Introduction

CISC 7404 - Decision Making

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University of Macau

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Prerequisites

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- Python numerical programming

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- Deep learning

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- Statistics and probability

Prerequisites

Python numerical programming:

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You should know:

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- Python loops, lists, dicts, etc

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  - Batch matrix multiply, elementwise product, sum, max, etc

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Assignments in `jax/equinox`, similar to `torch` - final project in `torch`

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If you do not know numerical programming, **you must learn immediately**: https://numpy.org/doc/stable/user/quickstart.html

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- How to construct a neural network in `torch`

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- Multilayer perceptrons

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If you do not, review the deep learning slides: https://github.com/smorad/um_cisc_7026

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- Random variables (X)

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- The entropy of a distribution

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Question: What does $P(X = x)$ mean?

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Question: What does $P(X = x)$ mean?

Answer: Probability of random variable X taking on a value of x

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Question: What does $P(X = x)$ mean?

Answer: Probability of random variable X taking on a value of x

If you did not know this, you should review!

Grading

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- Quizzes 30%

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- Assignments 30%

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- Assignments 30%
- Final Project 30%

Grading

- Quizzes 30%
- Assignments 30%
- Final Project 30%
- Participation 10%

Grading

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- I will tell you week before exam

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Final quiz score: (70 + 80) / 2 = 75%

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- I will tell you week before exam
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Example 1: Quiz 1: 70%, Quiz 2: 80%, Quiz 3: 60%

Final quiz score: (70 + 80) / 2 = 75%

Example 2: Quiz 1: 90%, Quiz 2: (sick) 0%, Quiz 3: 70%

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- I will tell you week before exam
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Example 1: Quiz 1: 70%, Quiz 2: 80%, Quiz 3: 60%

Final quiz score: (70 + 80) / 2 = 75%

Example 2: Quiz 1: 90%, Quiz 2: (sick) 0%, Quiz 3: 70%

Final quiz score: (90 + 70) / 2 = 80%

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Example 1: Quiz 1: 70%, Quiz 2: 80%, Quiz 3: 60%

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Question: What if you are sick for two quizzes?

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Example 1: Quiz 1: 70%, Quiz 2: 80%, Quiz 3: 60%

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Example 2: Quiz 1: 90%, Quiz 2: (sick) 0%, Quiz 3: 70%

Final quiz score: (90 + 70) / 2 = 80%

Question: What if you are sick for two quizzes? Only one quiz dropped, other quiz is zero

Grading

Assignments:

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Assignments:

- Programming

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Assignments:

- Programming
- Expect 2-3 assignments

Grading

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- We will use Google Colab: https://colab.research.google.com

Late assignment policy:

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Late assignment policy:

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- 2-3 days late (-50%)
- 3+ days late (-100%)

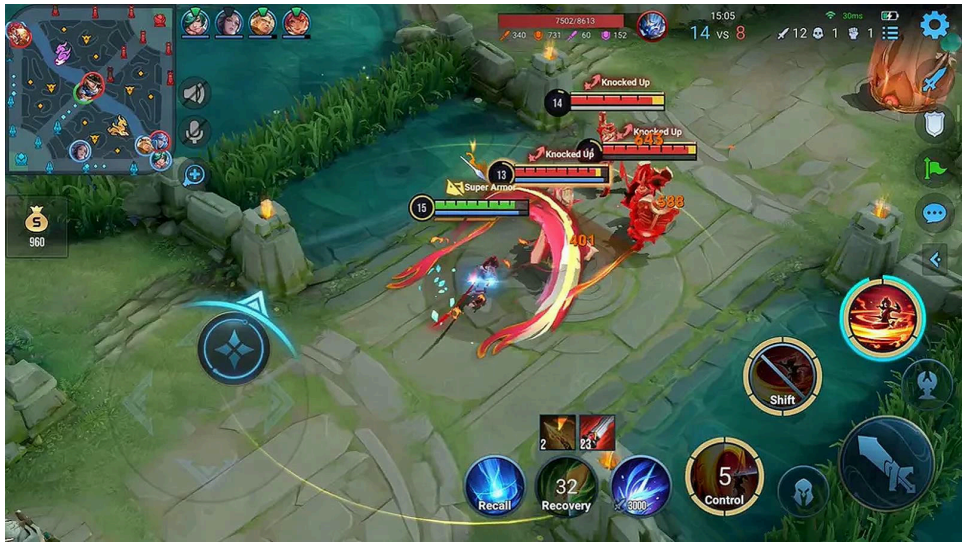
Grading

Final Project:

Grading

Final Project:

