

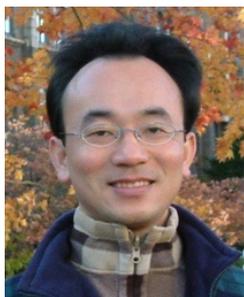
# 人工智慧 (Artificial Intelligence)

## 機器人技術 (Robotics)

1092AI11

MBA, IM, NTPU (M5010) (Spring 2021)

Wed 2, 3, 4 (9:10-12:00) (B8F40)



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<https://web.ntpu.edu.tw/~myday>

2021-06-02



# 課程大綱 (Syllabus)

週次 (Week)	日期 (Date)	內容 (Subject/Topics)
1	2021/02/24	人工智慧概論 (Introduction to Artificial Intelligence)
2	2021/03/03	人工智慧和智慧代理人 (Artificial Intelligence and Intelligent Agents)
3	2021/03/10	問題解決 (Problem Solving)
4	2021/03/17	知識推理和知識表達 (Knowledge, Reasoning and Knowledge Representation)
5	2021/03/24	不確定知識和推理 (Uncertain Knowledge and Reasoning)
6	2021/03/31	人工智慧個案研究 I (Case Study on Artificial Intelligence I)

# 課程大綱 (Syllabus)

週次 (Week)	日期 (Date)	內容 (Subject/Topics)
7	2021/04/07	放假一天 (Day off)
8	2021/04/14	機器學習與監督式學習 (Machine Learning and Supervised Learning)
9	2021/04/21	期中報告 (Midterm Project Report)
10	2021/04/28	學習理論與綜合學習 (The Theory of Learning and Ensemble Learning)
11	2021/05/05	深度學習 (Deep Learning)
12	2021/05/12	人工智慧個案研究 II (Case Study on Artificial Intelligence II)

# 課程大綱 (Syllabus)

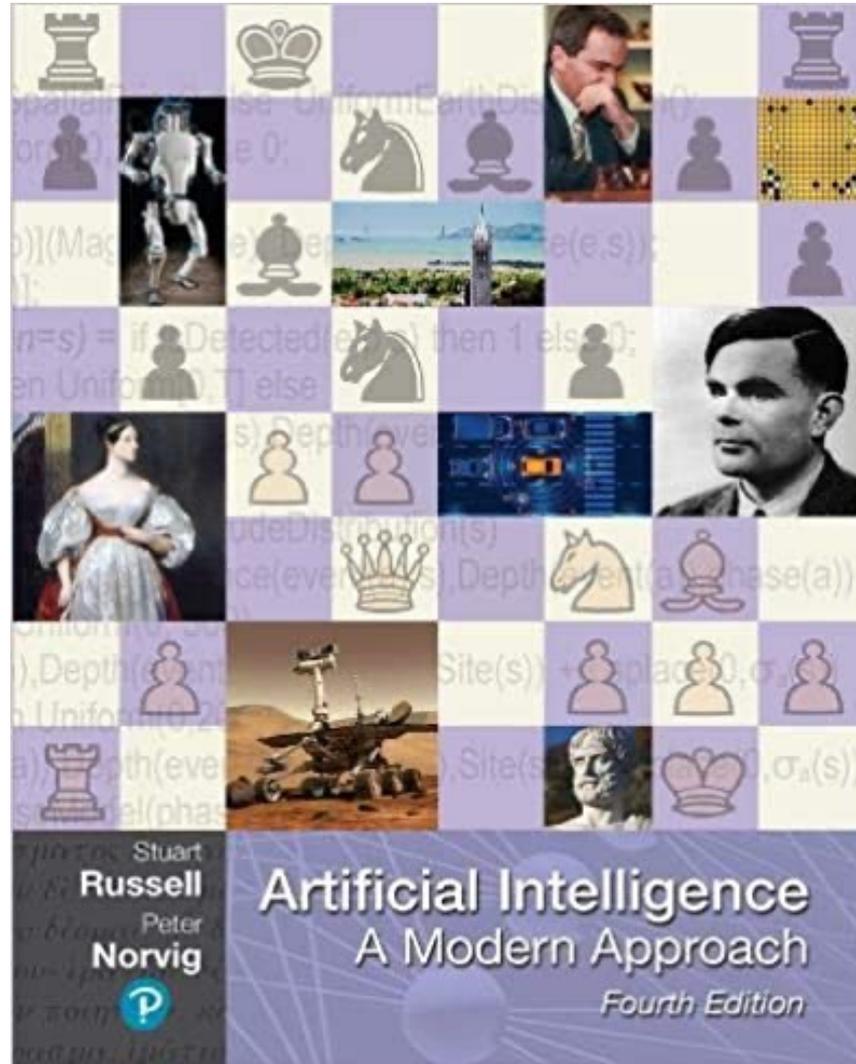
- | 週次 (Week) | 日期 (Date)  | 內容 (Subject/Topics)  |
|-----------|------------|--|
| 13        | 2021/05/19 | 強化學習<br>(Reinforcement Learning)                                     |
| 14        | 2021/05/26 | 深度學習自然語言處理<br>(Deep Learning for Natural Language Processing)        |
| 15        | 2021/06/02 | 機器人技術<br>(Robotics)  |
| 16        | 2021/06/09 | 人工智慧哲學與倫理，人工智慧的未來<br>(Philosophy and Ethics of AI, The Future of AI) |
| 17        | 2021/06/16 | 期末報告 I<br>(Final Project Report I)                                   |
| 18        | 2021/06/23 | 期末報告 II<br>(Final Project Report II)                                 |

