Robotics Project I

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Abstract

Brief description of the content (5-10 lines). Helps people decide whether the report is relevant for them or not. Usually written at the end.

Keywords: add, keywords, for, indexing

The use of LaTeX is mandatory for the Project I report. Apart from the examples in the appendix below, this template may not be modified. A good introduction to scientific writing is given by [1]

Contents

Chapter 1

Introduction

Objectives of this project, and brief description of the structure of the report.

Chapter 2

Sensors

Chapter about the sensors that will be used during Project I

2.1 Proximity infra-red sensors

In this section, the only sensors that are concerned are the front right and front left infra-red sensors (respectively "ps0" and "ps7" in Figure 2.1). To test them, the bot number 204 is firstly placed on a table, free of any obstacle, to calibrate the sensors. This calibration phase is necessary to suppress some amount of possible noise on the sensors on real bots. It is then placed in front of an obstacle and it is commanded to move away at a determined speed while taking periodic measurements. The data collected is put in a csv file and plotted with the help of a python script. The result can be seen in Figure 2.1.

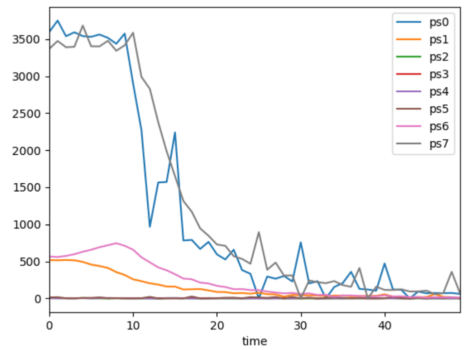

Figure 2.1: The calibrated measurement of bot 204

The y-axis represents the proximity from the object, the higher the number the closer the object. The x-axis represents the steps, it acts as a time notion.
Compared to the reference graph in Figure 2.2 given as part of this exercise, the curve follows approximately the same pattern after a certain number of steps, if not for some perturbation. The fact that the curve follows a linear pattern in the first steps is due to the bot taking some measurements before moving away, thus staying stationary in those steps. The perturbations are probably due to dust reflecting the light, glitch, unpredicted movement of the support or other form of noise.

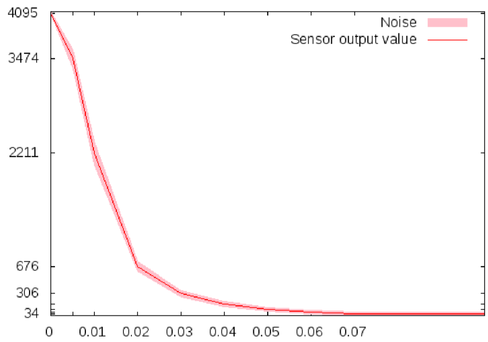

Figure 2.2: The reference graph

2.2 Infra-red ground sensor

Description of the sensor and graphs of measurements

2.3 Camera

Description of the camera and graphs of measurements

Chapter 3

Behaviours

Chapter about the behaviours that will be implemented for the assignments

3.1 Braitenberg vehicle

The Braitenberg vehicle is a thought experiment of an abstract vehicle equipped with motors and sensors said to mimic minimalist animal behaviours. The simplest Braitenberg vehicle is comprised of a motor linked to a sensor. The more the sensor is stimulated, the slower the motor performs.
By combining two motor and two sensors, it is possible to create more complex behaviours as seen in Figure 3.1. Two of those behaviours called "lover" and "explorer" are described in more details in secion 3.1.1 and 3.1.2. We are trying, in this section, to reproduce those behaviours with the help of the e-pucks.

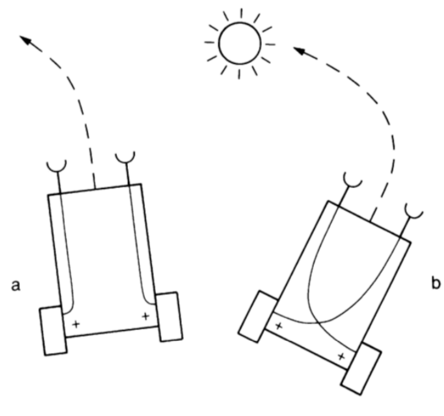

Figure 3.1: Different behaviours

3.1.1 LOVER

The lover behaviour is composed of two motors each linked to a sensor and a wheel, one on the left and one on the right, in the same manner as in point a of Figure 3.1. Since the motors slow down the closer the sensors gets to the stimulus, the vehicle gets closer to the stimulus. In our experience, the stimuli are represented as obstacles.
The proximity formula for the e-puck is calculated as the average of the four front sensors.
The speed of the wheels are reduced proportionally to its proximity formula. If the bot goes

too close to an obstacle, its speed ends up being negative and it goes backward for a short time until it is far enough for the speed to become positive again.

