ARTIFICIAL INTELLIGENCE AND ROBOTICS

LM IN ARTICIAL INTELLIGENCE

Assignment 2

SUBMISSION 1

Students :
Álvaro ESTEBAN MUÑOZ

Teacher :
Alessandro SAFFIOTTI
Andrea GOVONI

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Contents

1 Implement sonar-based building of occupancy grids, using an uncertainty theory: Fuzzy sets

1.1 The problem

The main idea of this first task is to understand how an uncertainty theory works in practice, i.e. how it is implemented. In our case we covered the Fuzzy sets theory. In practice, an uncertainty map (occupancy grid) is computed inside the robot so it gets the knowledge of which paths it can travel and which ones no. The computation of this map is performed in different steps, in the same way we did on the previous assignment where each step was performend in one component of the Robot Control Program (RCP) [see figure 1].

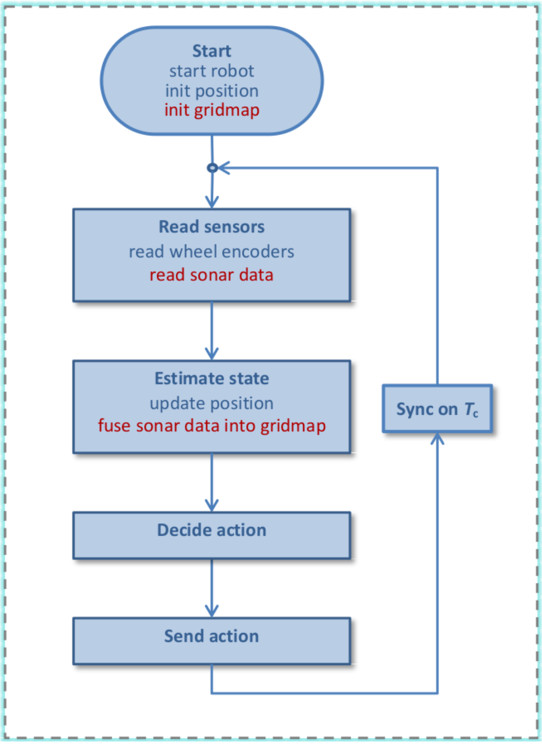

Figure 1: Computation of the occupancy grid inside the Robot Control Program

1.2 Objects and Data Structures

The structure of the RCP is the same as for the previous assignment, we just added some useful classes for the computation of the occupancy grid. These classes are listed below:

- **Gridmap**: class in charge of storing the occupancy grid cells. This class is able to update the gridmap, save it in a file and change from gridmap coordinates to gazebo coordinates and viceversa.
- **Occupancy**: this class represents a cell of the gridmap. It is initialized with the priors and it will store the probability of each state at each timestep.

- **Sonar_Model**: the Sonar_Model class is the most important one since is the one implementing the chosen uncertainty theory.

We also had to add some functions in order to retrieve information from the sonar sensors that are installed on the base of the robot.

1.3 Control and Information flow

Once more, control and information flow is pretty similar to the one on the previous assignment, on figure 2 you can see we just added how the gridmap is updated on the Observer component.