Honor of Kings



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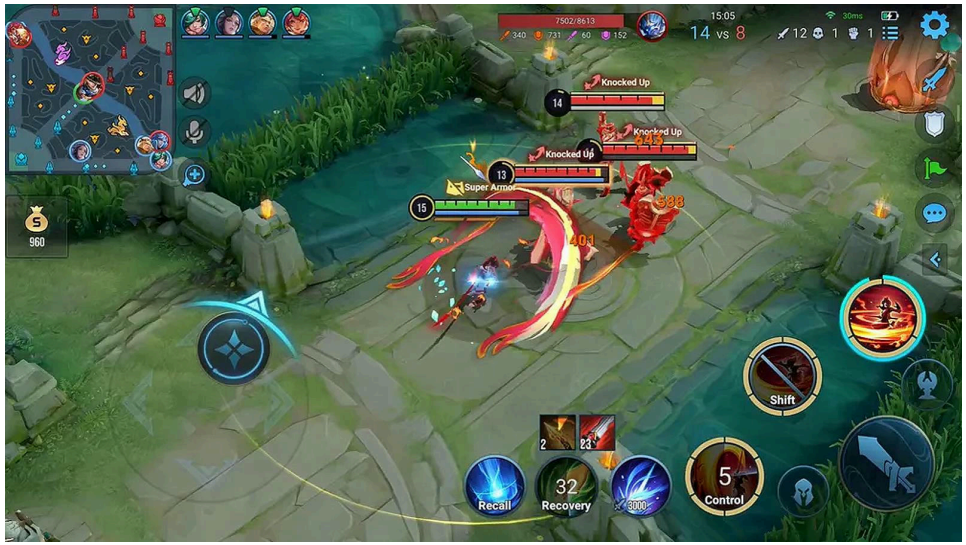

- Research project based on Tencent platform

Grading

Final Project:

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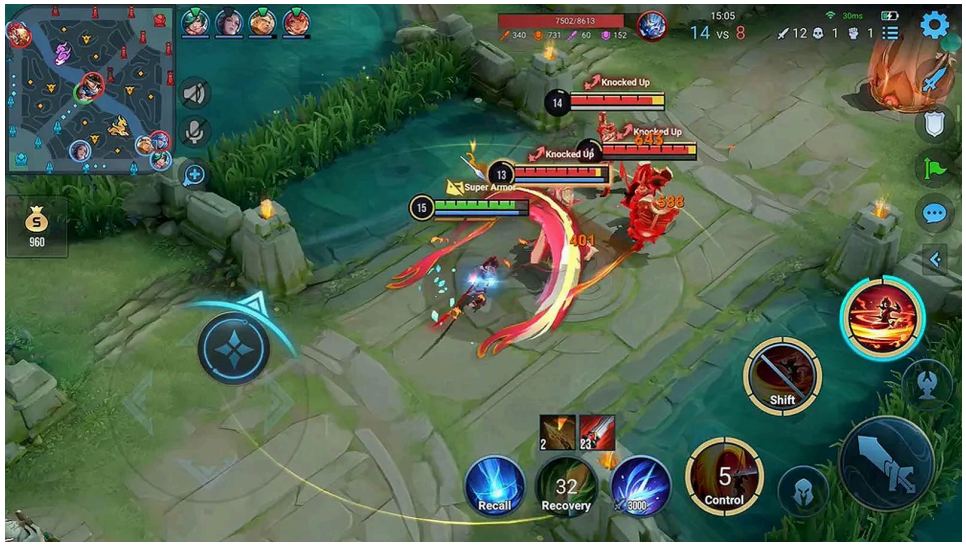

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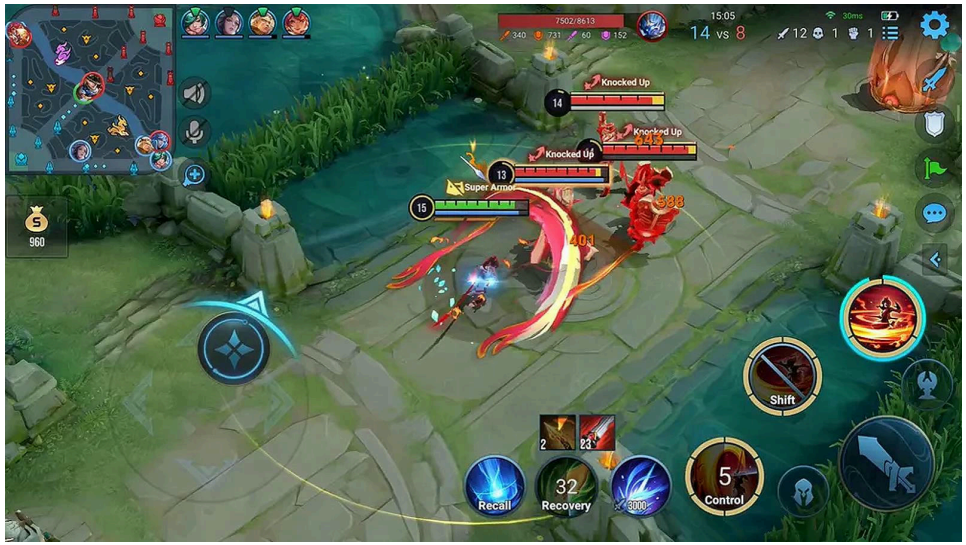

- Research project based on Tencent platform
- Train agents to play each other
- Implement RL algorithm, improve it, write up analysis

