power applied at time t, out_{t-1} the power applied at time $t-1$, and $\mathcal{N}(1, \sigma^2)$ Guassian noise with mean 1 and standard deviation σ.

Then, the movement is splitted in a translation of the robot position, considering its current orientation, followed by a the change of the orientation of the robot. For the translation one has

$$lin = \frac{out_t^l + out_t^r}{2} \tag{2}$$

$$x_t = x_{t-1} + lin * cos(\theta_{t-1}) \tag{3}$$

$$y_t = y_{t-1} + lin * sin(\theta_{t-1}) \tag{4}$$

and for the rotation

$$rot = \frac{out_t^r - out_t^l}{D} \tag{5}$$

$$\theta_t = \theta_{t-1} + rot \tag{6}$$

where D is the robot diameter (1 in the CiberRato environment). This provides the new robot pose (x_t, y_t, θ_t) at the next step, in case no collisions occur. If the new pose involves a collision, the simulator only applies the rotational component.

5 Assessment

The assessment of this assignment will be composed of 2 components: an execution test of the agents and a presentation.

- The agents will be tested and graded.
- Each group must submit a presentation of its work, based on a PDF file.

6 Deliverables and deadline

- Source code of the developed agents.
  - The code should be in folders called `agent1` and `agent2`, regardless of the programming language used.
  - **Source code must be submitted to the Moodle website by December, 31$^{\text{st}}$.**
- Presentation (in PDF format).
  - **Presentation must be submitted to the Moodle website by December, 31$^{\text{st}}$.**

Bibliography

- “Principles of Robot Motion: Theory, Algorithms, and Implementations”, Howie Choset et al., MIT Press, Boston, 2005.
- “Introduction to Autonomous Mobile Robots”, Second Edition, Roland Siegwart et al., MIT Press, 2011.
- “Artificial Intelligence: A Modern Approach”, 3rd edition, Russel and Norvig, Pearson, 2009.