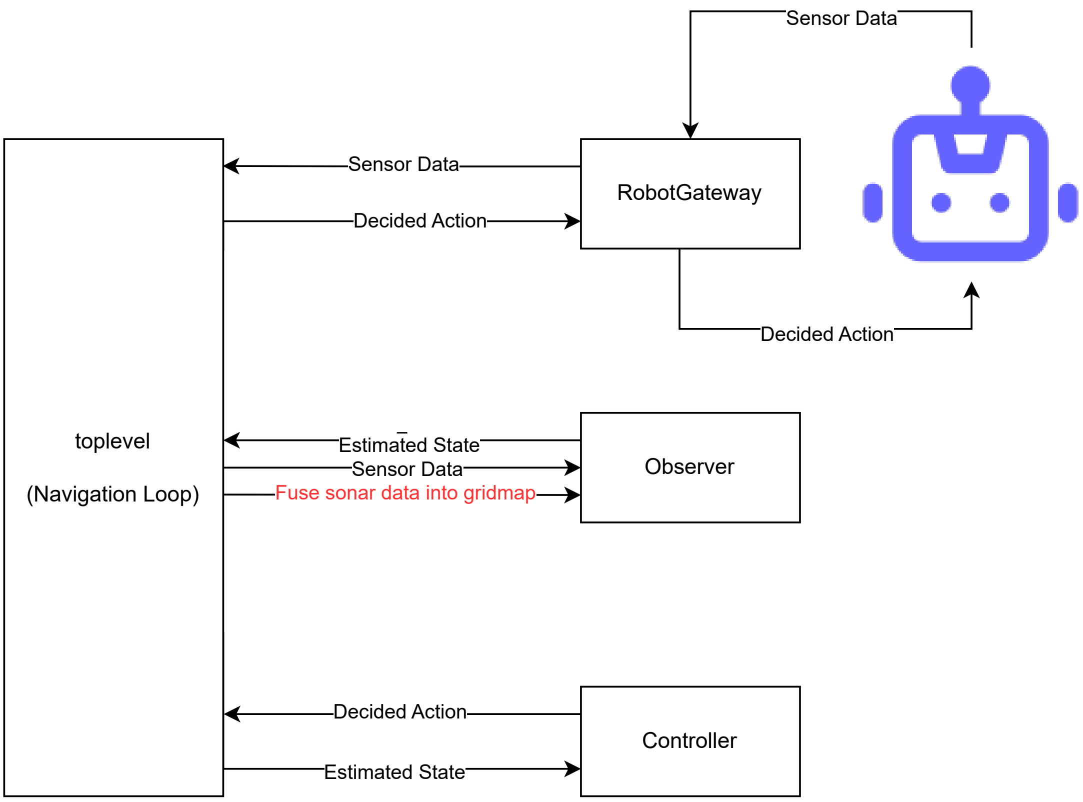

Figure 2: Flow of information diagram

1.4 Parameters

Through the whole program we can see the different parameters that had to be read, estimated or defined. We can divided them in the following:

Constant Parameters new parameters are given for this assignment, all related to the sonar sensors, these are the number of sonars, their maximum range and angle covered (Δ) as well as their different poses.

Read Parameters since we have twelve sonar sensors we will read twelve new parameters on this assignment, these are the minimum distance traveled by each sonar beam (see figure 3).

Estimated Parameters following fuzzy sets as uncertainty theory implies we need to compute the membership functions $f_o(\rho, r)$ and $f_\epsilon(\rho, r)$, which determine "how much it is possible that a cell located at distance ρ is occupied" and "how much it is possible that a cell located at distance ρ is empty" respectively. To do so, we also need to compute the distance at which the cell is located (ρ) and the angle from the center of the sonar (ϕ).

Computation of ρ and ϕ is given with the assignment so we are only in charge of computing the membership functions f_o and f_ϵ and the fusion of information. For the implementation of our theory we follow the approach in Oriol et al [1].

$$f_\epsilon = \begin{cases} k_\epsilon & 0 \leq \rho < r - \Delta r \\ k_\epsilon(\frac{r-\rho}{\Delta r})^2 & r - \Delta r \leq \rho < r \\ 0 & \rho \geq r \end{cases}$$

$$f_o = \begin{cases} 0 & 0 \leq \rho < r - \Delta r \\ k_o[1 - (\frac{r-\rho}{\Delta r})^2] & r - \Delta r \leq \rho < r + \Delta r \\ 0 & \rho \geq r \end{cases}$$

Where $k\epsilon$ and k_o denote the maximum values reachable by the functions and Δr denotes the "proximal arc" or the distance from the center at r that we consider to be part of the arc.

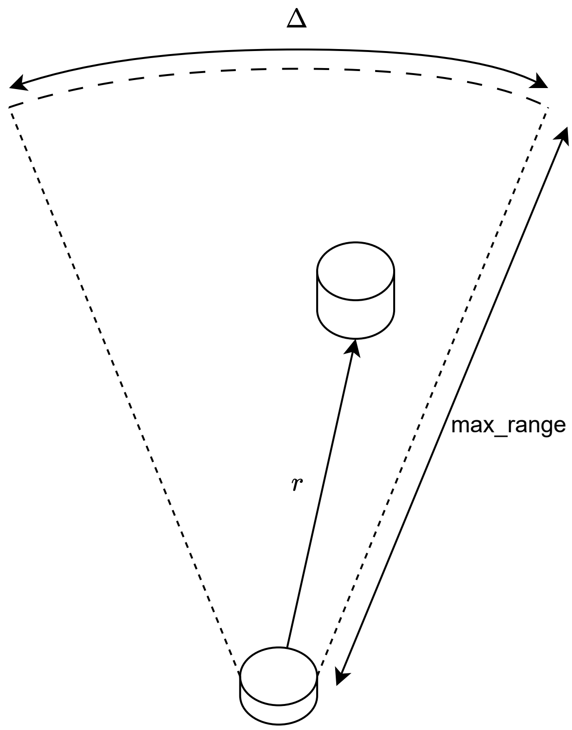

Figure 3: Representation of a sonar beam

1.5 Results Obtained

To test our implementation we applied the square trip as we did in the previous assignment. The path followed by the robot can be seen on figure 4.