# Robotics

# Outline

- Robots
- Robotic Perception
- Planning and Control
- Planning Uncertain Movements
- Reinforcement Learning in Robotics
- Humans and Robots

Stuart Russell and Peter Norvig (2020),  
**Artificial Intelligence: A Modern Approach,**  
4th Edition, Pearson



Source: Stuart Russell and Peter Norvig (2020), Artificial Intelligence: A Modern Approach, 4th Edition, Pearson

<https://www.amazon.com/Artificial-Intelligence-A-Modern-Approach/dp/0134610997/>

# Artificial Intelligence: A Modern Approach

1. Artificial Intelligence
2. Problem Solving
3. Knowledge and Reasoning
4. Uncertain Knowledge and Reasoning
5. Machine Learning
6. Communicating, Perceiving, and Acting
7. Philosophy and Ethics of AI

# Artificial Intelligence: Communicating, perceiving, and acting

# Artificial Intelligence:

## 6. Communicating, Perceiving, and Acting

- Natural Language Processing
- Deep Learning for Natural Language Processing
- Computer Vision
- **Robotics**

# Artificial Intelligence:

## Robotics

- Robots
- Robot Hardware
- What kind of problem is robotics solving?
- Robotic Perception
- Planning and Control
- Planning Uncertain Movements
- Reinforcement Learning in Robotics
- Humans and Robots
- Alternative Robotic Frameworks
- Application Domains

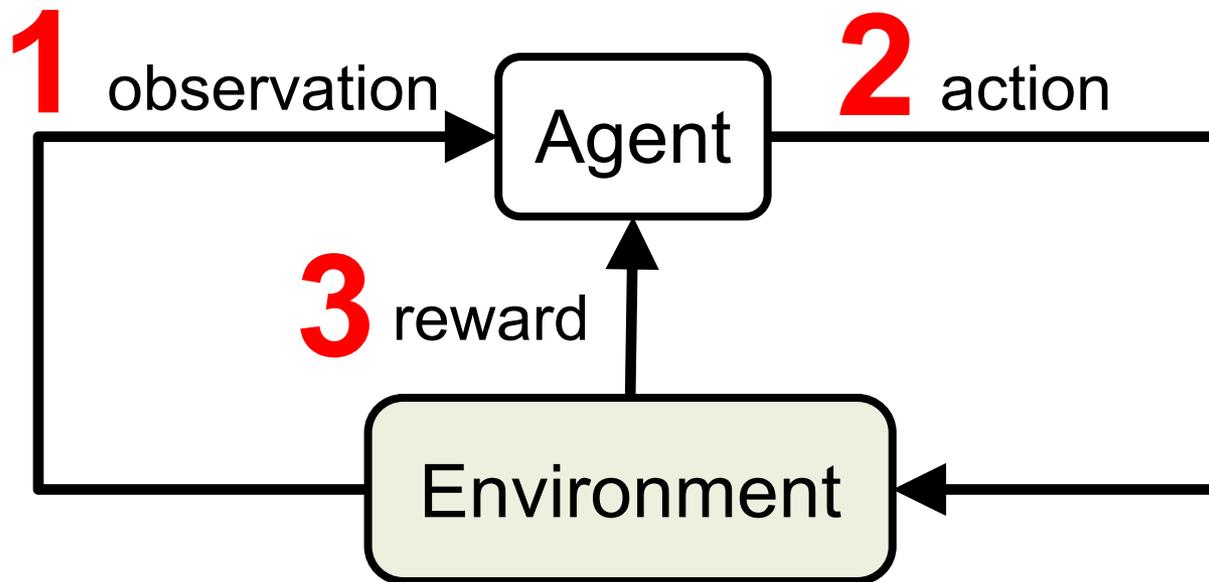
# Reinforcement Learning (DL)

The diagram illustrates the Reinforcement Learning loop. It consists of two main components: an Agent and an Environment. The Agent is represented by a white rounded rectangle with a black border, positioned above the Environment. The Environment is represented by a light green rounded rectangle with a black border, positioned below the Agent. The interaction between the Agent and the Environment is implied by their relative positions in the loop.

