DPRL Assignment week 1

- 这是一个季节性商品在T=1000个时间段内的随机库存问题，有销售损失。
- 除了物流成本外，还有采购成本和销售收入，因此所有的成本和回报都被考虑在内。

- 每个时间段都有一个随机需求Dt∈{0,1}，P(Dt=1)在时间t中从0到1线性增加。
- 销售价格为20，采购成本在500期之前为每件10，500至900之间为15，订单可以是任何大小≥0，900期之后不可能采购
- 持有成本h=0.01，每件物品的时间单位，订货成本K=10，立即交货
- 剩余的时间不能出售，没有滞销品

a) 选择合适的$\mathcal{X}$和$\mathcal{A}$，并使用动态编程（用python编程）来确定总预期利润和最佳订单政策，在时间0开始时库存为0
b) 将最优订单政策可视化，并用语言解释其结构，为什么你认为这是合理的?
c) 从0库存开始，模拟10倍的需求，记录状态并应用最优策略。对于每一次跟踪，将库存和销售损失绘制在图表中。

- This is a stochastic inventory problem of a seasonal item over T=1000 time periods with lost sales
- Next to the logistics costs there are purchase costs and revenue from sales, thus all costs and rewards are taken into account
- The details:
  - Every time period there is a random demand $D_t \in \{0,1\}$ with $P(D_t = 1)$ increasing in time t linearly from 0 to 1
  - The selling price is 20, purchase costs are 10 per item up to period 500, 15 between 500 and 900, the order can be of any size ≥ 0, no purchases possible after time 900
  - Holding costs h=0.01 per time unit per item, order costs K=10, deliveries are immediate
  - Left-over times cannot be sold, no backorders

a) Choose appropriate $\mathcal{X}$ and $\mathcal{A}$ and use dynamic programming (programmed in python) to determine the total expected profit and the optimal order policy, starting with 0 inventory at time 0

b) Visualise the optimal order policy and explain its structure in words, why you think this is logical

c) Simulate 10 times the demand over time starting from inventory 0, record the state and apply the optimal policy. For each trace plot the inventory and lost sales in a graph

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如何提交，提交什么。
- 最多两页A4纸的报告（.pdf），以及带有相关数字/表格/屏幕截图的附录
- 独立的Python代码文件(.py)
- 以有效的方式实现该算法，它应该运行得非常快。
- 报告应包括解决方法。从数学上描述你所编码的方法，包括实现选择和初始化
- 对你的发现进行评论，是否符合预期？评级。
- 1分 开始
- 4分 a) 动态编程，正确描述动态编程并正确实施
- 1分 a) 政策，确定了正确的政策。
- 2分 b) 解释，可以理解的解释，正确地证明了最佳的政策
- 1.5 分 c) 仿真，正确描述和实施仿真
- 0.5分 c) 库存图，库存图清晰整洁

How and what to submit:

- Report (.pdf) of max 2 A4 pages plus appendix with relevant figures/tables/ screenshots
- Separate Python code file (.py)
- Implement the algorithm in an efficient way, it should run very fast
- Report should include the solution method. Mathematically describe the method that you coded, including implementation choices and initialization
- Comment on your findings, are they as expected?

Grading:

- 1 pt start
- 4 pts a) Dynamic Programming, Correct description of dynamic programming and correctly implemented
- 1 pts a) Policy, Correct policy determined.
- 2 pts b) Explanation, Understandable explanation correctly justifying the optimal policy
- 1.5 pts c) Simulation, Simulation described and implemented correctly
- 0.5 pts c) Inventory plot, Inventory plot is clear and tidy

Details for this and future reports

Your report is expected to cover the following four points.

Explain the problem
At first, you should explain what the problem is that you are going to solve. What are your assumptions and why do they make sense or where do they deviate from reality.

首先，你应该解释你要解决的问题是什么。你的假设是什么，为什么它们有意义，或者它们在哪里偏离了现实。

Describe your methods
From your report, it should become clear what you did exactly and why this makes sense. In general, you can use as a guideline that a reader should be able to repeat your methods and is able to get to the same results. You can assume that your target audience would be any another student in the same study area. But this does **not** mean that you can leave out any parts up to be guessed / filled in by the reader. It is not required that your grandmother can understand it, however being able to explain her what you did is a good exercise that will come in handy whenever you plan to work in/for companies, where you will also often have to explain what you have done to persons lacking any mathematical/programming knowledge.

