Artificial Intelligence

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Self-introduction

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- Affiliation: National Institute of Informatics (NII)
  - Job: Assistant Professor
  - Concurrent post: The Graduate University for Advanced Studies, SOKENDAI
- Research interests
  - Programming language (PL)
  - Software verification (SV)
  - Connecting machine learning to PL and SV
  - Detail: https://researchmap.jp/t-sekiym/

Notice

All questions are welcome anytime

- Don’t hesitate asking and sharing your questions

This course is about

Artificial Intelligence

- Quoted from the syllabus:
  - “Artificial intelligence is a general term that includes ***all technologies to make machine intelligent***, such as search, logic, optimization, etc.”
  - “This course focuses on ***machine learning***, which is a field of computer science to ***learn statistical behavior from sample data***. This course overviews basic techniques of machine learning.”

Outline

- Objects
  - Understanding concepts of machine learning
  - Learning and being able to implement major machine learning algorithms
- Plan
  - Lectures: 10 / 15 weeks
  - Programming: 4 / 15 weeks
  - Exam: 1 / 15 weeks

Plan

Week 1: Overview of artificial intelligence and machine learning

Week 2-3: Supervised learning (I)

- Regression and K-nearest neighbor

Week 4: Programming (I)

Week 5-6: Supervised learning (II)

- Support vector machine and decision tree

Week 7: Programming (II)

Plan

Week 8-9: Supervised learning (III)

- Neural networks

Week 10: Programming (III)

Week 11: Unsupervised learning

- Clustering

Week 12-13: Reinforcement learning

- Temporal-Difference, Q-learning, and SARSA

Week 14: Programming (IV)

Plan

Week 15: Exam

Evaluation

- Exam (50%)
- Programming assignments (40%)
- Attendance (10%)

The rest of this lecture

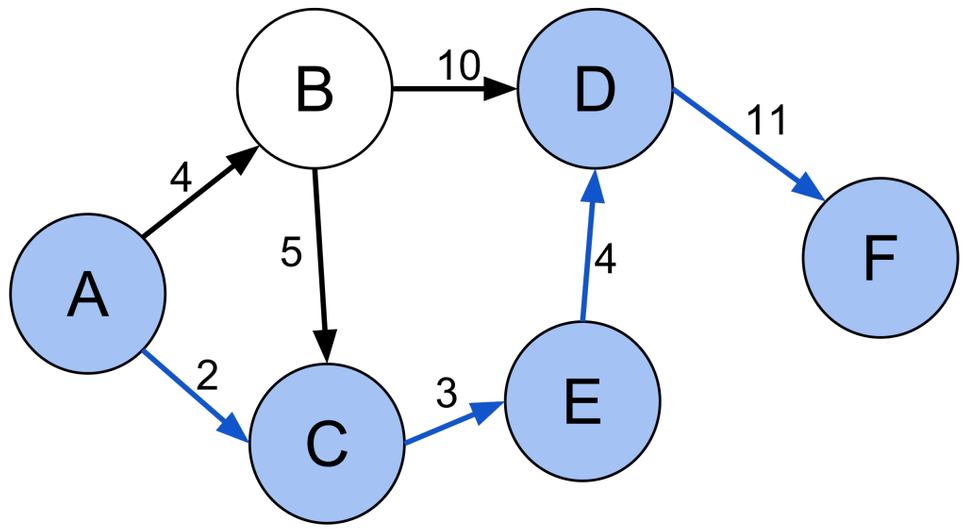
1. **Artificial intelligence**
2. Machine learning
3. Programming environment

Artificial Intelligence

- A general term for technologies to make machine intelligent
- Technologies include:
  - Search
  - Automated reasoning
  - Numerical optimization
  - Machine learning

Search

- Retrieval of some information from data
- Application example: **Route search**
  - Goal: finding a path between two nodes s.t. the sum of weights appearing in the path is minimized
  - Algorithms: A*, Dijkstra



https://en.wikipedia.org/wiki/Shortest_path_problem

Automated reasoning

- (Semi)-automatic reasoning with logical rules
- Application example: **Sudoku**
  - Goal: fill numbers so that each row, each column, and each 3x3 block contain all of the digits from 0 to 9

5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6					2	8	
			4	1	9			5
				8			7	9

https://en.wikipedia.org/wiki/Sudoku

- Other applications: automated theorem proving, design circuit, software verification, etc.