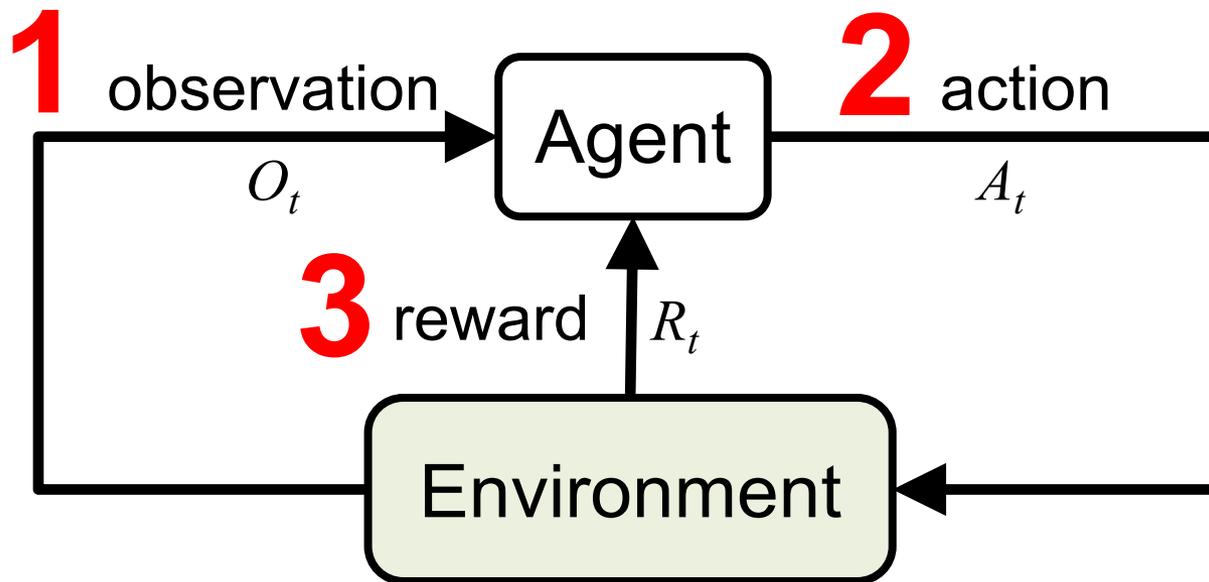
Agent

Environment

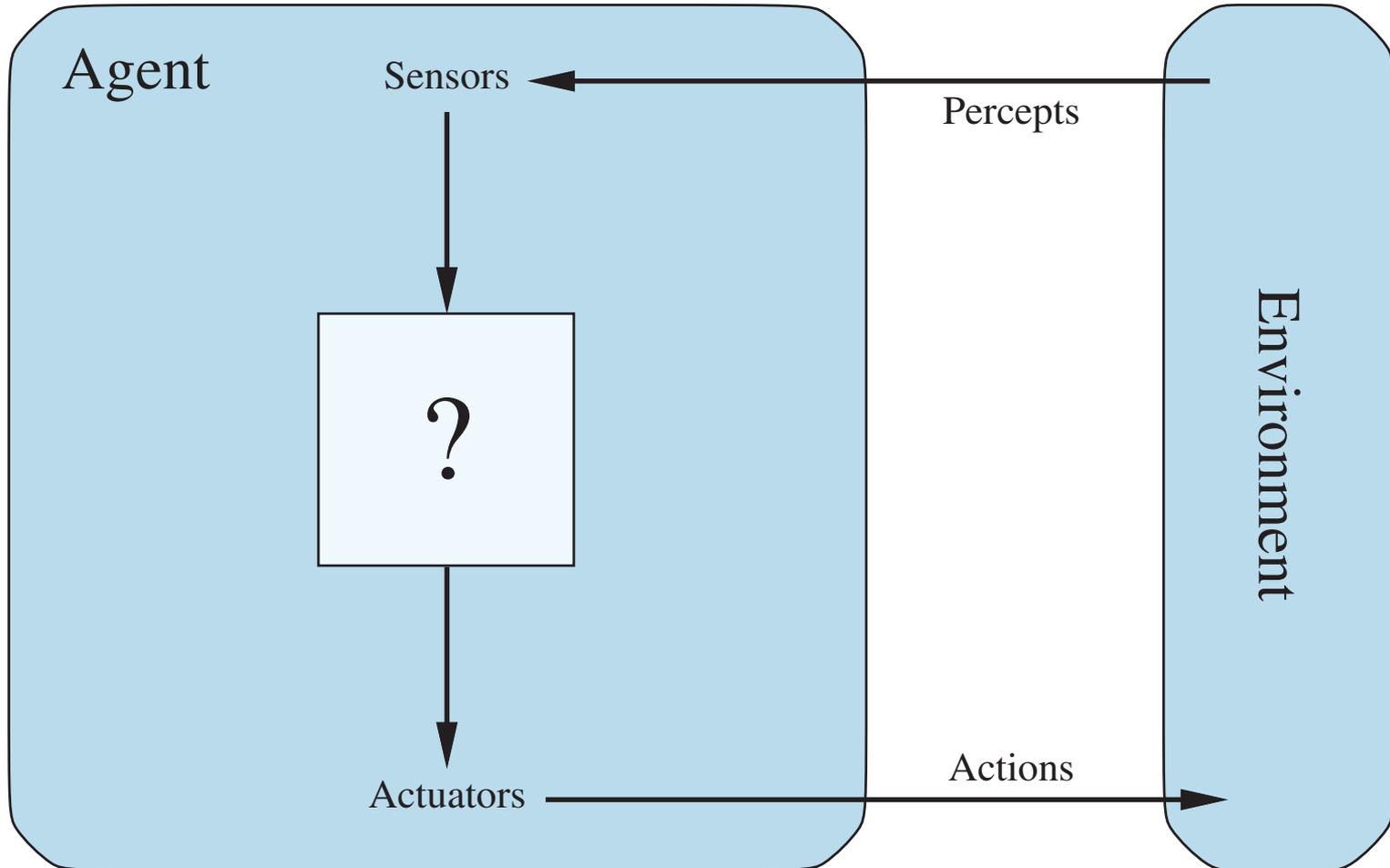
# Reinforcement Learning (DL)



