

# ROB6323: Reinforcement learning and optimal control for autonomous systems I

## Exercise series 4

For questions requesting a written answer, please provide a detailed explanation and typeset answers (e.g. using LaTeX<sup>1</sup>). Include plots where requested in the answers (or in a Jupyter notebook where relevant). For questions requesting a software implementation, please provide your code in runnable Jupyter Notebook. Include comments explaining how the functions work and how the code should be run if necessary. Code that does not run out of the box will be considered invalid.

### Exercise 1 [40 points]

Consider the grid-world shown in Figure 1. In each (non grey) cell, it is possible to perform five actions: move up, down, left, right or do nothing as long as the resulting move stays inside the grid world. Grey cells are obstacles and are not allowed. We would like to find the optimal value function and optimal policy that minimize the following cost

$$\min \sum_n \alpha^n g_n(x_n)$$

with discount factor  $\alpha = 0.99$  and where the instantaneous cost is defined as

$$g_n(x_n) = \begin{cases} -1 & \text{if } x_n \text{ is a violet cell} \\ 0 & \text{if } x_n \text{ is a white cell} \\ 1 & \text{if } x_n \text{ is a green cell} \\ 10 & \text{if } x_n \text{ is a red cell} \end{cases}$$

In a Jupyter notebook answer the following questions:

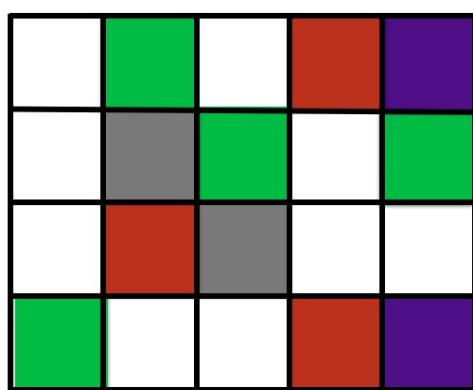
- a) Implement the value iteration algorithm to solve the problem (initialize the value function to 0). How many iterations does it take to attain convergence? (we assume here that convergence happens when all the elements of the value function do not change more than  $10^{-6}$  in a new iteration).
- b) Implement the policy iteration algorithm to solve the problem (use the version that solves the linear equation  $I - \alpha A J_\mu = \bar{g}$ ). Start with an initial policy that does not move. How many iterations does it take to converge?
- c) Compare the solutions and convergence/complexity of each algorithm to solve this problem.

### Exercise 2 [60 points]

Answer the questions in Jupyter notebook *exercise\_2.ipynb*

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<sup>1</sup><https://en.wikibooks.org/wiki/LaTeX>, NYU provides access to Overleaf to all the community <https://www.overleaf.com/edu/nyu>



**Figure 1:** Grid world