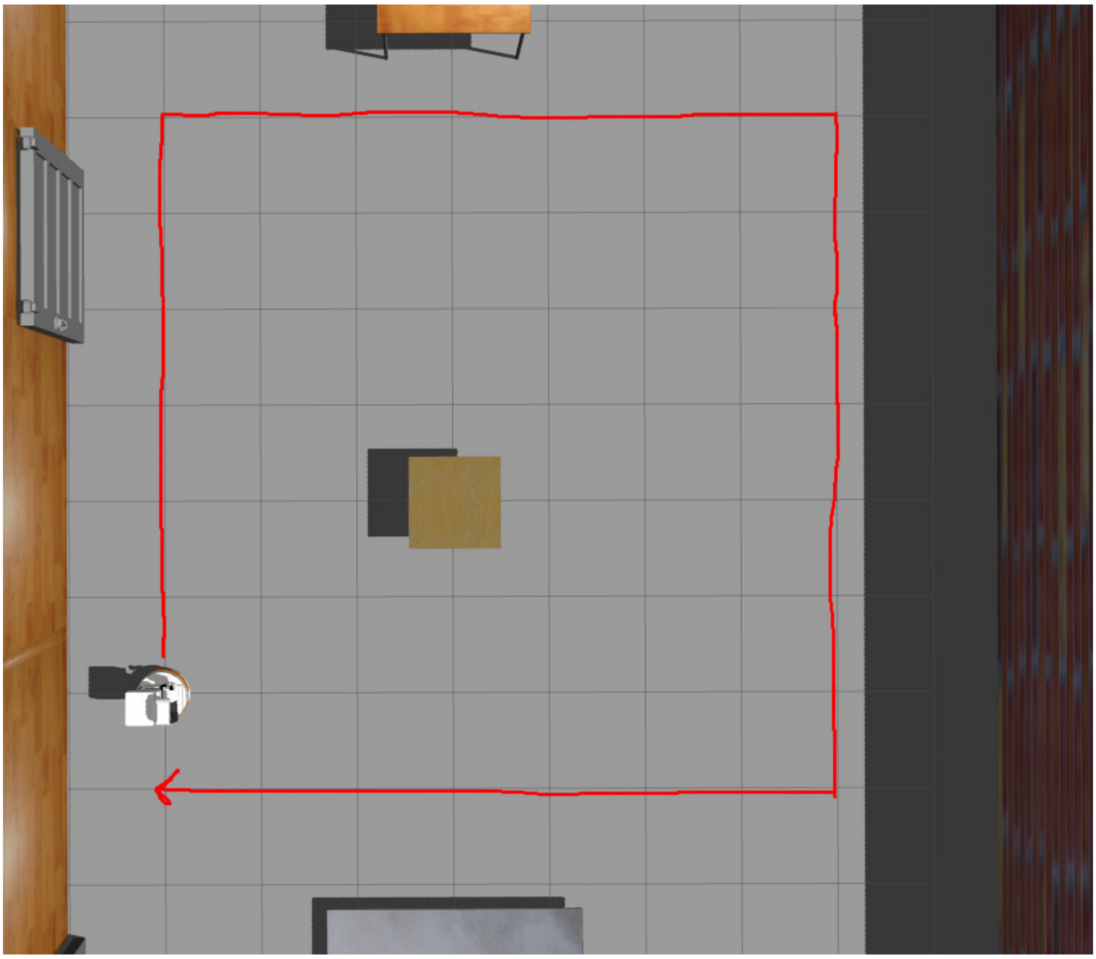

Figure 4: Path followed by the robot to test the occupancy grid

The generated occupancy grid can be seen on figure 5.

Figure 5: Occupancy grid of f_o (left) and f_ϵ (right)

1.6 Discussion

From the results on the generated occupancy grid we can definitely say that it works, thus the accuracy is not perfect, specially on the f_o one where we only detect the bottom table and just a bit the middle table and the left door.

There are many things influencing the accuracy of the occupancy grid, the most importants are related to the data. The rate with which the sonar data is retrieved, the path followed and the parameters applied.

2 Fine tune the parameters of your uncertainty models to get better maps

2.1 The problem

In this task we try to modify the parameters to obtain better results. We focus mainly on the max_range parameter of the sonar. After different trials the new sonar max_range was adjusted to 2.8 because it was the one giving the best results.

2.2 Results Obtained

The occupancy grids generated with the new parameters can be seen on 6 and 7.

Figure 6: Occupancy grid of f_o

Figure 7: Occupancy grid of f_ϵ

2.3 Discussion

Comparing this results with the ones on the previous task we can see we have improved the empty map even if it was already quite good. However, the occupied map is still not good enough, even though we detect the borders of the middle table they can be confused with the borders of the bottom table.

References

[1] Giuseppe Oriolo, Giovanni Ulivi, and Marilena Vendittelli. "Fuzzy maps: A new tool for mobile robot perception and planning". In: *Journal of Robotic Systems* 14.3 (1997), pp. 179–197. DOI: https://doi.org/10.1002/(SICI)1097-4563(199703)14:3<179::AID-ROB3>3.0.CO;2-O.