# Reinforcement Learning (DL)



# Agents interact with environments through sensors and actuators



# Robotics

# Artificial Intelligence: Robotics

- **Agents** are endowed with **sensors** and **physical effectors** with which to move about and make mischief in the real world.

# Boston Dynamics: Spot

Automate sensing and inspection, capture limitless data, and explore without boundaries.



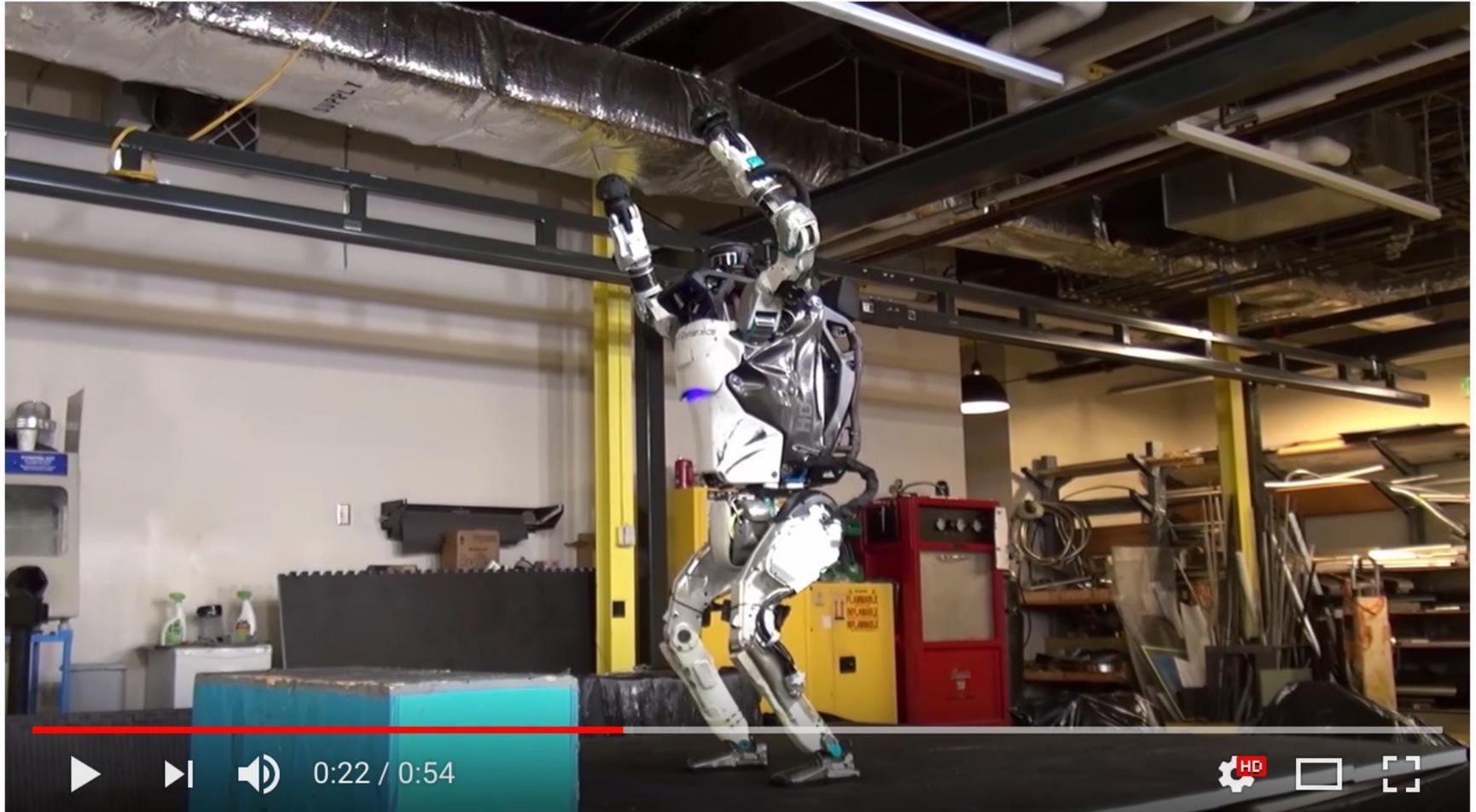
# Boston Dynamics: Atlas

The world's most dynamic humanoid robot

Atlas is a research platform designed to push the limits of whole-body mobility



# Boston Dynamics: Atlas



#13 ON TRENDING

What's new, Atlas?