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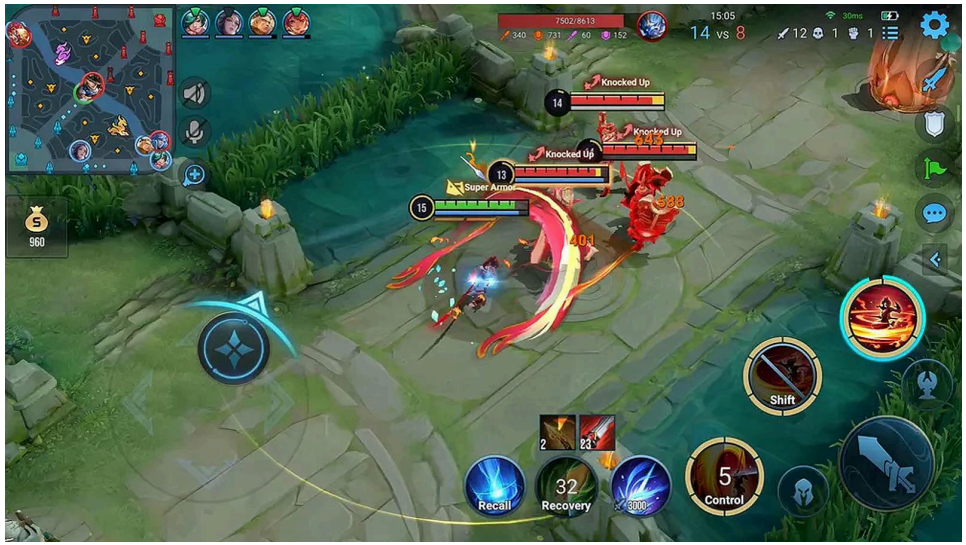

- Research project based on Tencent platform
- Train agents to play each other
- Implement RL algorithm, improve it, write up analysis
- More information later

Grading

Participation:

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Significance

Despite active learning being recognized as a superior method of instruction in the classroom, a major recent survey found that most college STEM instructors still choose traditional teaching methods. This article addresses the long-standing question of why students and faculty remain resistant to active learning. Comparing passive lectures with active learning using a randomized experimental approach and identical course materials, we find that students in the active classroom learn more, but they feel like they learn less. We show that this negative correlation is caused in part by the increased cognitive effort required during active learning. Faculty who adopt active learning are encouraged to intervene and address this misperception, and we describe a successful example of such an intervention.

Grading

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Participation is **asking** or **answering** questions during lecture

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- Individual participation

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Github: https://github.com/smorad/um_cisc_7404

Cheating

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Question: What is cheating?

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Answer:

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- Copying assignment or exam from another student

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- Submitting LLM output for assignments

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It is not worth cheating, do your best and you will get partial credit

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For AI jobs, you will do 5 hours of in-person interviews

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Your degree will be useless without the knowledge

I want you to **learn the material** so you succeed in life

Cheating

Machine Learning Engineer Interview

16 May 2024 •••

Anonymous interview candidate

✗ No offer — Neutral experience ✗ Difficult interview

Application
I interviewed at Baidu in 16/5/2024

Interview
it has 5 rounds of interviews, each of them is very long. I only managed to get to the second round with technical interview, and I failed. It's not a pleasent experience

Interview questions [1]
Question 1
describle tree algorithm and wirte in python
Answer question →

Helpful Share

Cheating

Machine Learning Engineer Interview

Aug 27, 2023 •••

Anonymous Interview Candidate

Beijing, Beijing

— Declined offer ✓ Positive experience ✗ Difficult interview

Application

I applied online. I interviewed at ByteDance (Beijing, Beijing) in 8/27/2023

Interview

machine learning knowledge, code. leetcode (medium, hard with python), AUC definition, method on dealing with long tailed data and causal inference, machine learning question and deep learning method such as attention mechaism.

Interview questions [1]

Question 1

machine learning knowledge, code. leetcode, AUC definition, method on dealin...

read more

Answer question →

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Ok: LLM, why does my Q function return large values?

Cheating: LLM, implement the policy gradient algorithm in pytorch

Lecture Topics

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- Basics

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- Basics
- Modern Methods

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- Modern Methods
- Active Research

Lecture Topics

Basics:

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Basics:

- Bandits

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Basics:

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- Decision Processes

Lecture Topics

Basics:

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Lecture Topics

Basics:

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- Policy Gradient
- Actor Critic

Lecture Topics

Modern Methods:

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Modern Methods:

- Advantage Actor Critic

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- Trust Region Policy Optimization

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- Trust Region Policy Optimization
- Proximal Policy Optimization

Lecture Topics

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- Deep Q Learning

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- Deep Deterministic Policy Gradient

Lecture Topics

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- Deep Deterministic Policy Gradient
- Soft Actor Critic

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- Soft Actor Critic
- Imitation learning

Lecture Topics

Active Research:

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- Memory

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Active Research:

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- Offline RL

Lecture Topics

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What is Decision Making?

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In this course, we will focus primarily on reinforcement learning

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But reinforcement learning is a method, not a problem

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The problem is **decision making**

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In this course, we will focus primarily on reinforcement learning

But reinforcement learning is a method, not a problem

The problem is **decision making**

In this course, we will learn how to make good decisions

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It depends, each field has their own definition

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- Philosophy

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- Philosophy
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- Machine learning

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Answer: Given information, make a choice that impacts the world

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Question: Why should we care about decision making?

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What is Decision Making?

Question: Why should we care about decision making?

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- What time should I leave for class?

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Question: Why should we care about decision making?

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- What time should I leave for class?
- Should I go to school or find a job?
- Should I date this person?
- Where should I live?
- What should we use taxes for?

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Humans are decision making machines – it is all we do!

