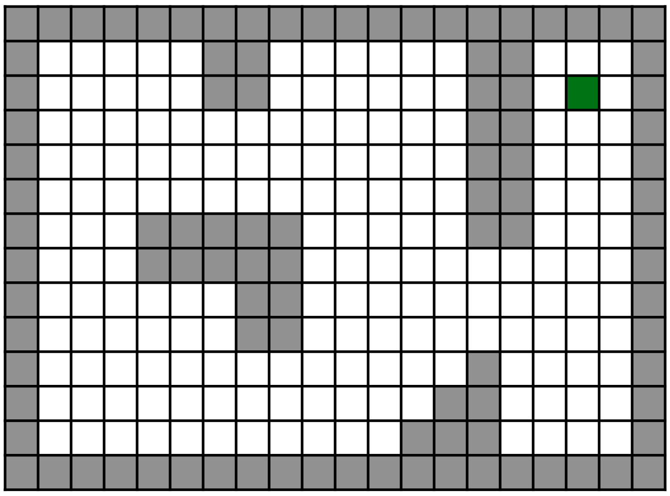
Autonomous Robots
Potential Functions – Wavefront planner

This document will guide you through the practical work related to path planning algorithms based on potential functions. In particular, this practical exercise consists on programming the wavefront planner algorithm to solve a simple path planning problem. All the code has to be programmed in Matlab.

1. Environment

The problem consists in finding the optimal trajectory towards the goal in a finite 2D environment that is closed and contains some obstacles (in grey) as shown in the figure:



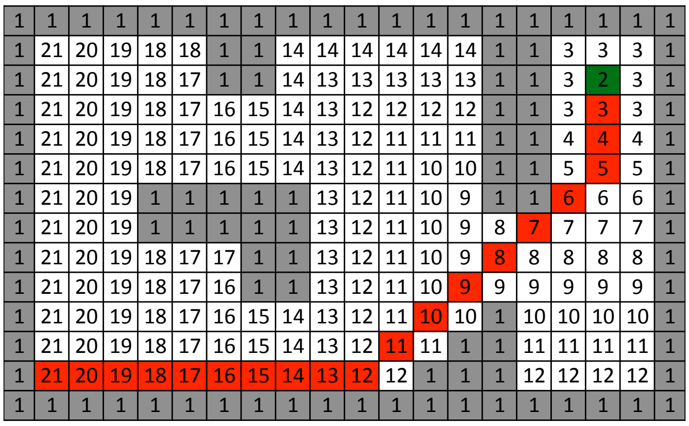
The size of the environment is 20x14. The goal position is marked in green. The environment will be represented as a matrix in the following way:

```
map=[
    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1;
    1 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 0 0 0 1;
    1 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 0 2 0 1;
    1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1;
    1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1;
    1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 1;
    1 0 0 0 1 1 1 1 1 0 0 0 0 0 1 1 0 0 0 1;
    1 0 0 0 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 1;
    1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1;
    1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 1;
    1 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1;
    1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1;
    1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 1;
    1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1;];
```

Note that the obstacle cells are marked with 1, free space with 0 and the goal position with a 2.

2. Wavefront planner.

Program in Matlab the wavefront planner algorithm to compute the optimal path towards the goal. Use 8-point connectivity.



1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	21	20	19	18	18	1	1	14	14	14	14	14	14	1	1	3	3	3	1
1	21	20	19	18	17	1	1	14	13	13	13	13	13	1	1	3	2	3	1
1	21	20	19	18	17	16	15	14	13	12	12	12	12	1	1	3	3	3	1
1	21	20	19	18	17	16	15	14	13	12	11	11	11	1	1	4	4	4	1
1	21	20	19	18	17	16	15	14	13	12	11	10	10	1	1	5	5	5	1
1	21	20	19	1	1	1	1	1	13	12	11	10	9	1	1	6	6	6	1
1	21	20	19	1	1	1	1	1	13	12	11	10	9	8	7	7	7	7	1
1	21	20	19	18	17	17	1	1	13	12	11	10	9	8	8	8	8	8	1
1	21	20	19	18	17	16	1	1	13	12	11	10	9	9	9	9	9	9	1
1	21	20	19	18	17	16	15	14	13	12	11	10	10	1	10	10	10	10	1
1	21	20	19	18	17	16	15	14	13	12	11	11	1	1	11	11	11	11	1
1	21	20	19	18	17	16	15	14	13	12	12	1	1	1	12	12	12	12	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

You must program a Matlab function with the following input and output parameters:

```
function [value_map, trajectory]=wavefront(map, start_row, start_column)
```

Your program, when called with the previous map and the following parameters should generate:

```
[value_map, trajectory]=wavefront(map, 13, 2)
```

```
value_map =

     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1
     1    21    20    19    18    18     1     1    14    14    14    14    14    14     1     1     3     3     3     1
     1    21    20    19    18    17     1     1    14    13    13    13    13    13     1     1     3     2     3     1
     1    21    20    19    18    17    16    15    14    13    12    12    12    12     1     1     3     3     3     1
     1    21    20    19    18    17    16    15    14    13    12    11    11    11     1     1     4     4     4     1
     1    21    20    19    18    17    16    15    14    13    12    11    10    10     1     1     5     5     5     1
     1    21    20    19     1     1     1     1     1    13    12    11    10     9     1     1     6     6     6     1
     1    21    20    19     1     1     1     1     1    13    12    11    10     9     8     7     7     7     7     1
     1    21    20    19    18    17    17     1     1    13    12    11    10     9     8     8     8     8     8     1
     1    21    20    19    18    17    16     1     1    13    12    11    10     9     9     9     9     9     9     1
     1    21    20    19    18    17    16    15    14    13    12    11    10    10     1    10    10    10    10     1
     1    21    20    19    18    17    16    15    14    13    12    11    11     1     1    11    11    11    11     1
     1    21    20    19    18    17    16    15    14    13    12    12     1     1     1    12    12    12    12     1
     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1     1

trajectory =

    13     2
    13     3
    13     4
    13     5
    13     6
    13     7
    13     8
    13     9
    13    10
    13    11
    12    12
    11    13
    10    14
     9    15
     8    16
     7    17
     6    17
     5    17
     4    17
     3    18
```