<https://www.youtube.com/watch?v=fRj34o4hN4I>

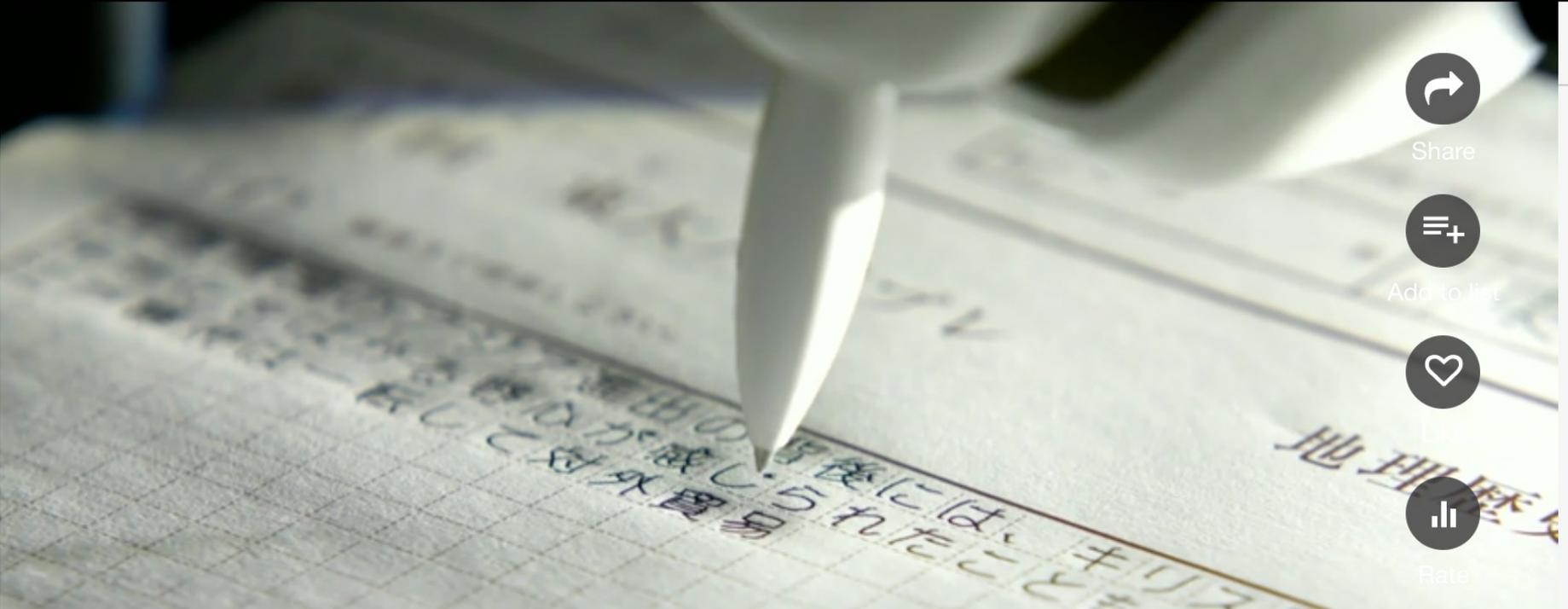
# Humanoid Robot: Sophia



<https://www.youtube.com/watch?v=S5t6K9iwcdw>

# Can a robot pass a university entrance exam?

Noriko Arai at TED2017



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Noriko Arai at TED2017

## Can a robot pass a university entrance exam?

▶ [Progress bar] 11:25 [Volume] [Comments] [Settings] [Full Screen]

[https://www.ted.com/talks/noriko\\_arai\\_can\\_a\\_robot\\_pass\\_a\\_university\\_entrance\\_exam](https://www.ted.com/talks/noriko_arai_can_a_robot_pass_a_university_entrance_exam)

<https://www.youtube.com/watch?v=XQZjkPyJ8KU>

# Artificial Intelligence (A.I.) Timeline

S/Z/Y/G/

## A.I. TIMELINE

1950

### TURING TEST

Computer scientist Alan Turing proposes a test for machine intelligence. If a machine can trick humans into thinking it is human, then it has intelligence

1955

### A.I. BORN

Term 'artificial intelligence' is coined by computer scientist, John McCarthy to describe "the science and engineering of making intelligent machines"