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We can represent life as a series of decisions

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“All we have to decide is what to do with the time that is given to us”

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To study decision making is to study ourselves

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To study decision making is to study ourselves

If we learn to make better decisions, we can lead better lives

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Make the best possible decision, given the information we have

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We will find methods that **guarantee** optimal decision making

What is Decision Making?

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Make the best possible decision, given the information we have

We will find methods that **guarantee** optimal decision making

With these methods, we can create optimal decision making machines

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In this course, we focus on **optimal** decision making

Make the best possible decision, given the information we have

We will find methods that **guarantee** optimal decision making

With these methods, we can create optimal decision making machines

With an optimal decision making machine, you can create:

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- Best possible scientist (what to research?)

If the machine understands **why** it makes decisions, it is conscious

What is Decision Making?

Let us discuss the history of decision making to better understand it

History of Decision Making

History of Decision Making

Question: Who was the first to apply decision making algorithms?

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3.5 GYA: Single cell organism

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Decides to move away from danger and move towards food

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Decision making is necessary for life

History of Decision Making

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200 kYA: Humanoid hunter-gatherers develop more complex decision making capabilities

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Sequence of decisions to make fire

History of Decision Making

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Sequence of decisions to make fire

Sequence of decisions to plant crops

History of Decision Making

500 BCE: Humans begin to study decision making

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Sun Tzu studies and writes about various forms of decision making

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E.g., zero sum games: “Attack where he is unprepared; appear where you are not expected.”

History of Decision Making

400 BCE: Aristotle creates the earliest recorded framework for decision making

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Syllogistic logic and deductive reasoning from axioms

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Axiom 1: All philosophers prioritize knowledge over leisure

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History of Decision Making

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Syllogistic logic and deductive reasoning from axioms

Axiom 1: All philosophers prioritize knowledge over leisure

Axiom 2: I am a philosopher

Decision: I must attend lecture instead of the party

History of Decision Making

1654: Pascal formalizes decision making under uncertainty with "Pascal's Wager"

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Premise: You are in bed, about to die. Should you believe in God?

History of Decision Making

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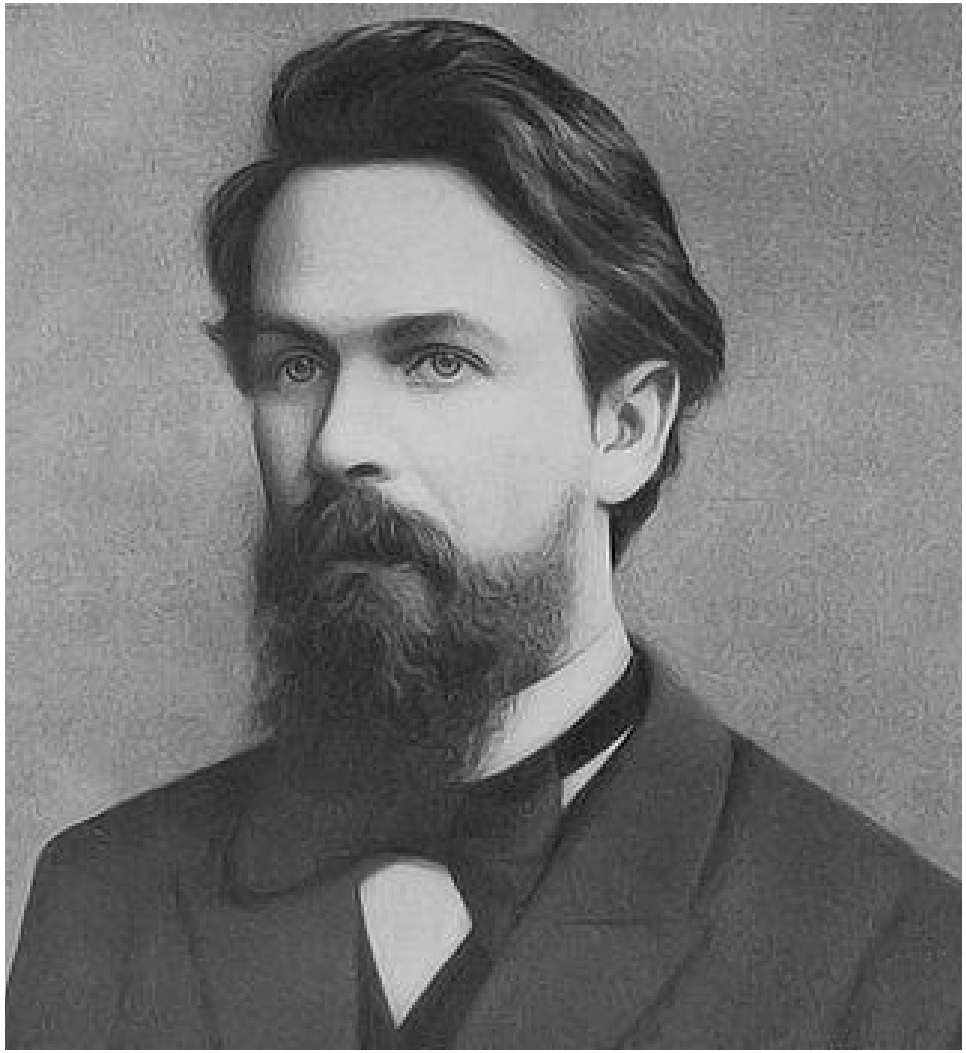
Premise: You are in bed, about to die. Should you believe in God?

