

Introduction to Reinforcement Learning

Lecture 1

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- 1 Reinforcement Learning
- 2 Reinforcement Learning Today
- 3 Machine Learning Overview
- 4 What is Reinforcement Learning?
- 5 Examples

How do we build intelligent machines?

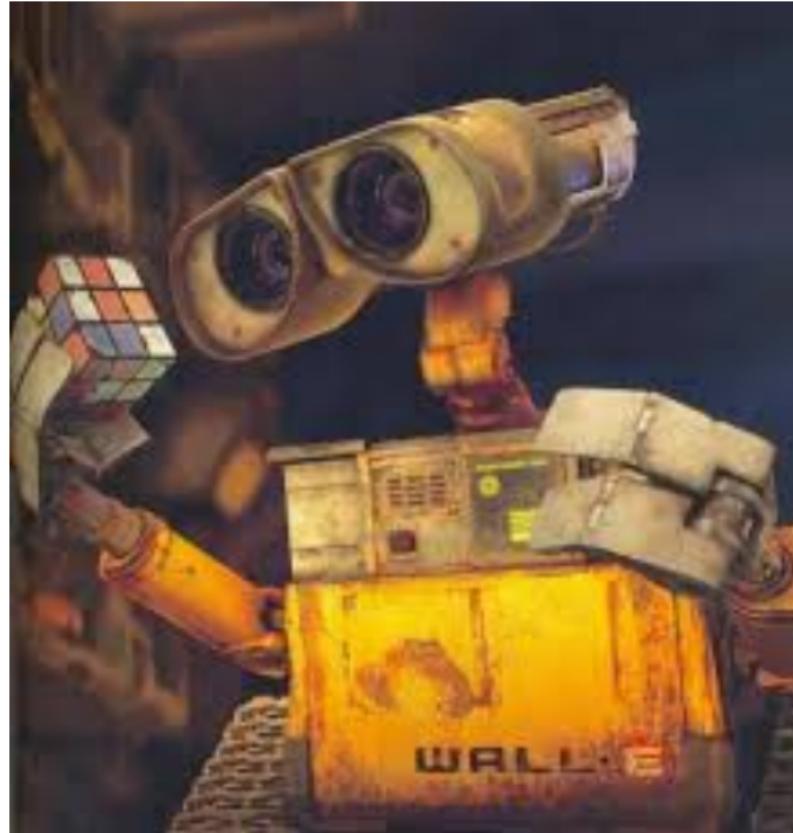


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Learn to make good sequences of decisions

Learn to make good **sequences of decisions**

Learn to make **good** sequences of decisions

Don't Know in Advance How World Works

Learn to make good sequences of decisions

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Mnih, Volodymyr, et al. "Human-level control through deep reinforcement learning." *Nature* 518.7540 (2015): 529.

- Learn to master 49 different Atari games from screens
- Excel human experts in 29 games
- Uses Deep Q-network receiving only the pixels and the game score as inputs



Click!