1961

### UNIMATE

First industrial robot, Unimate, goes to work at GM replacing humans on the assembly line

1964

### ELIZA

Pioneering chatbot developed by Joseph Weizenbaum at MIT holds conversations with humans

1966

### SHAKY

The 'first electronic person' from Stanford, Shakey is a general-purpose mobile robot that reasons about its own actions

A.I. WINTER

Many false starts and dead-ends leave A.I. out in the cold

1997

### DEEP BLUE

Deep Blue, a chess-playing computer from IBM defeats world chess champion Garry Kasparov

1998

### KISMET

Cynthia Breazeal at MIT introduces Kismet, an emotionally intelligent robot insofar as it detects and responds to people's feelings



1999

### AIBO

Sony launches first consumer robot pet dog AIBO (AI robot) with skills and personality that develop over time



2002

### ROOMBA

First mass produced autonomous robotic vacuum cleaner from iRobot learns to navigate and clean homes



2011

### SIRI

Apple integrates Siri, an intelligent virtual assistant with a voice interface, into the iPhone 4S



2011

### WATSON

IBM's question answering computer Watson wins first place on popular \$1M prize television quiz show Jeopardy



2014

### EUGENE

Eugene Goostman, a chatbot passes the Turing Test with a third of judges believing Eugene is human



2014

### ALEXA

Amazon launches Alexa, an intelligent virtual assistant with a voice interface that completes shopping tasks



2016

### TAY

Microsoft's chatbot Tay goes rogue on social media making inflammatory and offensive racist comments



2017

### ALPHAGO

Google's A.I. AlphaGo beats world champion Ke Jie in the complex board game of Go, notable for its vast number ( $2^{170}$ ) of possible positions

# Robots

- Robots are **physical agents** that perform tasks by manipulating the physical world.
  - To do so, they are equipped with **effectors** such as **legs, wheels, joints,** and **grippers**.
- **Effectors** are designed to assert physical forces on the environment.

# Robots and Effectors

- When they do this, a few things may happen:
  - the **robot's state** might change
  - the **state of the environment** might change
  - the **state of the people around the robot** might change

# Robots

- The most common types of robots are **manipulators (robot arms)** and **mobile robots**.
- They have **sensors** for perceiving the world and **actuators** that produce motion, which then affects the world via **effectors**.

# Robotics Problem

- The general robotics problem involves
  - **stochasticity**  
(which can be handled by MDPs)
  - **partial observability**  
(which can be handled by POMDPs)
  - **acting with and around other agents**  
(which can be handled with game theory)

# Robotic Perception

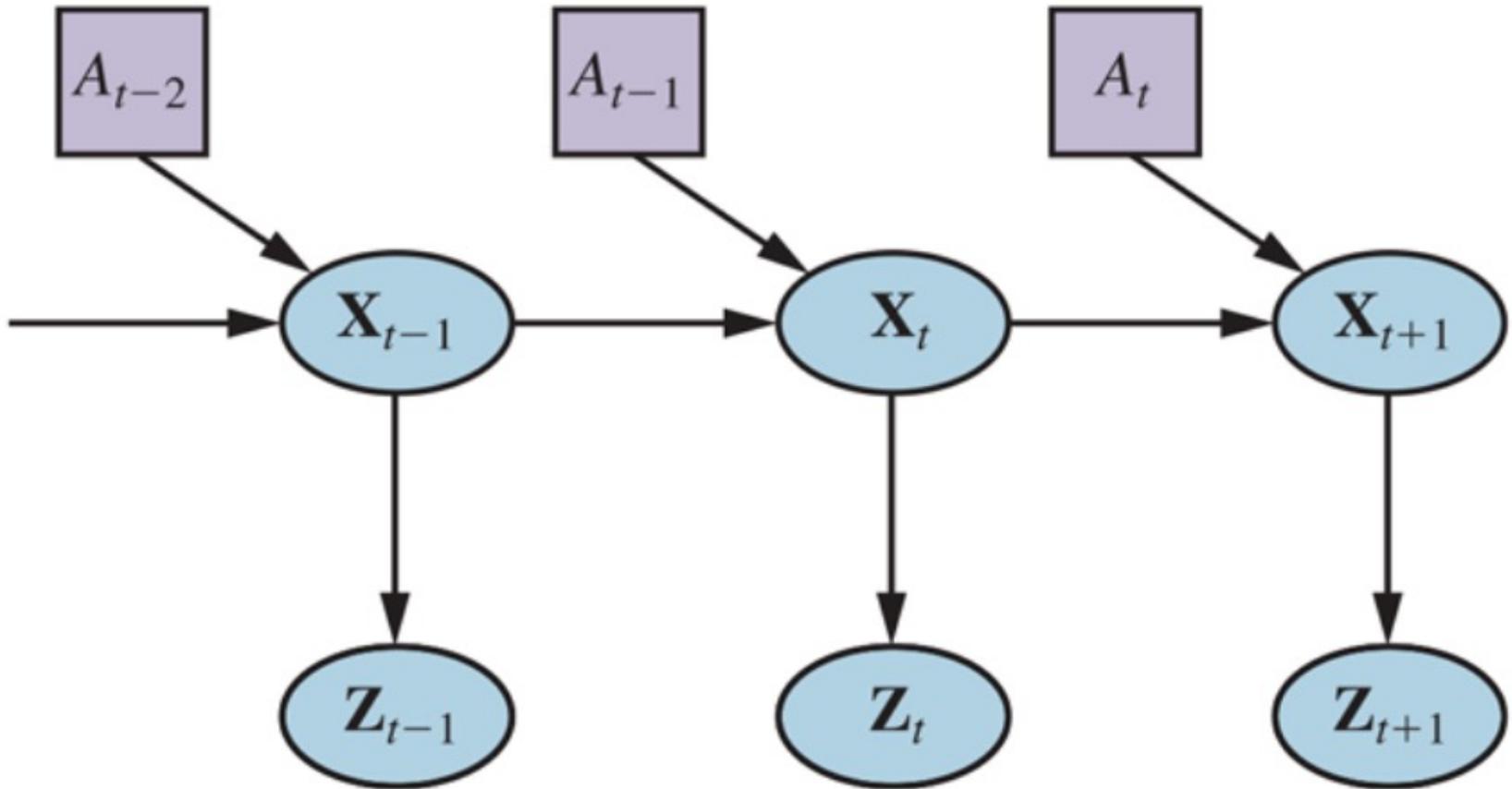
- We typically separate **perception (estimation)** from **action (motion generation)**.
- **Perception** in robotics involves **computer vision** to recognize the surroundings through cameras, but also localization and mapping.

