UNIVERSITY OF MALTA

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Department of Artificial Intelligence

Study-Unit: ARI2202 (Robotics 1)

Task 2: Robot Path Planning and PID Control

Submission Deadline: 26th May 2021 23:59

- This task contributes towards 50% of your final project mark (i.e. 35% of your global assessment mark for this study-unit)
- You may submit your work multiple times. Only your final submission will be assessed.
- Please submit a **jupyter notebook** with your complete solution.
- The submission deadline is 26th May 2021 23:59.
- Late submissions will not be accepted.

Part a: Path planning

Your first task is to guide a robot positioned at location S to its goal located at G, using the A* algorithm. The robot can only move up, down, left and right (diagonal movement is not allowed).

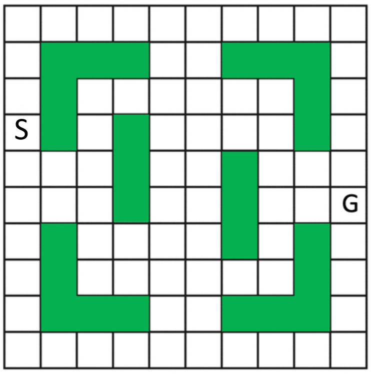


Figure 1: Robot's map

Your solution should include:

(i) A grid that represents the robot's environment and the green obstacles within it, as shown in Figure 1.

[2 marks]

(ii) A heuristic function that provides the minimum number of steps it takes to get to the goal in the absence of obstacles.

[4 marks]

(iii) A function **A_star** which takes as input a grid that represents the robot's environment, the robot's starting location, goal location, a cost of 1 for each step travelled by the robot, and a heuristic function. Your solution should return the optimal actions that the robot should take, as follows:

^	move up
<	move left
>	move right
v	move down
*	goal

[9 marks]

Part B: Path smoothing

Your second task is to smoothen a path that a robot must follow.

(i) Write a function **smooth** which takes in a path (represented by a series of coordinates), the weighting parameter α, the weighting parameter β and a tolerance. Your function should return a smoothened path. The first and last nodes of the original path should remain unchanged. For your solution, set $\alpha = 0.5$, $\beta = 0.1$ and tolerance 0.000001.

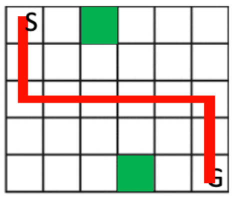
Hint: You can smoothen a path x into a path y using the following formula

$$y_i = y_i + \alpha(x_i - y_i) + \beta(y_{i-1} + y_{i+1} - 2y_i),$$

where y_i represents the points along the smooth path, x_i represents the points along the original path, α is a weighting parameter that controls by how much the smoothened path will differ from the original path, and β is a weighting parameter that controls the amount of smoothness.

[12 marks]

(ii) Using the function **smooth**, print the smoothened version of the following path:



[3 marks]

Part C: PID Control

Your final task is to implement a Proportional Integral Derivative (PID) controller that will take a robot from its current state to the path along the line $y = 0$. The robot has a steering drift of 10 degrees. Your solution should include:

(i) A function **pid_control** which takes as input an instance of the class robot, a proportional gain τ_p, a differential gain τ_d, an integral gain τ_i, the number of iterations of robot motion n, and the robot speed. Your function should return the x and y trajectory which will be followed by the robot.

Hint: $steering = -\tau_p CTE - \tau_d \Delta CTE - \tau_i \int CTE,$

Where CTE is the crosstrack error, ΔCTE is the differential crosstrack error and $\int CTE$ is the integral crosstrack error

[15 marks]

(ii) A plot of the trajectory that will be followed by a robot of length 20cm, at state (0, 1, 0), i.e. a robot located at x = 0, y = 1, and orientation = 0, and which needs to reach the path along y = 0. The robot has a steering drift of 10 degrees. Set the PID gains as follows: $\tau_p = 0.2$, $\tau_d = 3$, $\tau_i = 0.004$.

Your plot should also include the intended trajectory (i.e. the path at y=0). Use a legend to indicate which path is which.

[5 marks]