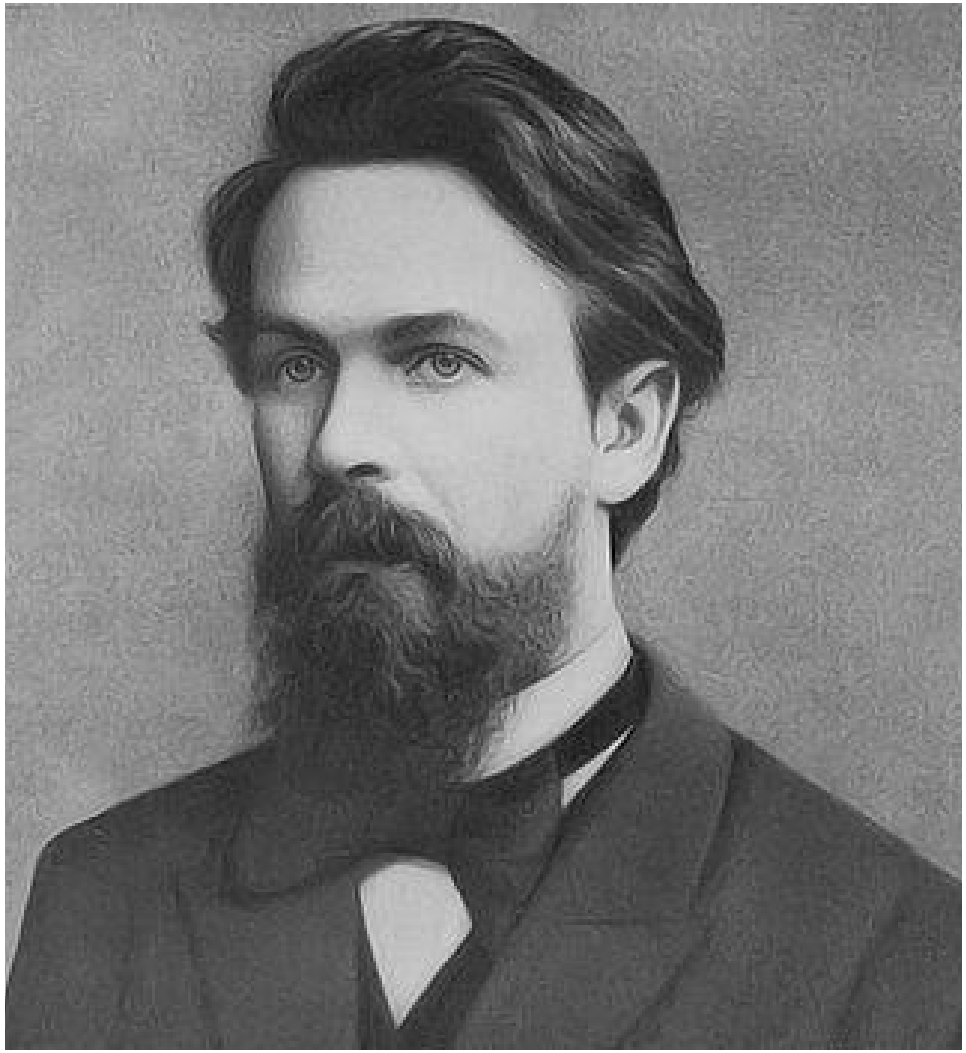
	Believe	Do not believe
God exists	Good	Bad
God does not exist	Neutral	Neutral