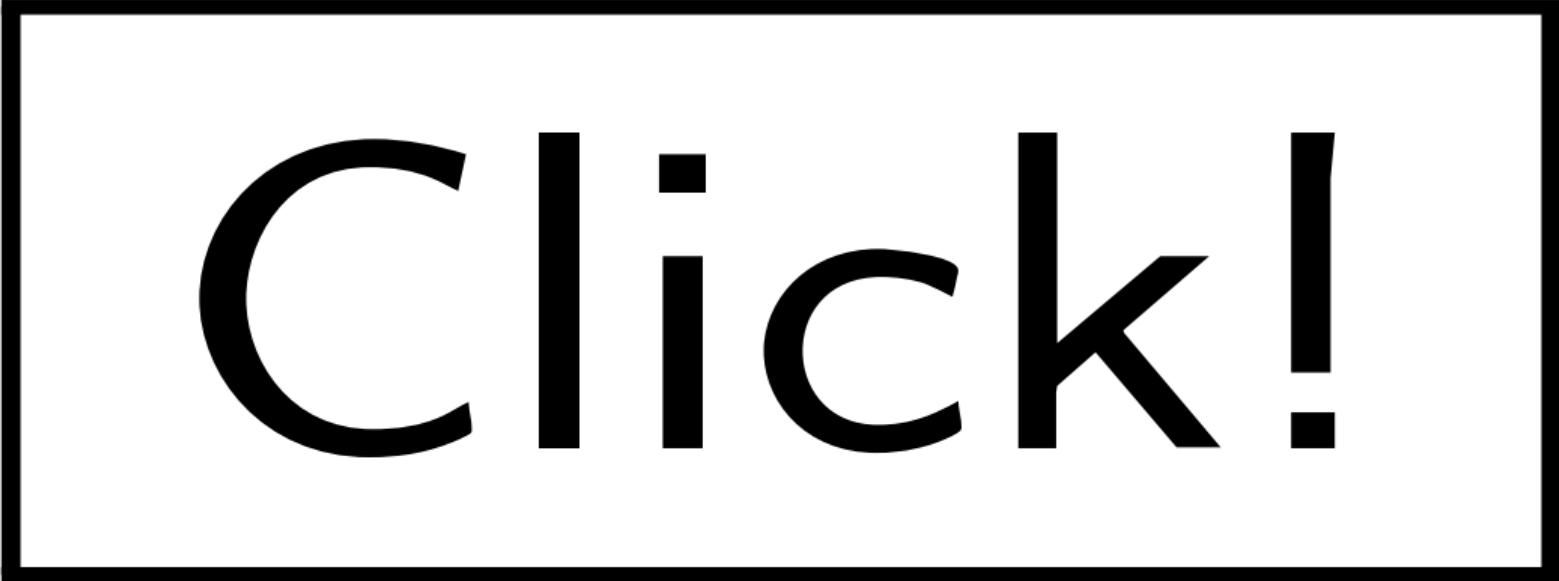
Google DeepMind 2016 - AlphaGo

Silver, David, et al. "Mastering the game of Go with deep neural networks and tree search." *nature* 529.7587 (2016): 484.

- AlphaGo achieved a 99.8% winning rate against other Go programs
- Defeated the human European Go champion by 5 games to 0
- Uses 'value networks' to evaluate board positions and 'policy networks' to select moves



AI that has managed to learn how to walk, run, jump, and climb without any prior guidance



Click!

- Dactyl is a system for manipulating objects using a Shadow Dexterous Hand.
- Trained entirely in simulation and transfers its knowledge to reality
- One of the first RL to be working in the real world



Click!

What is next?

NeurIPS 2019 Will Host Minecraft Reinforcement Learning Competition



Synced

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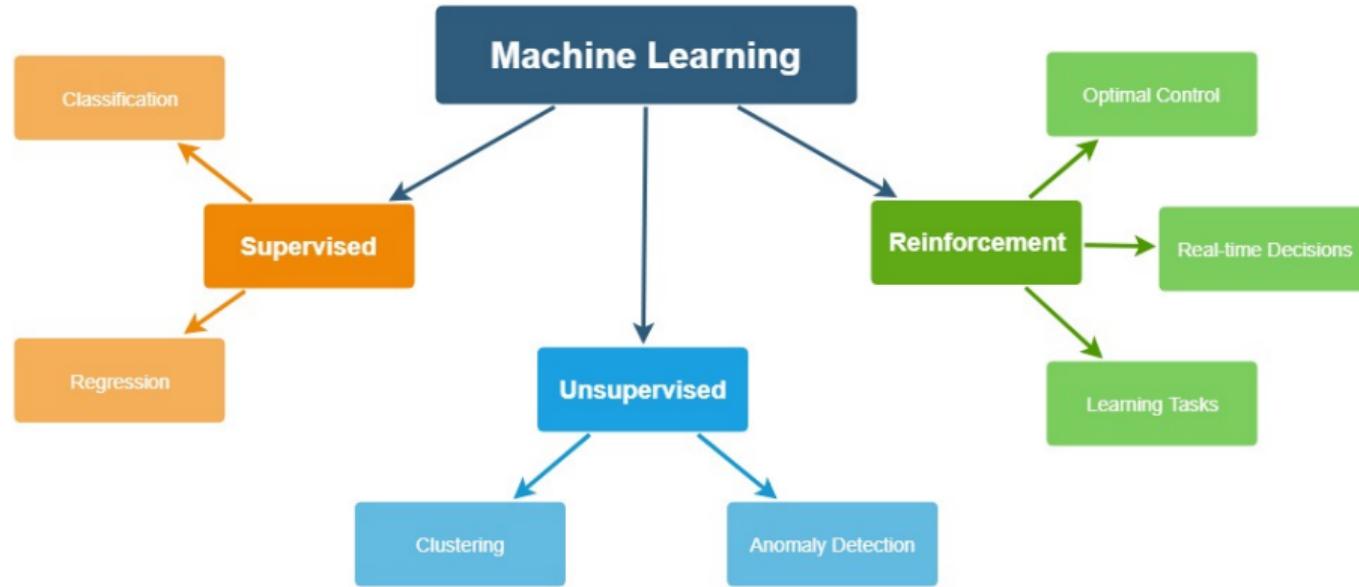


