FBA | QUANTITATIVE FINANCE RESEARCH GROUP

Specialization 3. Financial Reinforcement Learning

About the Principal

Name	Jo Seong Min	Email	emoticon012600@gmail.com
Phone:	+82 10-6207-7455	LinkedIn:	

Course Description

Learn how to define Reinforcement Learning (RL) tasks and core principles behind the RL, including policies, value functions, derivation of Bellman equations with Application in various finance field such as Derivatives Pricing and Hedging and Optimal Execution. Code implement of RL algorithms and libraries in Python will also be covered.

Notice

- Meetings will be held online.
- Principal will assign each new member coverage to summarize course materials in a lecture note form (LATEX)
- New members should deliver a presentation using lecture note during the session (10 – 15 minutes long)
- Lecture notes must be re-arranged in a consistent, readable format which strictly follows the guideline before the submission
- Lecture notes must be submitted before the next session starts
- Principles are responsible for keeping the copies of assembled lecture notes

Useful tools when presentation:

- Overleaf: Allows writing in LATEX form without installing any additional programs (link: http://overleaf.com/)
- Mathpix: Converts screen capture to LATEX equations (link: https://mathpix.com/)

Meeting Schedule

Sunday 08:00 to 9:5 pm

Course Materials

Textbook

Foundation of Reinforcement Learning with Applications in Finance (RAO)

Lecture

Udacity – Deep Reinforcement Learning

Reinforcement Learning (Daivid Silver)

Paper

Optimal Execution of Portfolio Transactions by Robert Almgren, Neil Chriss

Video

Week	Curriculum
1	**Overview of FRL** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Overview • Deep Reinforcement Learning (Udacity) - 1. Introduction Lesson 1. Welcome to Deep Reinforcement Learning, Lesson 3. Introduction to Reinforcement Learning
2	**RL framework – Markov Process** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 1. The Concept of State in a Process – Chapter 1. Markov Processes: Markov Processes: Simple Inventory Example • Deep Reinforcement Learning (Udacity) - 1. Introduction Lesson 5. The RL Framework – The Problem, Lesson 6. The RL Framework – The Solution • OPTIONAL - [David Silver] Lecture 2. Markov Decision Process
3	**Dynamic programming** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 1. Markov Processes: Stationary Distribution of a Markov Process – Chapter 1. Markov Processes: Summary of Key Learnings from this Chapter • Deep Reinforcement Learning (Udacity) - Lesson 8. Dynamic Programming • OPTIONAL - [David Silver] Lecture 3. Planning by Dynamic Programming
4	**Markov Process** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 2. Markov Decision Processes: Simple Inventory Example: How much to Order? – Chapter 2. Markov Decision Processes: Simple Inventory Example as a Finite Markov Decision Process
5	**Markov Process** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 2. Markov Decision Processes: MDP Value Function for a Fixed Policy – Chapter 2. Markov Decision Processes: Summary of Key Learnings from this Chapter
6	**Dynamic Programming** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 3. Dynamic Programming Algorithms: Planning versus Learning – Chapter 3. Dynamic Programming Algorithms: Bellman Optimality Operator and Value Iteration Algorithm

7	**Dynamic Programming** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 3. Dynamic Programming Algorithms: Optimal Policy from Optimal Value Function – Chapter 3. Dynamic Programming Algorithms: Summary of Key Learnings from this Chapter
8	**Function Approximation** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 4. Function Approximation and Approximate Dynamic Programming: Function Approximation – Chapter 4. Function Approximation and Approximate Dynamic Programming: Approximate Value Iteration
9	**Function Approximation** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 4. Function Approximation and Approximate Dynamic Programming: Finite-Horizon Approximate Policy Evaluation – Chapter 4. Function Approximation and Approximate Dynamic Programming: Key Takeaways from this Chapter
10	**Utility Theory** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 5. Utility Theory
11	**Application in Finance** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 6. Dynamic Asset-Allocation and Consumption
12	**Application in Finance** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 7. Derivatives Pricing and Hedging: A Brief Introduction to Derivatives – Chapter 7. Derivatives Pricing and Hedging: Derivatives Pricing in Single-Period Setting
13	**Application in Finance** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 7. Derivatives Pricing and Hedging: Derivatives Pricing in Multi-Period/Continuous-Time Settings – Chapter 7. Derivatives Pricing and Hedging: Key Takeaways from this Chapter
14	**Optimal Execution** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 8. Order-Book Trading Algorithms: Basics of Order Book and Price Impact - Chapter 8. Order-Book Trading Algorithms: Optimal Execution of a Market Order
15	**Optimal Execution** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 8. Order-Book Trading Algorithms: Optimal Market-Making – Chapter 8. Order-Book Trading Algorithms: Key Takeaways from this Chapter
16	Mid-Term
17	Mid-Term

18	**Monte Carlo & TD** • Deep Reinforcement Learning (Udacity) - 1. Introduction Lesson 10. Monte Carlo Methods - 1. Introduction Lesson 11. Temporal-Difference Methods
19	**Monte Carlo & TD** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 9. Monte-Carlo (MC) and Temporal-Difference (TD) for Prediction: Overview of the Reinforcement Learning approach – Chapter 9. Monte-Carlo (MC) and Temporal-Difference (TD) for Prediction: TD versus MC
20	**Monte Carlo & TD** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 9. Monte-Carlo (MC) and Temporal-Difference (TD) for Prediction: TD(λ) Prediction
21	**Monte Carlo & TD** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 10. Monte-Carlo (MC) and Temporal-Difference (TD) for Control : ~ SARSA(λ)
22	**Monte Carlo & TD** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 10. Monte-Carlo (MC) and Temporal-Difference (TD) for Control : Off-Policy Control ~ Key Takeaways from this Chapter
23	Final-Term
24	Final-Term
25	**Value-Based Method** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 11. Experience-Replay, Least-Squares Policy Iteration, and Gradient TD : Batch RL and Experience-Replay ~ Least-Squares RL prediction • Deep Reinforcement Learning (Udacity) - 2. Value-Based Methods Deep-Q-Networks
26	**Value-Based Method** • Foundations of Reinforcement Learning with Applications in Finance (RAO) - Chapter 11. Experience-Replay, Least-Squares Policy Iteration, and Gradient TD : Q-Learning with Experience-Replay ~ Key Takeaways from this Chapter