从你的报告中，应该清楚你到底做了什么，以及为什么这有意义。一般来说，你可以把读者应该能够重复你的方法并能够得到相同的结果作为准则。你可以假设你的目标受众是同一研究领域的任何其他学生。但这并不意味着你可以不写任何部分让读者去猜测/填写。不要求你的祖母能够理解，但是能够向她解释你所做的事情是一个很好的练习，当你计划在公司工作时将会很有用，在那里你也将不得不向缺乏任何数学/编程知识的人解释你所做的事情。

For this specific assignment, this means that:
- -Copying the provided value function as given is not sufficient. Explain why it makes sense and don't forget to add the base cases/boundary conditions.
- -Just stating that you did a simulation is not sufficient. Explain how this was done / what was exactly simulated and what was used from your solution in the first part.
- -Adding the requirement of non-decreasing prices, requires a (mathematical) explanation of you new method as well as some argument why this will work as expected. Not just the results.

-复制所提供的价值函数是不够的。解释为什么它是有意义的，不要忘记添加基数/边界条件。
-仅仅说你做了一个模拟是不够的。解释这是如何做到的/到底模拟了什么以及在第一部分的解决方案中使用了什么。
-增加价格不递减的要求，需要对你的新方法进行（数学）解释，并论证为什么会有预期效果。预期的效果。而不仅仅是结果。

Report your results
You should report all (requested and/or relevant) results in a meaningful way. Report on the exact outcomes or provide plots, whatever makes the most sense in the situation. The goal should be that the reader gets presented all the insights that you want to show, in a clear way.

你应该以一种有意义的方式报告所有（要求的和/或相关的）结果。报告确切的结果或提供图表，只要在这种情况下最有意义。目标应该是让读者以一种清晰的方式获得你想要展示的所有见解。

For this assignment, this means that:
- -You should provide the expected revenue for your optimal policy and the total revenue of your simulation.
- -Providing the optimal policy and offered prices/remaining capacity over time makes the most sense as a plot. Printing e.g. (a part of) a 600x100 matrix, does not provide any insights to the reader.
- -You should make sure all the plots are interpretable. At least add labels to all axes, including the color scale! (And do not use a continuous color scale for discrete values)
- -You should make sure all plots make sense. E.g. using 0 as optimal policy for the boundary in your implementation is okay, but does not make sense to include in your results/plots.

-你应该提供你的经营政策的预期收入和你的模拟总收入。
-提供最终政策和提供的价格/剩余容量的时间，作为图表是最有意义的。打印例如600x100矩阵的一部分，并不能为读者提供任何见解。
-你应该确保所有的图都是可解释的。至少要给所有的坐标轴加上标签，包括色标！（而且不要使用连接线。(不要对离散值使用连续的色标）。
-你应该确保所有的图都有意义。例如，在你的实现中使用0作为边界的最佳策略是可以的，但在你的结果/图中包含的意义不大。结果/图中

Discuss your results
Often more important than the exact values you obtained, are the conclusions you can draw from them. What do the results show, what can be seen in a plot, why do certain values do make sense. E.g. a good way to check yourself was to see if the average revenue over a large number of simulations converged towards your expected revenue. But be careful to draw conclusions on one single random simulation run!

通常比你获得的确切数值更重要的是你能从中得出的结论。结果显示了什么，在图表中可以看到什么，为什么某些数值确实有意义。例如，检查自己的一个好方法是看大量模拟的平均收入是否向你的预期收入靠拢。但要小心在一次随机的模拟运行中得出结论！

These expectations have been shortly mentioned in the assignment, but are also very general for any report, ranging from a two pager up to your thesis. In total, this should lead to a report that is fully self-containing without the need to read/understand your code. We use the provided code to check your implementation, as well as to be able to give you partial points for correct results with incorrect/insufficient explanations. But for the rest, the code is mainly the way to get to your report/results, it is not the result itself.

这些期望在作业中已经有了简要的说明，但对于任何报告来说也是非常普遍的，从两页纸到你的论文。总的来说，这应该导致一份完全自含的报告，而不需要阅读/理解你的代码。我们使用所提供的代码来检查你的实现，以及能够给你正确的结果与不正确/不充分的解释打分。但对于其他方面，代码主要是获得报告/结果的方法，它不是结果本身。