A group of AI experts from top US universities is organizing a sample-efficient reinforcement learning competition, MineRL, which will start on June 1,

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Machine Learning Overview



Supervised Learning

Data: (x, y)

x is data; y is label

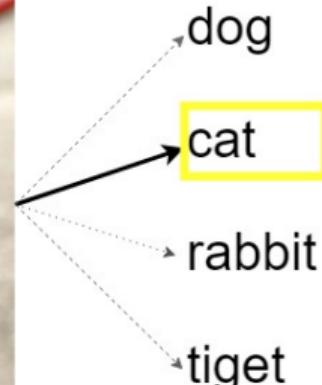
Goal: Learn a function to map

$$X \rightarrow y$$

$$y = f(x)$$

Examples: Classification, regression
decision trees, object detection, etc.

Classification



Unsupervised Learning

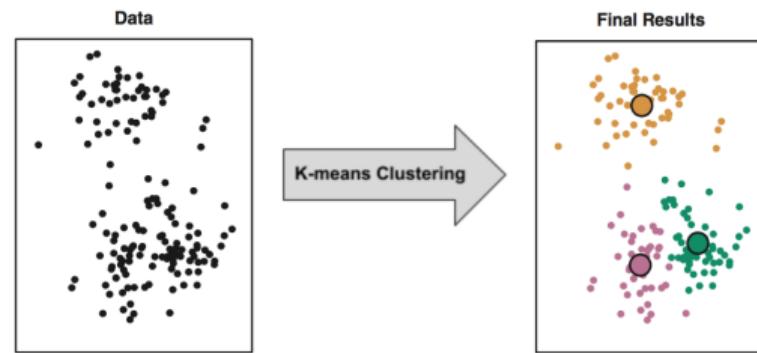
Data: (x)

Just data, no labels

Goal: Learn some underlying hidden structure of the data

Examples: Clustering, dimensionality reduction, feature learning, anomaly detection, etc

Clustering



Reinforcement Learning

Problems involving **an agent** interacting with **an environment**, which provides numeric reward signals.