History of Decision Making



1906: Markov discovers Markov processes

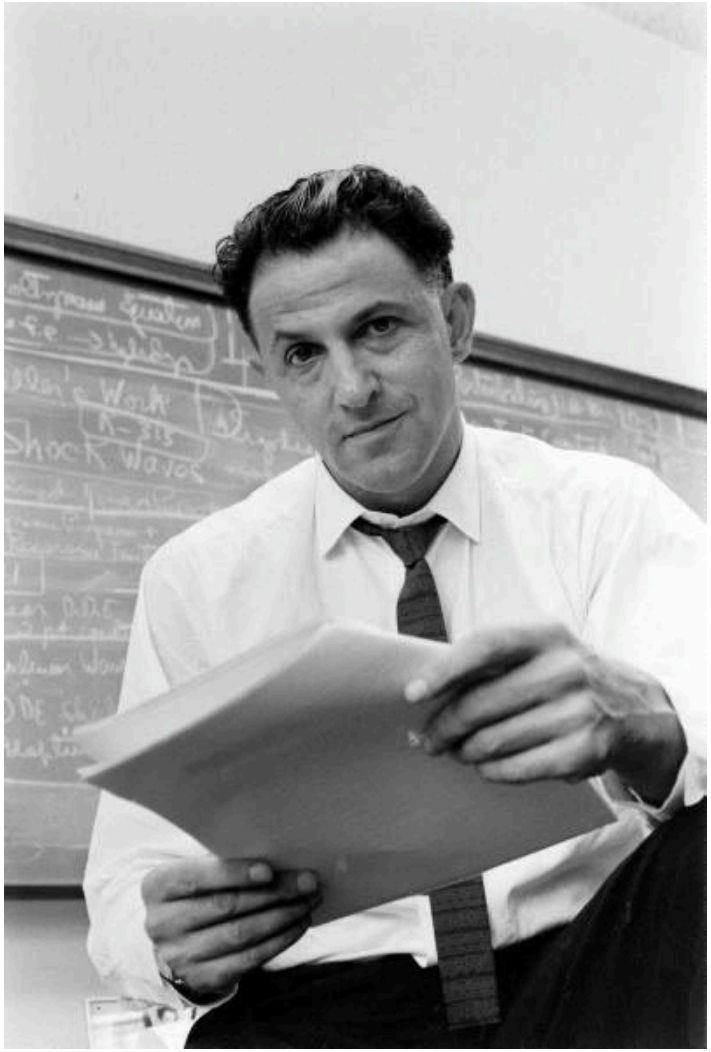
History of Decision Making



1906: Markov discovers Markov processes

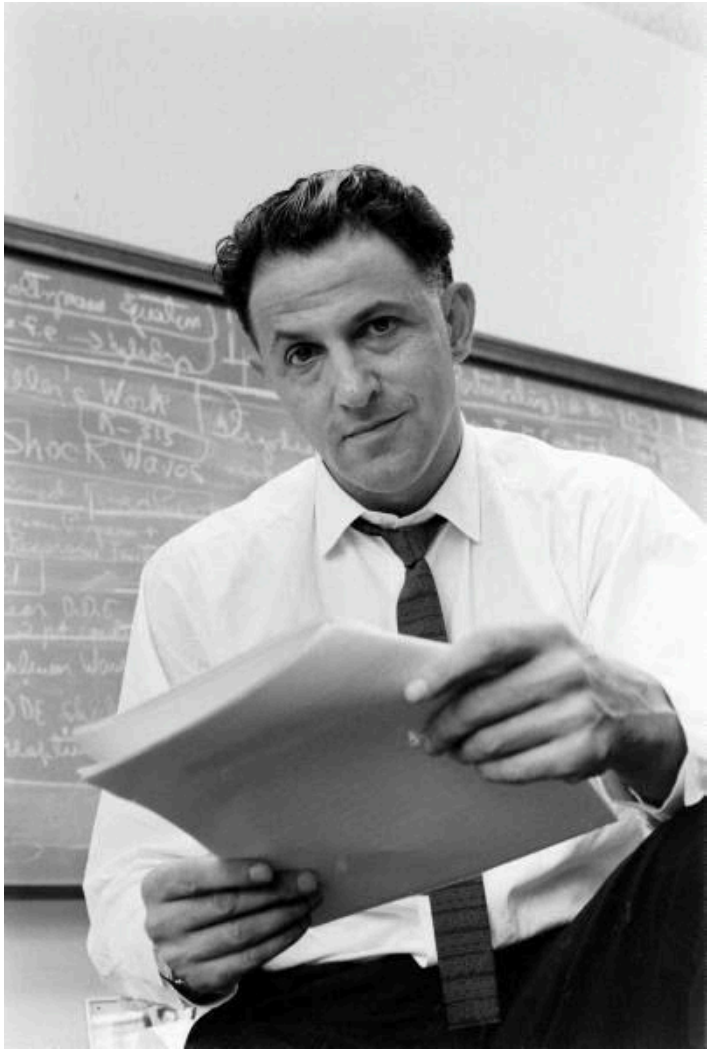
Modern decision making relies on Markov processes

History of Decision Making



1953: Bellman discovers dynamic programming

History of Decision Making



1953: Bellman discovers dynamic programming

Gives us the **Bellman equation**, the basis for optimal decision making

History of Decision Making

1983: Sutton solves the Bellman equation using neural networks

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Combines reinforcement learning and neural networks

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He is still alive and might answer your emails

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We use his textbook: *An Introduction to Reinforcement Learning*

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Chess AIs play each other because humans are too easy

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https://www.youtube.com/watch?v=KF6sLCeBj0s

History of Decision Making

2016: AlphaGo beats world champion Sedol at Go

History of Decision Making

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https://www.youtube.com/watch?v=tXlM99xPQC8

History of Decision Making

2018: OpenAI Five beats world champions at Dota2

History of Decision Making

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https://www.youtube.com/watch?v=eHipy_j29Xw

History of Decision Making

2020-2024: GPT-3, GPT-4 trained using reinforcement learning

History of Decision Making

2025?

Decision Making and Deep Learning

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We will formally define decision making and reinforcement learning later in the course

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For now, I want to clarify decision making in the context of machine learning

