



UMEÅ UNIVERSITY
DEPARTMENT OF COMPUTING SCIENCE

ARTIFICIAL INTELLIGENCE
METHODS AND APPLICATIONS

5DV181

Map maker

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January 10, 2019

Abstract

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Contents

1	How to use our program	3
2	Mapping	4
3	Planning	8
3.1	Find a goal point	8
3.1.1	Detect the frontiers	8
3.2	Build the path	12
3.3	Follow the path	12
	Conclusion	13
	List of algorithms	14

Chapter 1

How to use our program

For this assignment we used Python 3 as programming language, to run the program you can use the following syntax:

```
> python3 main.py
```

Our program is divided in two main modules, the mapping module and the planning module. The role of the first one is to build the map of the environment of the robot using the echoes of the lasers. The role of the second one is to plan the path that the robot must follow in order to explore the world.

To communicate with the MRDS server we created a class named 'Robot', it is used as an interface to send and receive informations to and from the MRDS server easily. The received informations are directly adapted to our needs and stored using our 'Position' and 'Laser' datastructures in this class.

Chapter 2

Mapping

The first point on which we worked was to find a way of building a map of the environment of the robot using the lasers echoes.

To do so we created a class 'Map' that contains a grid of values between 0 and 1. Those values represent probability that there is an obstacle on that cell. All the values are initialized to 0.5 which is the average value between 0 and 1 since we do not know if there is an obstacle or not at that place.

To update this grid we created a class 'Cartographer' that uses the echoes of the lasers. For each laser echoe we compute the distance between the robot cell and the cell hit by the laser in the grid. Then we use the 'Bresenham' algorithm to update all the cells in between the two above. For all those cells we compute an increment that is added or subtracted to them using the following procedure:

1. First we compute an increment factor in regard of the value of the cell:

$$inc_factor_iro_certainty = 1 - (abs(cell_value - 0.5) \cdot 2)$$

2. Then we compute an increment factor in regard of the distance between the robot and the cell to update:

$$inc_factor_iro_dist = 1.5 \cdot (1 - abs(distance/max_lasers_distance))$$

3. The final increment is computed by multiplying the two factors with a defined increment value (we used 0.1):

$$final_increment = inc_factor_iro_certainty \cdot inc_factor_iro_dist \cdot increment$$

4. The final increment is added to the cell if the cell corresponds to the cell hit by the laser and that the distance of the echoe is below the maximum laser distance. Otherwise it is subtracted.

The certainty factor is useful because it will make the cells that are near 0 and near 1 harder to change than the cells near 0.5, the effect is that the cells

defined as obstacle will have to be seen as empty for a long time before being changed and inversely. The distance factor is useful because it will make the cells near the robot update more easily than the cells far away, since the further away the cell is from the robot the less precise the laser information is.

This is the factory map built moving the robot by hand using the cartographer described above.



Figure 1: Explored map by hand

The mapping module also contains the 'ShowMap' class which is used to display the built map.

Chapter 3

Planning

The planning module is divided in three different parts.

1. The first thing to do is to find a goal point, that goal point must be chosen in a way that will make the robot explore unknown parts of the environment.
2. Then we have to build a path for the robot to follow between the actual position of the robot and the target.
3. The final thing to do is to use a path tracking algorithm that will make the robot follow the built path.

3.1 Find a goal point

In order to find a goal point we have to detect an unexplored zone that we can access to, to do so we used an approach based on frontier detection. A frontier is a region on the border between an explored zone and an unexplored zone. Then the first thing to do in order to determine the next goal point is to detect the frontiers.

3.1.1 Detect the frontiers

To detect the frontiers we go through all the unexplored cells of the grid and if that cell has an explored empty cell in its Von Neumann neighbourhood we know it is part of a frontier. The Von Neumann neighbourhood is composed of the four adjacent cells around a cell. Once we went through the whole grid we have a list of all the cells that are on a frontier, the next step is to divide them into several regions.

To divide the frontiers in regions we go through the previously built list, each time we put a cell in its region we delete it from the initial list. For each cell we go through its Moore neighbourhood (The entire 8 cells neighbourhood). If one of its neighbour is in the initial list we recursively call the same function.