3.1.2 EXPLORER

The explorer behaviour follow a similar structure as the lover behaviour except the sensor are linked to the opposite motors. Therefore, the vehicle behave in the opposite way of the lover behaviour and will avoid any stimuli.
Two proximity formulas, one for the left wheel and one for the right wheel, are calculated identically as in the lover behaviour.However, they are both weighted, in the same manner, with the two frontal sensors (prox7 and prox6 for the left, prox1 and prox0 for the right) without weights, the side one (prox5 for the left, prox2 for the right) weighted at 70% and the one on the back (prox4 for the left, prox3 for the right) weighted at 20%.
The speed of the wheel is set in the same manner as the lover mode, the difference being the each wheel is set separately since the proximity formula is not the same for each one. The speed of each wheel is also reduced by 550 units to avoid collision with the obstacle.

3.1.3 Exploring Lover

The Exploring Lover behavior is a combination of both the EXPLORER and LOVER behavior which allow the bot to approach obstacles and avoid them by switching between the two. The bot switches behavior whenever it reaches an equilibrium point. In LOVER state, the equilibrium would be that the bot reached an obstacle, as in EXPLORER, it would be that the bot no longer perceive any obstacle in front of it. For a better understanding, refer to the Figure 3.2 which features the finite-state machine diagram of this behaviour.
To find the equilibrium point in LOVER state, a counter is set. Each time the bot goes back and forth the counter is incremented. If the counter reaches 10, the bot is considered to have found the equilibrium point.
In EXPLORER state, the equilibrium is reached whenever the average of the front and side proximity sensor are below 50 unit, meaning there is no longer any obstacle in the e-puck's path.

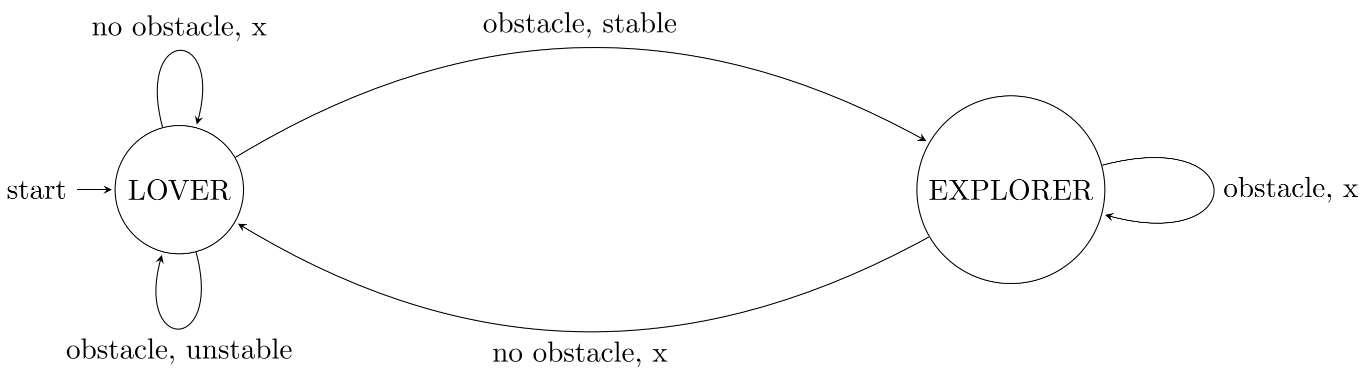

Figure 3.2: The FSM schema of the Exploring Lover Behaviour

Here is a video of the bot in action: `https://youtu.be/rDlxz8RVZrM`

3.2 Line-following

Description of the line following behaviour using a braitenberg (reactive) controller

3.3 Wall-following

Description of the wall-following behaviour using a PID controller (including a description of the PID in general)

3.4 Color recognition

Description of the color recognition behaviour

3.5 Multi-robot coordination

Description of the Multi-robot coordination using communication between robots

Chapter 4

Conclusion

Synthesis of the report and outlook for further work.

Bibliography

[1] Justin Zobel. *Writing for Computer Science*, 2nd edition. Springer-Verlag, London, 2004, 275 pages.

[2] Valentino Braitenberg. *Vehicles: Experiments in Synthetic Psychology*. MIT Press, 1986.

[3] *Webots Reference Manual*. `https://www.cyberbotics.com/reference.pdf` version 2019a Last visited: 11.02.2019.

Appendix

Appendix A Experimental Results

Place to list the gathered data.