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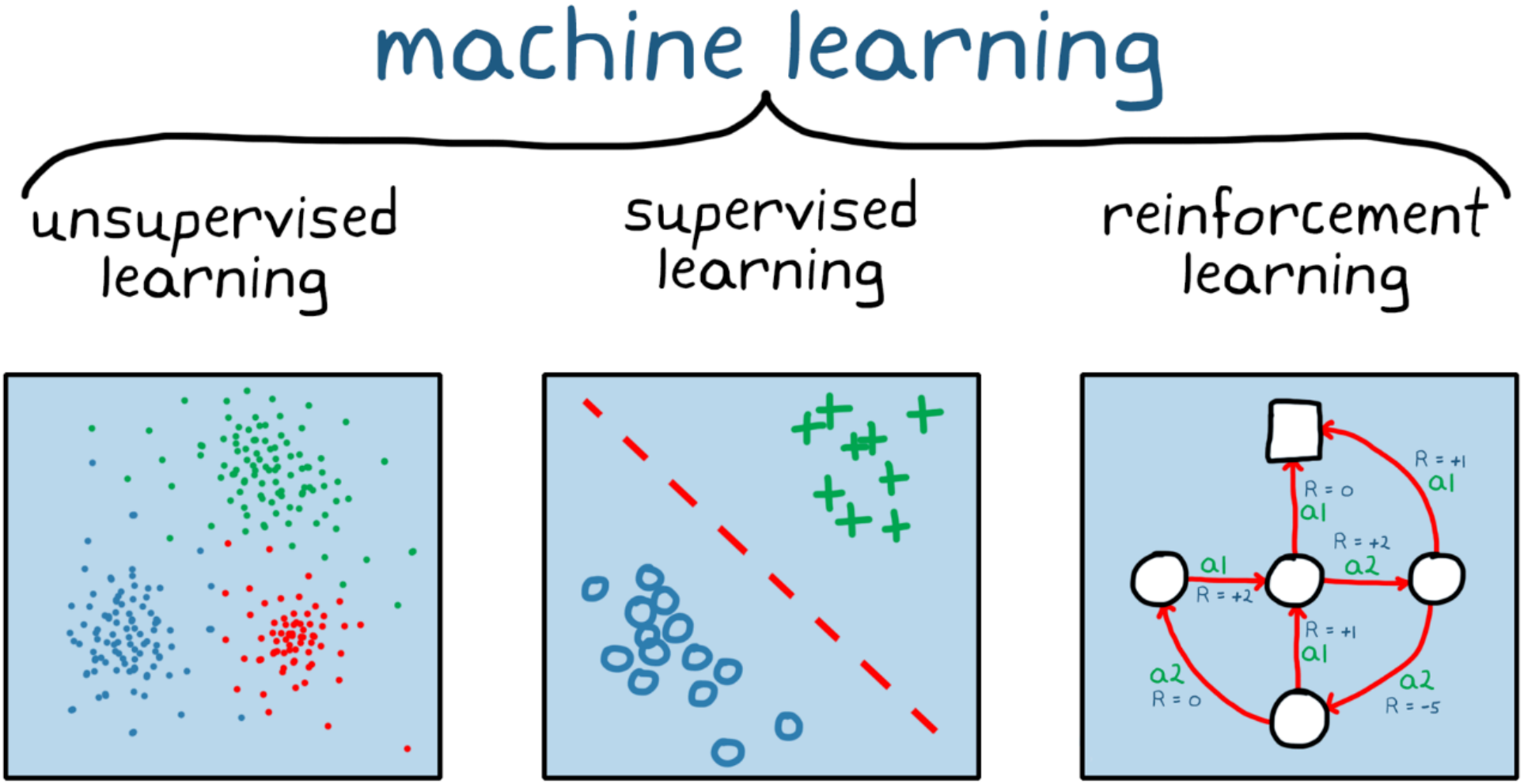
How does decision making differ from regular deep learning?

Decision Making and Deep Learning



Decision Making and Deep Learning

In deep learning, we usually know the answer

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$$f(\boldsymbol{x}, \boldsymbol{\theta}) = \boldsymbol{y}$$

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$$f(\boldsymbol{x}, \boldsymbol{\theta}) = ?$$

What does this mean?

Decision Making and Deep Learning

Example: You train a model f to play chess

Decision Making and Deep Learning

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$$f : X \times \Theta \mapsto Y$$

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$X \in$ Position of pieces on the board $\quad$ $Y \in$ Where to move piece

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Decision Making and Deep Learning

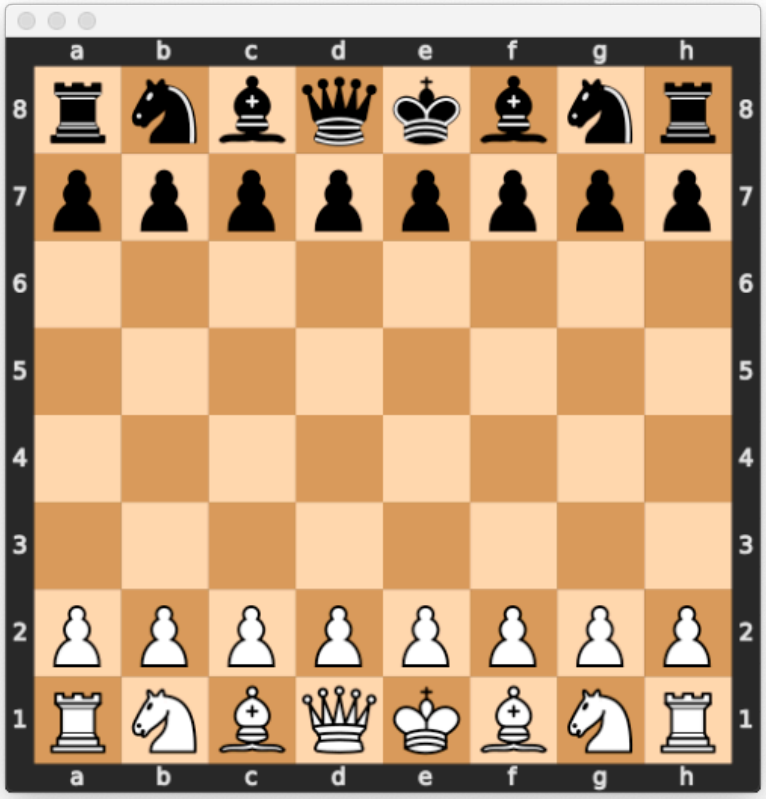
What is the correct answer?