This is the pseudocode of the 'get_divided_frontiers' function:

Algorithm 1 get divided frontiers

```
1: procedure GET_FRONTIERS(map)
2:   frontiers is an empty array
3:   for cell in map do
4:     if is_unknown(cell) then
5:       for neighbour in von_neumann_neighbourhood(cell) do
6:         if neighbour not in frontiers and is_empty(neighbour)
7:         then
8:           frontiers.append(neighbour)
9:         end if
10:      end for
11:    end if
12:  end for
13:  return frontiers
14: end procedure
15: procedure BUILD_FRONTIERS(frontiers, current_frontier, cell)
16:   neighbours  $\leftarrow$  moore_neighbourhood(cell)
17:   for neighbour in neighbours do
18:     if neighbour in frontiers then
19:       current_frontier.append(neighbour)
20:       frontiers.remove(neighbour)
21:       build_frontier(frontiers, current_frontier, cell)
22:     end if
23:   end for
24: end procedure
25: procedure GET_DIVIDED_FRONTIERS(map)
26:   frontiers  $\leftarrow$  get_frontiers
27:   divided_frontiers is an empty array
28:   while frontiers is not empty do
29:     current_frontier is an empty array
30:     cell  $\leftarrow$  frontiers.pop(0)
31:     current_frontier.append(cell)
32:     build_frontier(frontiers, current_frontier, cell)
33:     divided_frontiers.append(current_frontier)
34:   end while
35:   return divided_frontiers
36: end procedure
```

On the following figure we can see an example of the detected frontiers, the black pixels are obstacles, the white ones are empty cells, the red spot is the robot position and the other spots are the regions of frontiers. The map is 10 by 10 and there is a different color for each region.

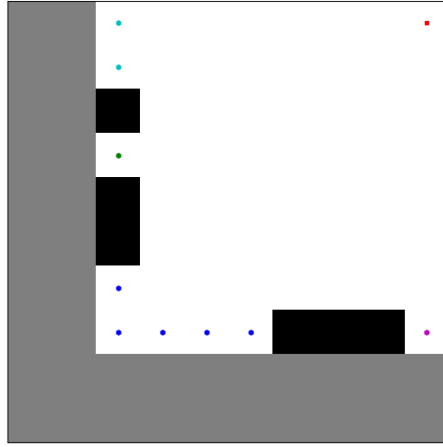


Figure 2: Frontiers test map

By testing this same function on a real map built by the robot in MRDS we noticed that it is not efficient enough (it took around 5 to 10 seconds to get the frontiers). However, the function gave a very good result as we can see below:

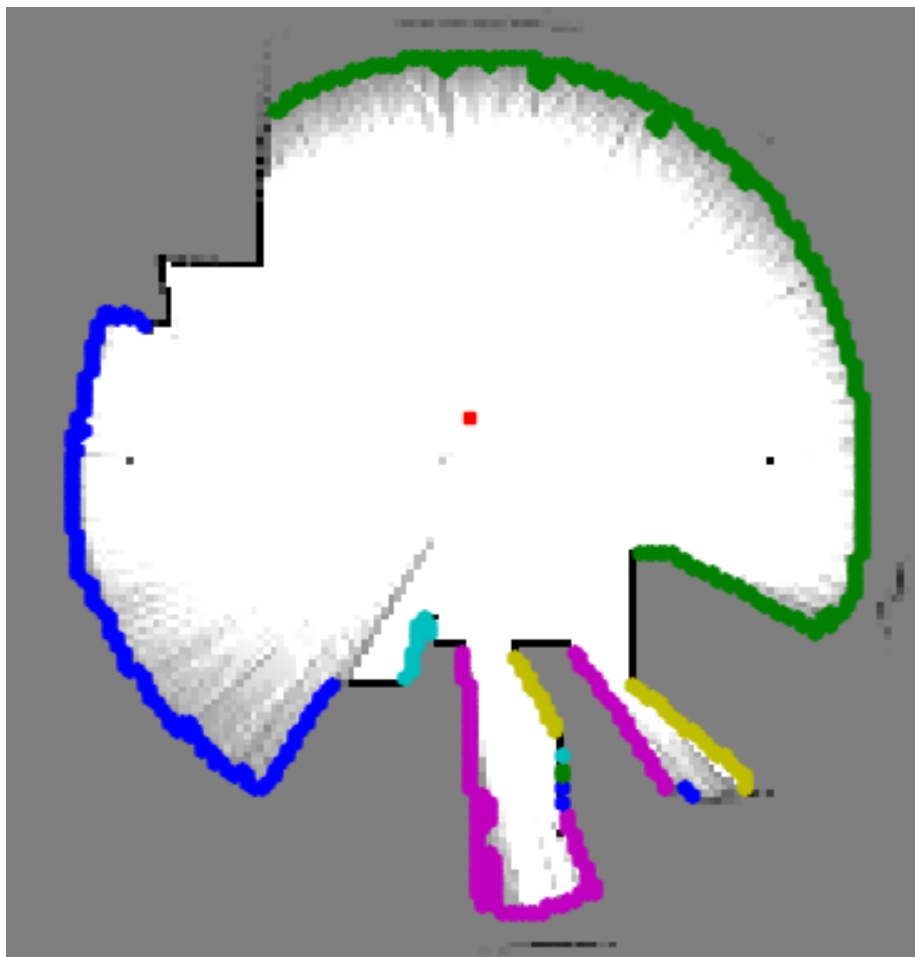


Figure 3: Frontiers real map

3.2 Build the path

3.3 Follow the path

Conclusion

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List of Algorithms

1	get divided frontiers	10
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