Goal: Learn how to take actions in order to maximize reward

Examples: Learning tasks, navigation, etc

Manipulating physical objects

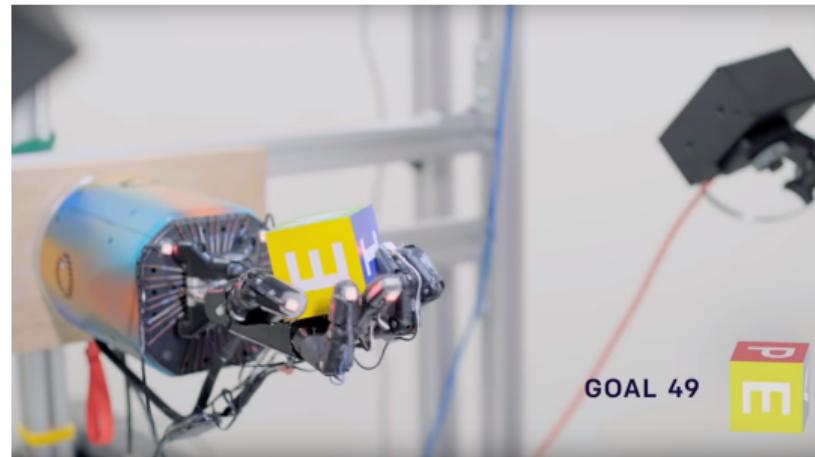
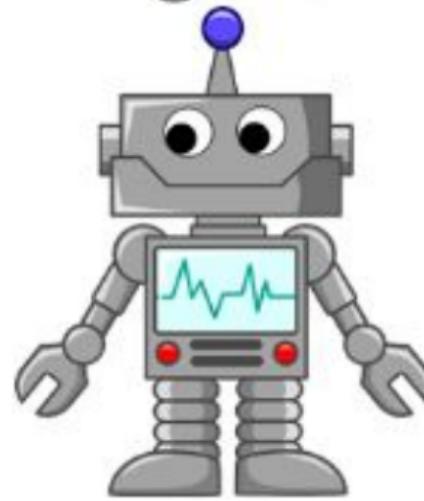


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What is Reinforcement Learning?

Agent

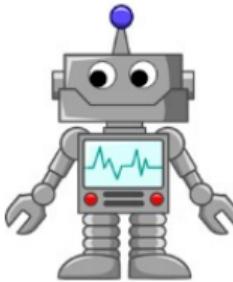


What is Reinforcement Learning?

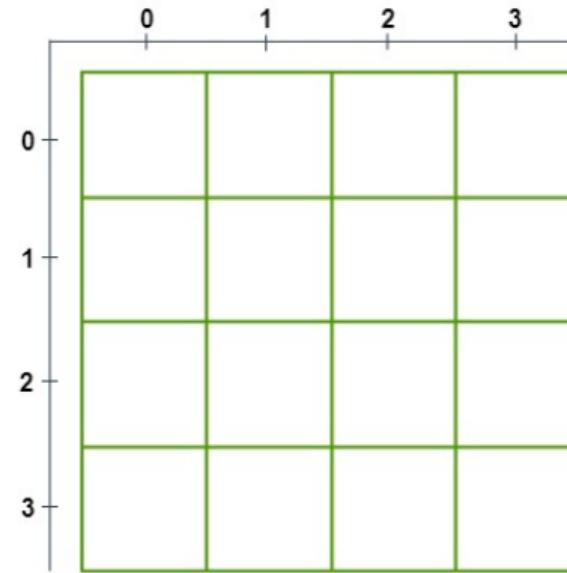
Environment



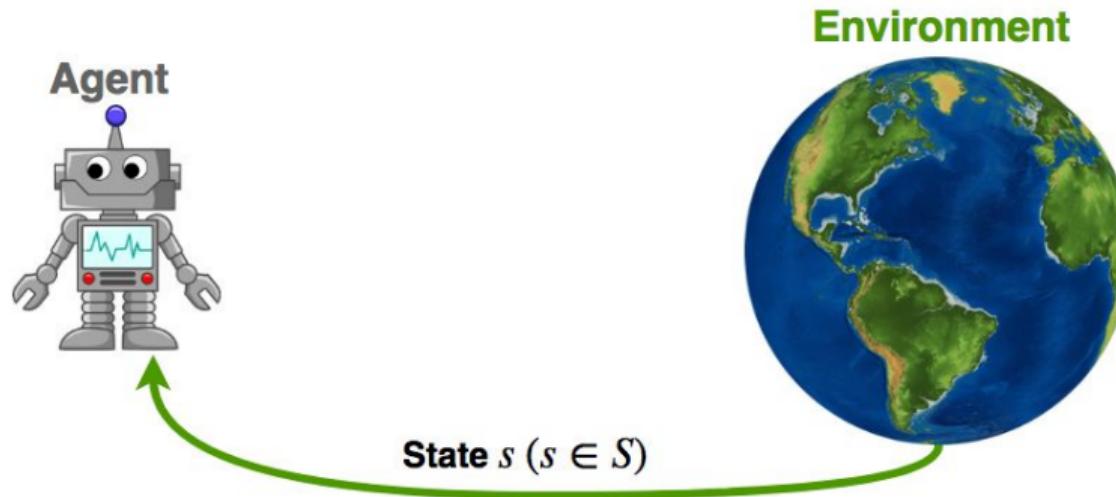
What is Reinforcement Learning?