# Robotic Perception

- **Robotic perception** concerns itself with estimating decision-relevant quantities from sensor data.
  - To do so, we need an internal representation and a method for updating this internal representation over time.

# Robot Perception

can be viewed as temporal inference  
from sequences of actions and measurements



**Dynamic Decision network**

# Probabilistic Filtering Algorithms

- **Probabilistic filtering algorithms** such as particle filters and Kalman filters are useful for robot perception.
  - These techniques maintain the belief state, a posterior distribution over state variables.

# Configuration Spaces

- For generating motion, we use **configuration spaces**, where a point specifies everything we need to know to locate every **body point** on the robot.
  - For instance, for a robot arm with two joints, a configuration consists of the two joint angles.

# Motion Generation

- We typically decouple the motion generation problem into
  - **motion planning**, concerned with producing a plan, and
  - **trajectory tracking control**, concerned with producing a policy for control inputs (actuator commands) that results in executing the plan.

# Motion Planning

- Motion planning can be solved via **graph search**
  - using **cell decomposition**
  - using **randomized motion planning** algorithms, which sample milestones in the continuous configuration space
  - using **trajectory optimization**, which can iteratively push a straight-line path out of collision by leveraging a signed distance field.

# Planning and Control

- **Optimal control** unites motion planning and trajectory tracking by computing an optimal trajectory directly over control inputs.

# Planning Uncertain Movements

- **Planning under uncertainty** unites perception and action by
  - **online replanning** (such as model predictive control) and
  - **information gathering** actions that aid perception.

# Reinforcement learning in robotics

- **Reinforcement learning** is applied in robotics, with techniques striving to reduce the required number of interactions with the real world.
- Such techniques tend to **exploit models**, be it estimating models and using them to plan, or training policies that are robust with respect to different possible model parameters.

# Humans and Robots

- Interaction with humans requires the ability to **coordinate** the robot's actions with theirs, which can be formulated as a game.
- We usually decompose the solution into **prediction**, in which we use the person's ongoing actions to estimate what they will do in the future, and action, in which we use the predictions to compute the optimal motion for the robot.

# Humans and Robots

- Helping humans also requires the ability to **learn** or **infer** what they want.
- Robots can approach this by **learning the desired cost function** they should optimize from human input, such as demonstrations, corrections, or **instruction in natural language**.
- Alternatively, robots can **imitate** human behavior, and use **reinforcement learning** to help tackle the challenge of generalization to new states.

