Assistant Professorship of Operations Management

Introduction to Reinforcement Learning

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Final group assignment

1 Overview

In your groups, you will work on implementing the $Q-learning$ reinforcement learning algorithm for typical application areas in supply chain management. These include inventory management, vehicle routing, forecasting, and scheduling. You will need to write a report describing the specific problem setting that you want to solve as well as outlining the logic for data generation and discussing your results. Throughout the group work, we will have two discussion opportunities where you can bring your questions.

2 Detailed instructions

Your report should include details on the sections highlighted below. In addition, you need to hand-in a running code including input data that is sufficiently commented. There is no need to describe the code in the report in detail.

2.1 Problem description

Describe the detailed problem you want to solve within the typical application area and the idea of using reinforcement learning to bring value compared to "traditional methods". This should include an overview on:

- Set of possible states
- Set of possible actions
- Transition probabilities (for Q-learning) or mechanics for transition steps (for DQN)
- Reward the agent receives from the environment

2.2 Data generation

You will need data to test and train your algorithms for the specific problem setting outlined. Two options are possible:

- Exemplary case data that is available open-source (e.g., kaggle.com, data provided as part of paper)

- Generate realistic data based on problem assumptions

Both options work equally good. In either case, outline either the public data that you found our the process of data generation.

2.3 Implementation

2.3.1 Implementation of Q-learning algorithm

Implement a Q-learning algorithm for the specific problem instance outlined in 2.1 and train with the data from 2.2. Conduct the implementation in Python. Conduct sensitivities on key parameters to discuss the model performance.

2.3.2 Moving to DQN

Discuss how your implementation would needs to be adjusted to account for Deep Q-networks. *Bonus: Try to extend your model to a DQN.*

2.4 Discussion and results

Summarize your findings on model performance after testing different parameters. Further, discuss how well reinforcement learning is suited to the problem setting that you looked into (or not).

3 Topics

Each team will work on one topic as briefly outlined below. We will share examples of scientific papers as starting point. As part of 2.1, outline one very specific problem setting within the topic area that you want to analyze / implement.

3.1 Inventory management

Inventory management deals with the questions on when to order, in which quantity, potentially even from which source (supplier) to balance availability and costs. The main challenge in inventory management consists in dealing with changing demands, varying lead times, and / or disruptions. There are many different specific problem settings in inventory management (e.g., single vs. multiple supplier, fixed reorder vs. variable reorder quantity, etc.).

3.2 Vehicle rescheduling

In many transportation problems, the schedule of vehicles is established a long time before the actual vehicle operations by extensive planning in advance. Due to smaller or larger disturbances, however, this schedule becomes infeasible or at least sub-optimal. Thus, in re-scheduling operational changes to the original schedules are discussed to improve the original schedules in reasonable computation times.

3.3 Production scheduling

In production scheduling, different jobs need to be scheduled on a set of heterogeneous machines where different jobs require different machines and processing times. The overall goal is to minimize certain metrics, such as the tardiness of jobs. In addition, a number of constraints need to be fulfilled, e.g, which job can be processed on which machine etc.