Reinforcement Learning in Digital Finance

Course introduction

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Reinforcement Learning in Digital Finance

"Live can only be understood backwards, but it must be lived forward"

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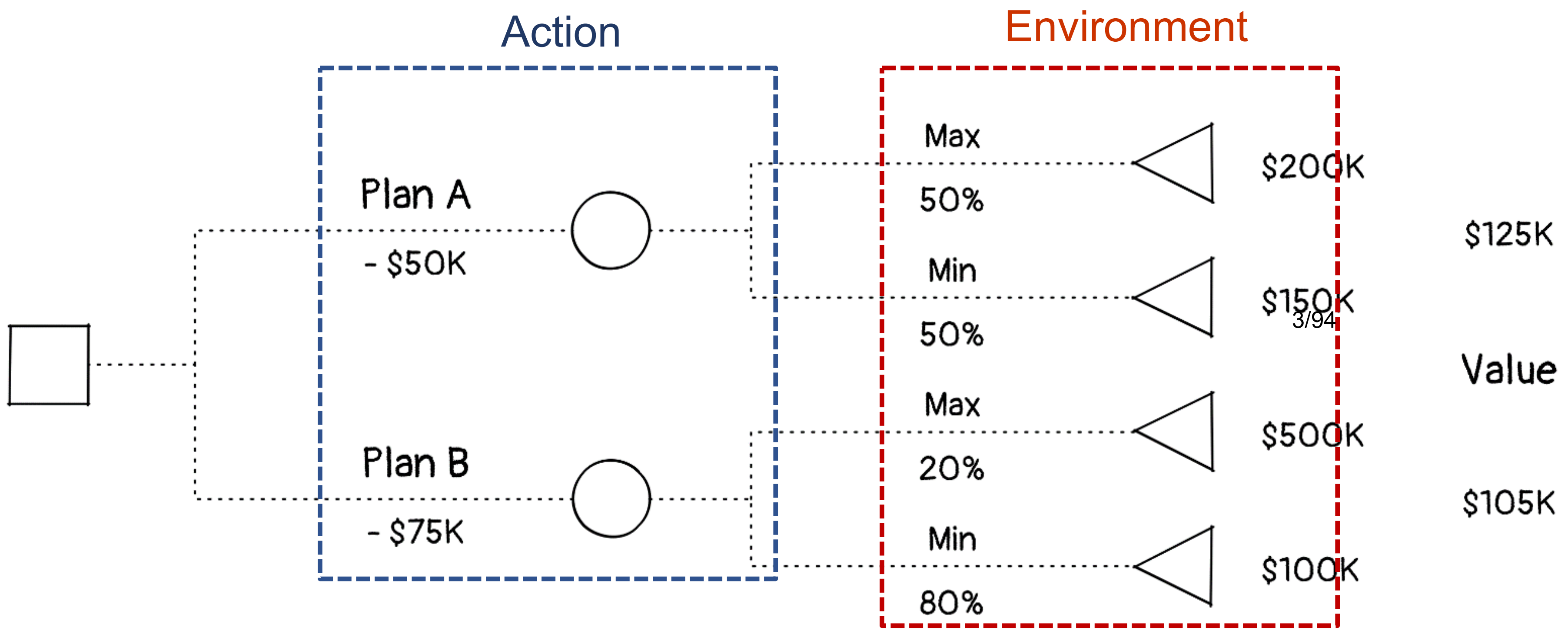
Sequential decision making

- Reinforcement Learning (RL) tries to make optimal decisions sequentially over time, given the uncertainty we face



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Sequential decision making in finance

- Constant dynamics and uncertainty
  - Fluctuating stock prices
  - Economic developments
  - Changes in consumer behavior

- Periodic decisions to maximize rewards
  - Rebalance stock portfolio
  - Accept loan requests
  - Flag/do not flag transaction as fraud

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Arguments for using RL in finance

- Sequential decision-making
- Adaptability to market dynamics
- Exploration and exploitation
- Risk management and reward optimization
- Non-stationarity handling
- Scalability and versatility
- Real-time decision support
- Adaptive policy learning

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Course organisation

Learning goals

- Learn core concepts of Reinforcement Learning (RL)
- Formulate dynamic resource allocation problems as Markov Decision Process models
- Design suitable features to capture values of problem states
- Apply neural networks within the context of Deep RL
- Select appropriate RL techniques for relevant sequential decision-making problems in finance

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Course setup

- One week of on-site training
- Project assignment in groups of 2-3
- Regular online progress meetings
- Deliverables:
  - Final presentation online
  - Written report (paper style)
  - Codebase

- Course evaluation pass/fail based on deliverables
  - One repair opportunity

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Teaching team

- Wouter van Heeswijk
- Assistant professor in Financial Engineering
- University of Twente

- Martijn Mes
- Full professor in Transport Optimization
- University of Twente

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Teaching team

- Jörg Osterrieder
- Associate Professor
- Applied University of Bern

- Branka Hadji Misheva
- Professor
- Applied University of Bern

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Teaching team

- Anne Zander
- Assistant Professor in Stochastic Optimization
- University of Twente

- Adrian Costea
- Professor in Econometrics and Data Mining
- ASE

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Teaching team

- Stefano Penazzi
- Senior Data Scientist
- Cardo AI

- Christian Spethmann
- Data Scientist
- Swedbank

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Keynote speaker

- Warren Powell
- Professor Emeritus
- Princeton University

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Project - Introduction

- Core component of this course
- Recommendation to use Python
  - Common language in industry and academia
  - Extensive library support
- Starting models will be provided
  - Learn RL concepts through implementation and experimentation
- Working paper to summarize project
  - Prospective papers may be transformed into publishable work

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Project - Requirements

- Problem formulation as Markov Decision Process
  - Clear textual description with literature-based motivation
  - Time horizon with decision epochs (time-based or event-based)
  - State, action, reward, transition function, discount rate
- Experimental requirements
  - Learning behavior: convergence of average rewards and loss function, explanation of policy outputs, etc.
  - Benchmark heuristics: can be simple baselines, e.g., random trading agent, buy&hold, trend heuristic.

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Project - Outputs

- Codebase
  - Environment dynamics: state, actions, rewards, transitions
- Final presentation (online)
  - 15 minute presentation + 10 minutes Q&A
- Short paper, ~6 pages
  - Academic style (e.g., introduction with background, some literature, problem formulation, solution method, experimental design, results, conclusion)

- Evaluation: pass/fail

Course materials

- The lecture slides will be shared as background material.
- Sutton & Barto (2018) "*Reinforcement Learning: An Introduction*"
  - Most common RL textbook, freely available online
- Selected reading materials (linked in syllabus)

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Expected background knowledge

- Statistics and probability
- Calculus
- Linear algebra
- Programming (Python)

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Learning objectives

- Understanding the basics of RL
  - Many tools and libraries available
  - Must understand basics to properly apply RL
  - Model by combining existing techniques
  - Industry is focused on results 'today'

- Applications to relevant problems in finance
  - Complementary perspectives and techniques
  - Link new content to existing knowledge
  - Deterministic problem variants can often be extended

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