Decision Making and Deep Learning

What is the correct answer?

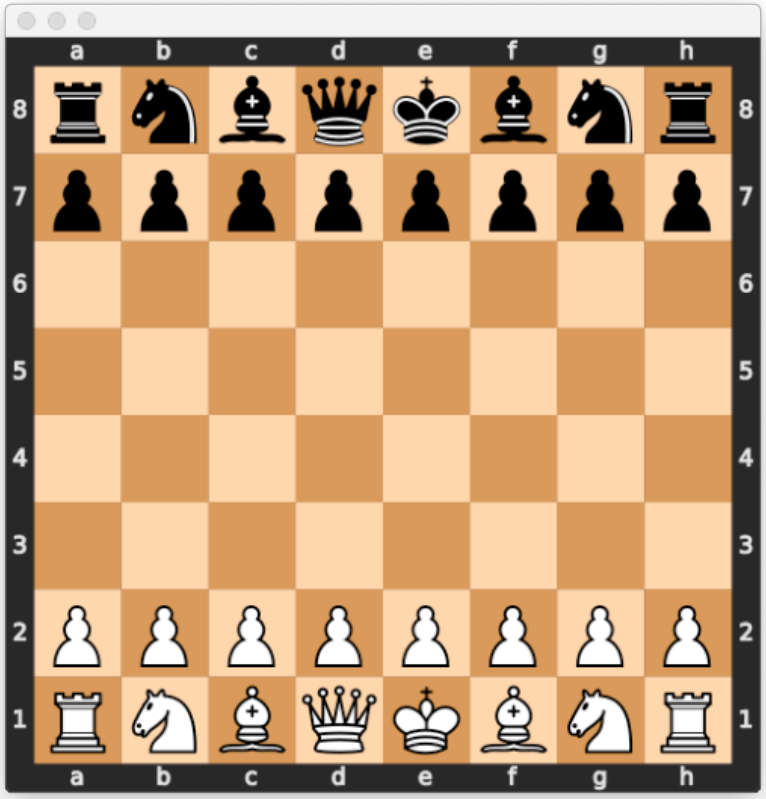
We do not know the answer

Decision Making and Deep Learning



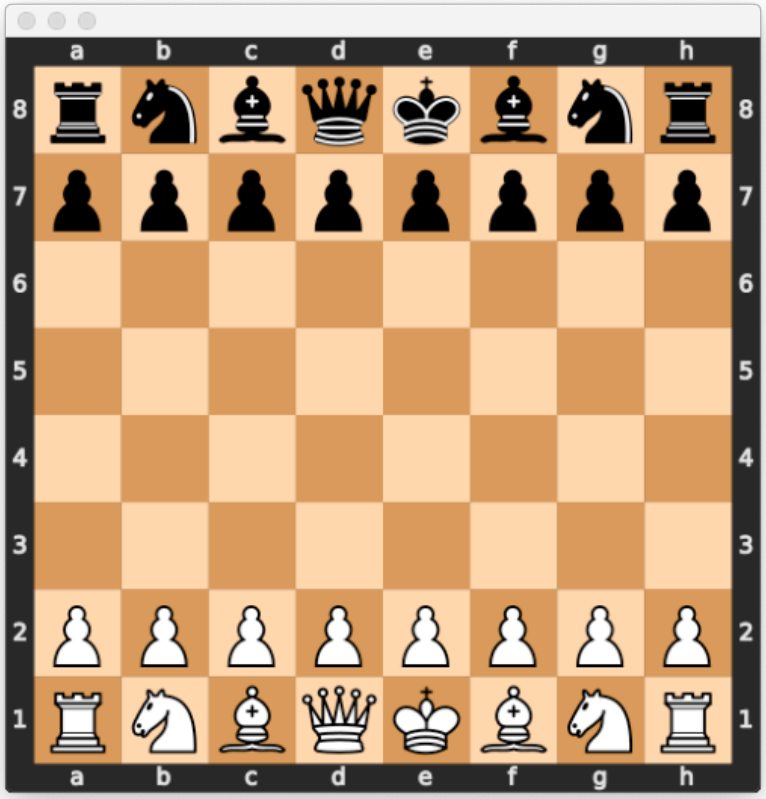
How can we learn a model without an answer?

Decision Making and Deep Learning



An answer gives us just one move

Decision Making and Deep Learning



An answer gives us just one move

We need many moves to win

Decision Making and Deep Learning

Decision making can give us the best **sequence** of moves to:

Decision Making and Deep Learning

Decision making can give us the best **sequence** of moves to:

- Win a game of chess

Decision Making and Deep Learning

Decision making can give us the best **sequence** of moves to:

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Decision making can give us the best **sequence** of moves to:

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- Prevent climate change

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Decision making can give us the best **sequence** of moves to:

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- Reduce human suffering

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- Prevent climate change
- Reduce human suffering

We do not know the correct moves

But with decision making, we can find them!

Questions?

Homework

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  - Especially probability

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