Grid world

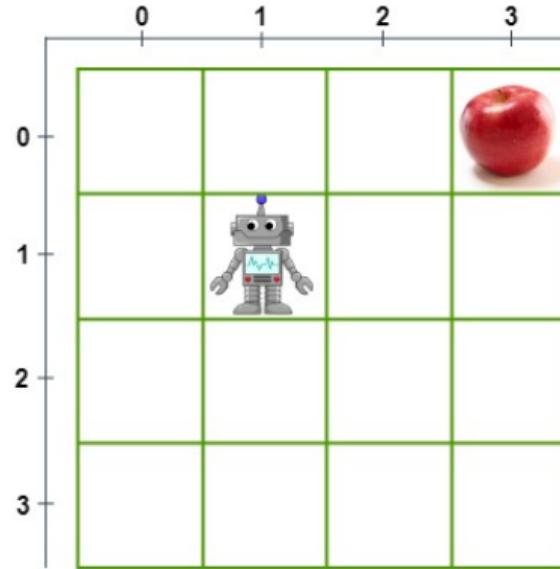


What is Reinforcement Learning?

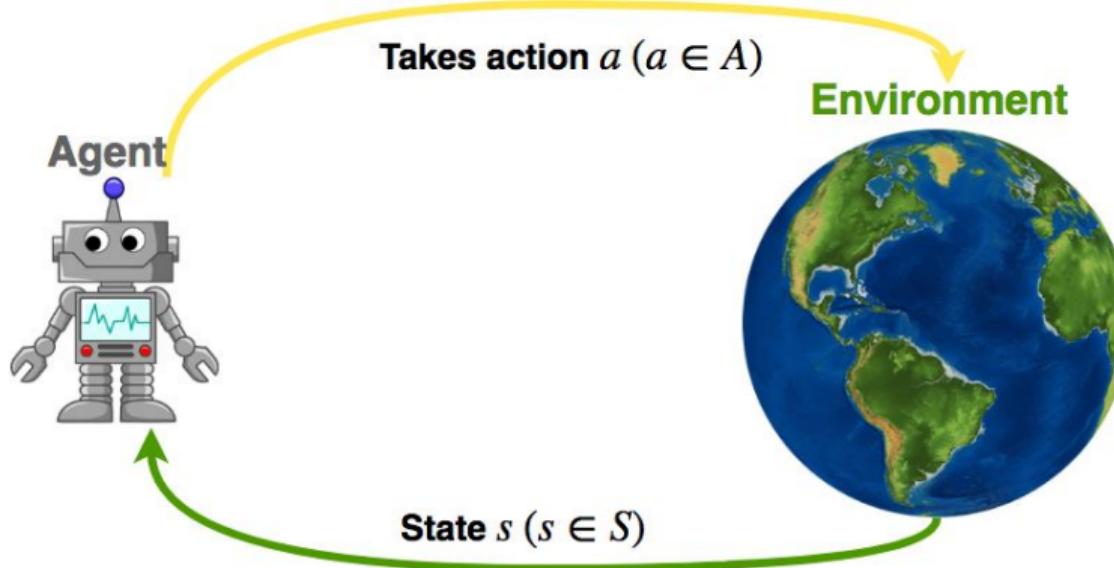


What is Reinforcement Learning?