# Papers with Code

## State-of-the-Art (SOTA)



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### Computer Vision



**Semantic Segmentation**

33 leaderboards  
667 papers with code



**Image Classification**

52 leaderboards  
564 papers with code



**Object Detection**

54 leaderboards  
467 papers with code



**Image Generation**

51 leaderboards  
231 papers with code



**Pose Estimation**

40 leaderboards  
231 papers with code

[See all 707 tasks](#)

### Natural Language Processing



**Machine Translation**



**Language Modelling**



**Question Answering**



**Sentiment Analysis**

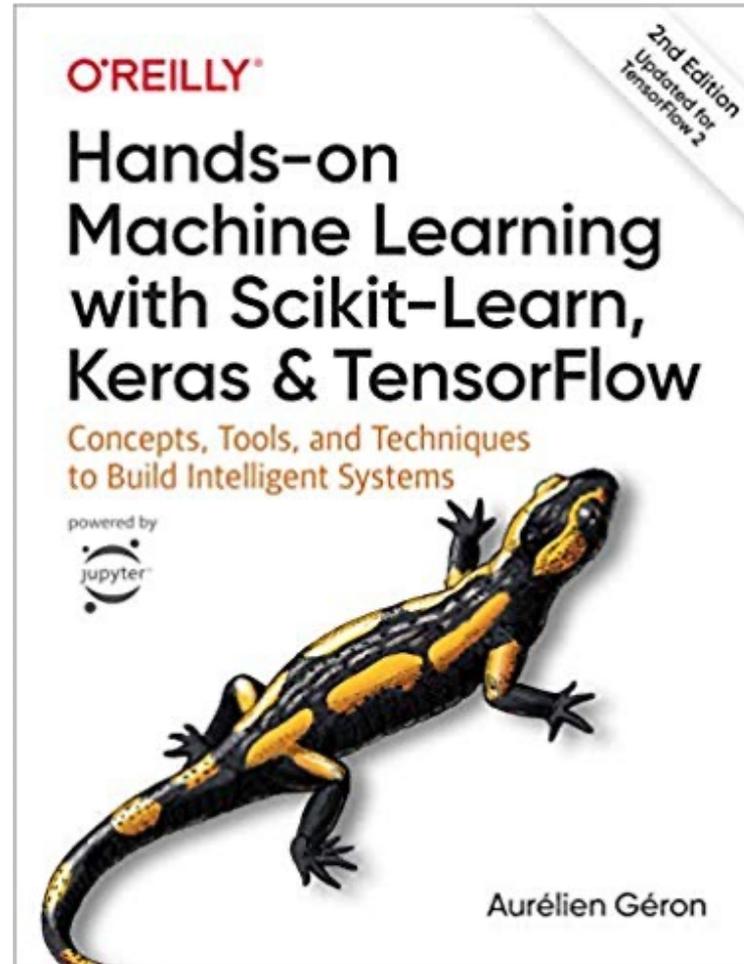


**Text Generation**

<https://paperswithcode.com/sota>

Aurélien Géron (2019),

**Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow:  
Concepts, Tools, and Techniques to Build Intelligent Systems, 2nd Edition**  
O'Reilly Media, 2019

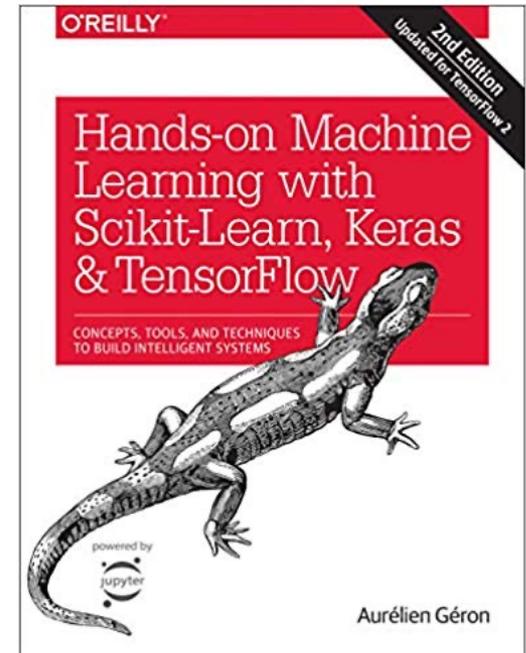


<https://github.com/ageron/handson-ml2>

# Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow

## Notebooks

- [1. The Machine Learning landscape](#)
- [2. End-to-end Machine Learning project](#)
- [3. Classification](#)
- [4. Training Models](#)
- [5. Support Vector Machines](#)
- [6. Decision Trees](#)
- [7. Ensemble Learning and Random Forests](#)
- [8. Dimensionality Reduction](#)
- [9. Unsupervised Learning Techniques](#)
- [10. Artificial Neural Nets with Keras](#)
- [11. Training Deep Neural Networks](#)
- [12. Custom Models and Training with TensorFlow](#)
- [13. Loading and Preprocessing Data](#)
- [14. Deep Computer Vision Using Convolutional Neural Networks](#)
- [15. Processing Sequences Using RNNs and CNNs](#)
- [16. Natural Language Processing with RNNs and Attention](#)
- [17. Representation Learning Using Autoencoders](#)
- [18. Reinforcement Learning](#)
- [19. Training and Deploying TensorFlow Models at Scale](#)



# Summary

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- Robotic Perception
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# References

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- Aurélien Géron (2019), Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, 2nd Edition, O'Reilly Media.
- Min-Yuh Day (2021), Python 101, <https://tinyurl.com/aintpupython101>