Universidade de Aveiro

DETI - Departamento de Eletrónica Telecomunicações e Informática

Perceção e Controlo

2024/25

Assignment 1

Markov Localization in the CiberRato simulation environment

Objective

In this assignment you should develop a robotic agent to command a simulated mobile robot, using the CiberRato Tools, that provides a probability distribution over the cells of the labyrinth on its possible position. The map of the labyrinth is known by the agent, but its initial position is not. The only sensors that can be used to update the probability distribution on the position are the Obstacle/IRSensors. The simulator is configured so that there is no noise in actuators/motors but there is noise in the obstacle sensors.

Environment

The CiberRato simulation environment will be used to test and assess the developed agent.

The simulated robot is equipped with 2 motors (left and right) and 3 leds (visiting, returning and finish). Its sensors include 4 obstacle sensors, a GPS and a ground sensor but GPS and ground may not be used in this assignment (except for debug purposes).

The simulated robot navigates in a delimited rectangular arena that can be seen as a bi-dimensional array of fixed size cells. Each cell is a square with side length equal to twice the diameter of the robot. The maximum size of the arena is 7-cells tall and 14-cells wide. Cells may be referenced by their position in the labyrinth where cell (0,0) is located at the bottom left corner and cell (6,13) is located at the top right corner.

A maze is defined by putting thin walls between adjacent cells. The target cell is detected by the ground sensor. Figure 1 shows a possible scenario.

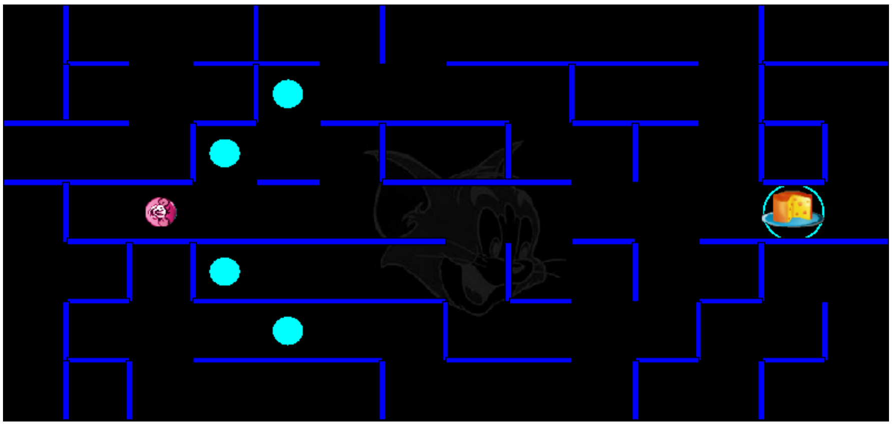

Figure 1: Scenario of the assignment: the pink robot should find the cheese (target) and return to start position,

Some scenarios are defined by XML files that are contained in the `Labs/PathFinder` folder. The groups should test their agents in new scenarios that stress the different capabilities of their agents.

The XML file that defines the scenario of the previous scenario contents is the following:

```
<Lab Name="Default LAB" Height="14" Width="28">
      <Beacon X="25" Y="7.0" Height="4.0"/>
      <Target X="25" Y="7.0" Radius="1.0"/>
      <Row Pos="12" Pattern="  |        |     |                 |     "  />
```

```
    <Row Pos="11" Pattern="  ·--·  ·--·--·  ·  ·--·--.--·--·  ·--·--"  />
    <Row Pos="10" Pattern="  |        |              |        |     "  />
    <Row Pos="9"  Pattern="--·--·  ·--·  ·--·--·--·  ·--·--·  ·--·  "  />
    <Row Pos="8"  Pattern="        |        |     |     |     |  |  "  />
    <Row Pos="7"  Pattern="--·--·--·  ·--·  .--·--·--·  ·  ·  ·--·  "  />
    <Row Pos="6"  Pattern="  |                                      "  />
    <Row Pos="5"  Pattern="  ·--·--·--·--·--·--·  ·  ·--·  ·--·--·--"  />
    <Row Pos="4"  Pattern="     |  |              |     |     |     "  />
    <Row Pos="3"  Pattern="  ·--·  ·--·--·--·--·  ·--·  ·  ·--·  ·  "  />
    <Row Pos="2"  Pattern="  |                 |           |     |  "  />
    <Row Pos="1"  Pattern="  ·--·  ·--·--·--·  ·--·--·  ·--·  ·--·  "  />
    <Row Pos="0"  Pattern="  |  |           |           |     |     "  />
</Lab>
```

The agent may be developed in C/C++, Java or Python. The CiberRato Environment includes libraries that provide adequate APIs for communication between the agent and the simulator in these programming languages, and a parser for labyrinth files that can be used for challenge 1.

The simulator may be configured to remove motors noise and the agent should advance forward from cell centre to cell centre until it finds a wall in front.

Implementation

- The agent should be able to use one of the following command line formats:

  ```
  ./robsample -h host_or_ip -m lab.xml -p 1
  ./GUISample -h host_or_ip -m lab.xml -p 1
  java jClient -h host_or_ip -m lab.xml -p 1
  python mainRob.py -h host_or_ip -m lab.xml -p 1
  ```

  to connect to a simulator that is executing in a different computer (-h), read the map description from *lab.xml* (-m), start at position 1 in the grid (-p).
- The estimated probability distribution should be saved in a file called “localization.out” after each update. This file is a text file in which the probability will be defined by 14 values in each line, corresponding to the 14 columns of the labyrinth, and by 7 lines, corresponding to each row, different updates are separated by a newline.

Movement Model

Consider that the robot 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_{left_t}, in_{right_t}), then the following equations determine the new robot pose.

An IIR filter is applied to each of the powers provided by the agent (in_{left_t} and in_{right_t}) that models the inertial characteristics of the motors and generates the effective powers that will be applied to the motors:

$$out_t = \frac{in_t + out_{t-1}}{2} * noise$$

Then, the movement is separated in a translation of the robot position, considering its current orientation, and the change of the orientation of the robot.

For translation, we have:

$$lin = \frac{out_{\text{right}} + out_{\text{left}}}{2}$$

$$x_t = x_{t-1} + lin * \cos(\theta_{t-1}) \qquad y_t = y_{t-1} + lin * \sin(\theta_{t-1})$$

For rotation, we have:

$$rot = \frac{out_{\text{right}} - out_{\text{left}}}{robotDiam}$$

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

This provides the new robot pose (x_t ,y_t, θ_t) at the next step.

Deliverables

- Source code of the developed agent
- Report (in PDF format; according to Springer LNCS paper template)

All deliverables must be available at the group repository at the code.ua platform after the relevant “Important date” (see below).

Important dates

- Submission: November 25, 2024

Bibliography

- "Markov Localization for Mobile Robots in Dynamic Environments", Dieter Fox, Wolfram Burgard, Sebastian Thrun, Journal of Artificial Intelligence Research 11 (1999)
- “Probabilistic Robotics”, Sebastian Thrun et a. MIT Press, 2005.
- “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”, 4th edition, Russel and Norvig, Pearson, 2021