Grid world

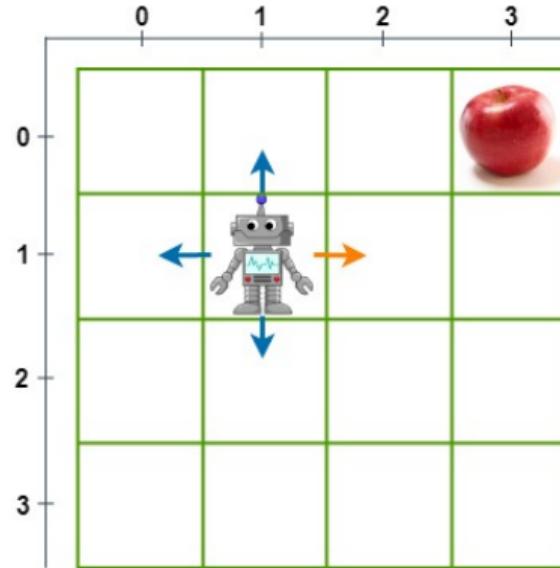


What is Reinforcement Learning?



What is Reinforcement Learning?

Grid world



What is Reinforcement Learning?

Reinforcement learning provides a formalism for behavior.

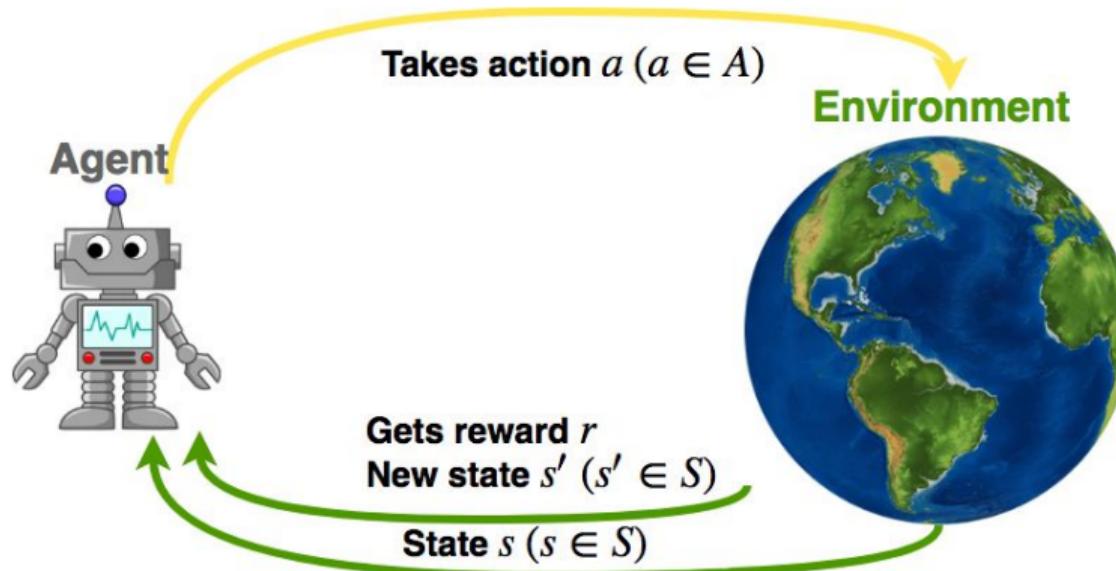


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Dog



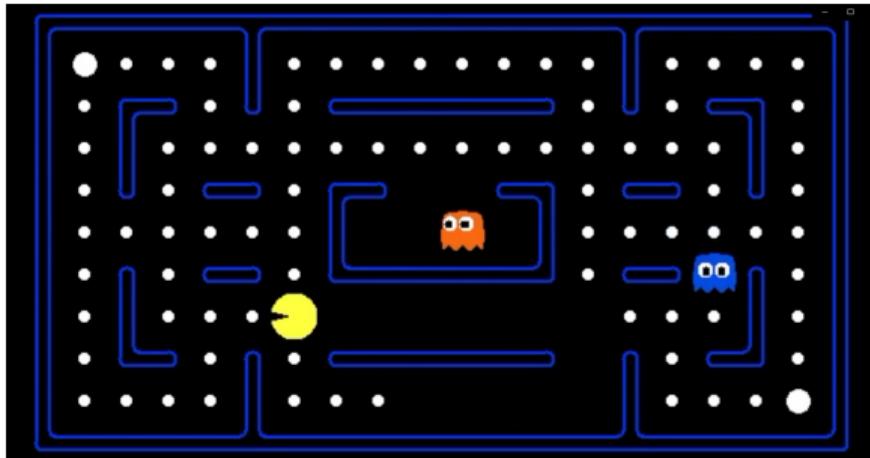
Objective: Eat something tasty

State: Position of the instructor

Action: Give a paw

Reward: Food

Deep Mind: Arcade Games 2015



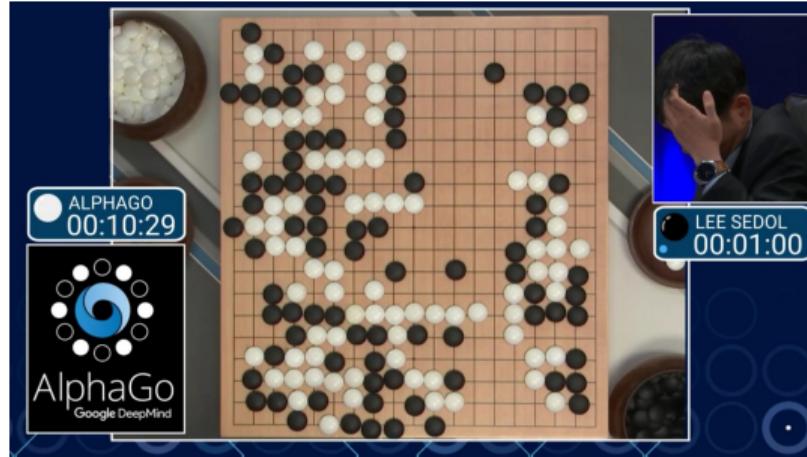
Objective: Complete the game with the highest score

State: Raw pixel inputs of the game state

Action: Game controls e.g. Left, Right, Up, Down

Reward: Score increase/decrease at each time step

Google Deep Mind: AlphaGo 2016

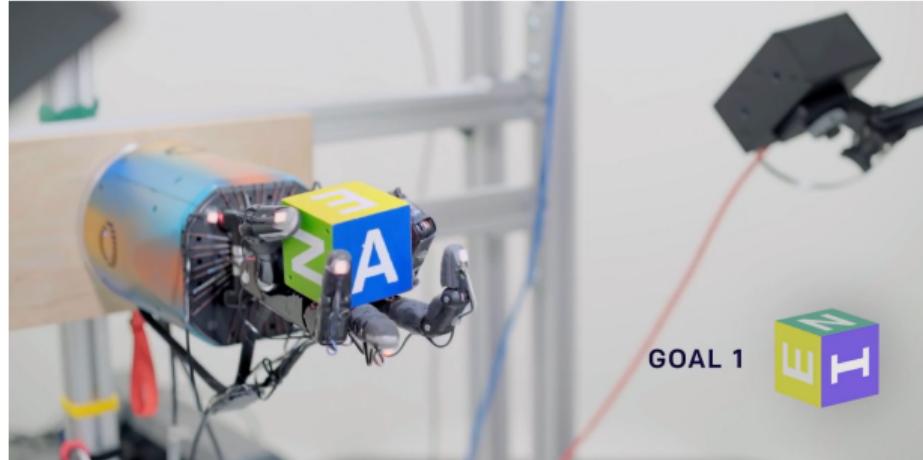


Objective: Win the game

State: Position of all pieces

Action: Where to put the next piece down

Reward: 1 if win at the end of the game, 0 otherwise



Objective: Manipulate physical objects with unprecedented dexterity

State: Coordinates of the fingertips and the images from cameras

Action: Changing the position of fingertips

Reward: Small reward for every simulated movement that brought the cube closer to the goal

Google Deep Mind: AlphaStar 2019



Objective: Win the game

State: Current state of the game, positions of other agents

Action: Take one of the legal action, e.g. where to click and what to build

Reward: Points

Summary so far

- The goal of reinforcement learning is to learn how to take actions in order to maximize the reward
- Reinforcement learning provides a formalism for behavior: we make decisions (action) and get consequences (new state, reward)
- Now is a perfect time to start doing research in reinforcement learning!