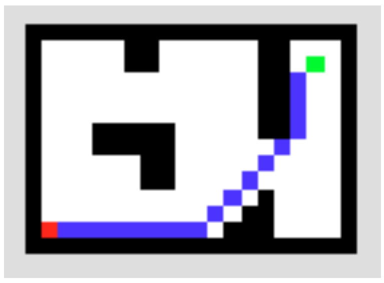
It is very important that you generate the wavefront planner map (value_map) and the trajectory using EXACTLY the same format you can see in the previous example. Your "wavefront.m" file will be evaluated exclusively based on the results it generates which must follow the previous format. The algorithms will be tested with different environments.

Note that several trajectories can be obtained, all of them being optimal. Your code must generate one of the optimal trajectories considering an 8-point connectivity. So, the previous trajectory is only one example of several optimal trajectories you could generate.

Note finally that the wavefront planner does not distinguish between up, down, left, right movements and diagonal movements. Since we know that diagonal movements will be longer, you can modify your code to prioritize up, down, left, right movements if possible.

3. Representation

In order to correctly show the trajectory that your algorithm is generating, you can use the Matlab plotting capabilities to automatically plot the map and the trajectory, such that:



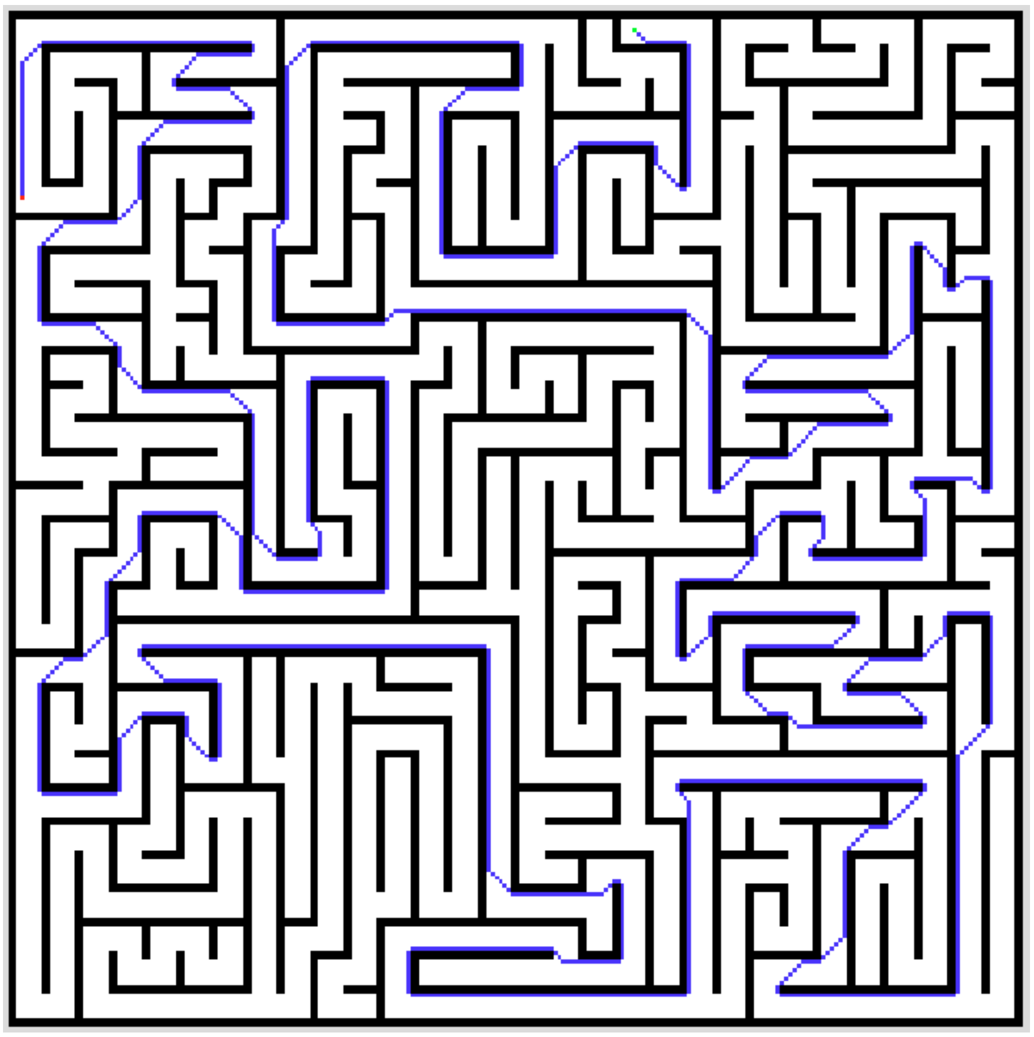
Use your own map and trajectory representation, and include these figures in your laboratory report.

4. Big maze environment

Load the map from the maze.mat file and run your algorithm and representation utility. Use as initial point the one indicated in the next call:

```
[value_map, trajectory]=wavefront(map, 45, 4)
```

The map and one of the optimal trajectories is:



5. Submission.

Submit a report in pdf and the Matlab file “wavefront.m”. Explain in detail, in the report, the work done in all the sections. Explain also the problems you found. You might want to test your algorithm in other environments.

NOTE that only these 2 files are required and will be evaluated. Do not send more files.