Appendix B Source Code

Place to list source code.

B.1 IR sensors calibration procedure

The code below shows the IR sensor calibration procedure.

```
// get the correction values for prox sensors
void get_prox_corr_vals() {
  int i, j;

  // init array for calibration values
  for (i=0; i<PROX_SENSORS_NUMBER; i++) {
    prox_corr_vals[i] = 0;
  }

  // get multiple readings for each sensor
  for (j=0; j<NBR_CALIB && wb_robot_step(TIME_STEP)!=-1; j++) {
    for (i=0; i<PROX_SENSORS_NUMBER; i++) {
      prox_corr_vals[i] += wb_distance_sensor_get_value(prox_sensor_tags[i]);
    }
  }

  // calculate average for each sensor
  for (i=0; i<PROX_SENSORS_NUMBER; i++) {
    prox_corr_vals[i] = prox_corr_vals[i] / NBR_CALIB;
  }
}
```

Appendix C LaTeX Examples

This section shows some common uses of LaTeX features.

C.1 Images

Example of how to include an image can be seen in Figure 4.1. All figures must be referenced somewhere in the report.

C.2 Tables

Example of how to include a table can be seen in Figure 4.2. All figures must be referenced somewhere in the report.

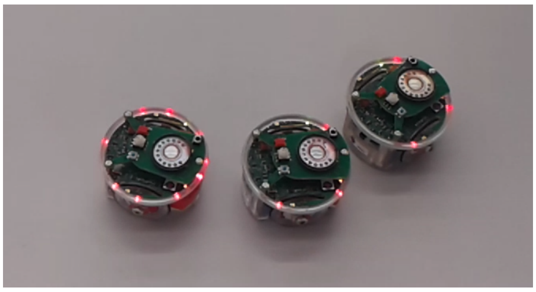

Figure 4.1: Including an image.

Title 1	**Title 2**
item 11	item 12
item 21	item 22

Figure 4.2: Table with caption.

C.3 Listings

Example of how to include listing can be seen in Figure 4.3 and Figure 4.4. All figures must be referenced somewhere in the report.

```c
// get the correction values for prox sensors
void get_prox_corr_vals() {
  int i, j;

  // init array for calibration values
  for (i=0; i<PROX_SENSORS_NUMBER; i++) {
    prox_corr_vals[i] = 0;
  }

  // get multiple readings for each sensor
  for (j=0; j<NBR_CALIB && wb_robot_step(TIME_STEP)!=-1; j++) {
    for (i=0; i<PROX_SENSORS_NUMBER; i++) {
      prox_corr_vals[i] += wb_distance_sensor_get_value(prox_sensor_tags[i]);
    }
  }

  // calculate average for each sensor
  for (i=0; i<PROX_SENSORS_NUMBER; i++) {
    prox_corr_vals[i] = prox_corr_vals[i] / NBR_CALIB;
  }
}
```

Figure 4.3: Listing included from file.

```c
// constrain speed to +/- MAX_SPEED
double bounded_speed(double speed) {
  if (speed > MAX_SPEED) return MAX_SPEED;
  else if (speed < -MAX_SPEED) return -MAX_SPEED;
  else return speed;
}
```

Figure 4.4: Listing within LaTeX.

C.4 Font Style and Text Size

The font style may be modified: **bold**, *italic*, *Emphasis*, CAPITALS, `verbatim`, etc.
The text size can be changed: tiny, small, large, huge, etc.

C.5 Enumerations and Other Lists

Enumerations are easy, there is the `enumerate` environment:

1. First item
2. Second item
3. Third item

For lists, there is the `itemize` environment:

- First item
- Second item
- Third item

For definitions lists, there is the `description` environment:

First term – Description of the first term

Second term – Description of the second term

C.6 Quotations and References

Books and other documentation can be referenced as [2] and websites as [3].

C.7 FSM diagram

In Figure 4.5 is depicted a Finite State Automata diagram as presented in Lecture 02.

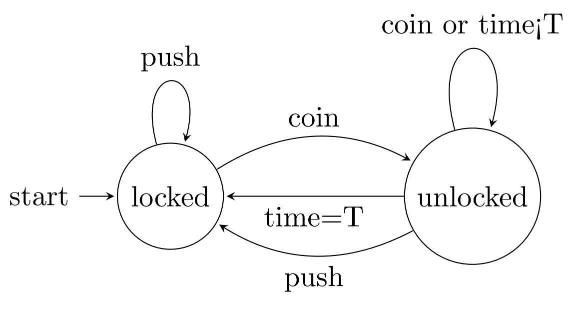

Figure 4.5: FSM diagram in LaTeX.