Numerical optimization

- Finding a best numerical answer satisfying some constraints
- Problem example
  - Goal: Minimizing the payment cost to buy 10 fruits (🍎 or 🍌)
  - Formulation
    - Finding x and y s.t. $ax + by$ is minimized, subject to $x + y = 10$
      - x and y: the numbers of 🍎 and 🍌
      - a and b: the prices of 🍎 and 🍌

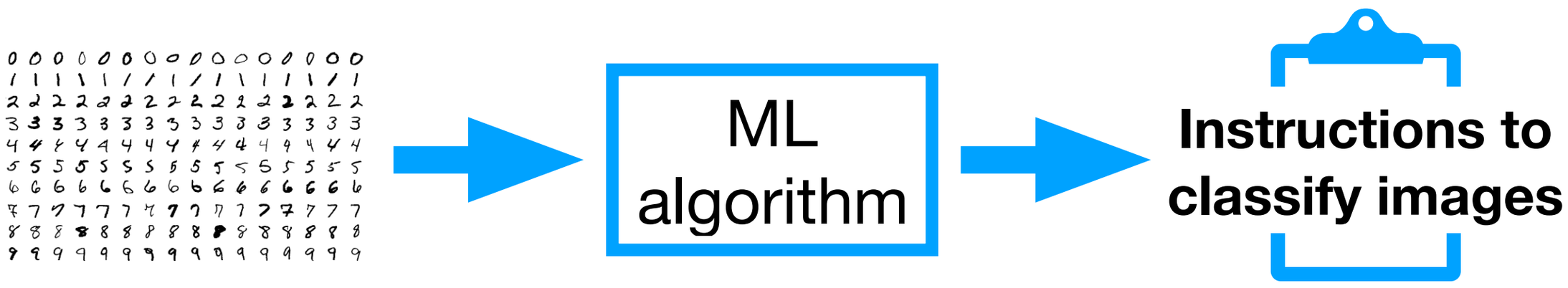
Machine learning (ML)

- Learning statistical behavior from sample data
- Application example: **image classification**
  - Problem: classifying hand-written digits

https://en.wikipedia.org/wiki/MNIST_database

Machine learning (ML)

- Learning statistical behavior from sample data
- Application example: **image classification**
  - ML algorithms yield a classifier by learning what digits the given images stand for



Machine learning (ML)

- Statistical learning of mathematical models from sample data

Concepts in math (for example, functions)

- Application example: **image classification**
  - ML algorithms yield a classifier by learning what digits the images represent

Machine learning (ML)

ML is not an all-purpose technology

- It is important to understand the advantages and disadvantages in its use

Machine learning (ML)

Strong point

- Applicable to solve problems that don’t have clear criteria of whether answers are correct
  - Example: Image classification
    - “Correctness" depends on the intuition of human beings
    - Hard to give rules to distinguish images

Machine learning (ML)

Weak point

- Almost impossible to yield instructions that work perfectly even for simple problems
- A large quantity of data is necessary for learning
- Difficult to reason about success / failure of learning
- May not be optimal in terms of time and space complexity

Machine learning (ML)

Summary

- Good to keep ML in your toolbox
- ML is just one of tools to solve problems
- Important to understand
  what problems ML ***is*** and ***is not*** suitable for

Outline

1. Artificial intelligence
2. **Machine learning**
3. Programming environment

Types of ML algorithms

- Supervised learning
- Unsupervised learning
- Reinforcement learning

Supervised learning

- Building a ***function*** from ***input-output samples***
- Example: image classification
  - Inputs: images of a hand-written digit
  - Outputs: the digits
  - Built function: a classifier
- Problems solved by supervised learning
  - Classification
  - Regression

Supervised learning

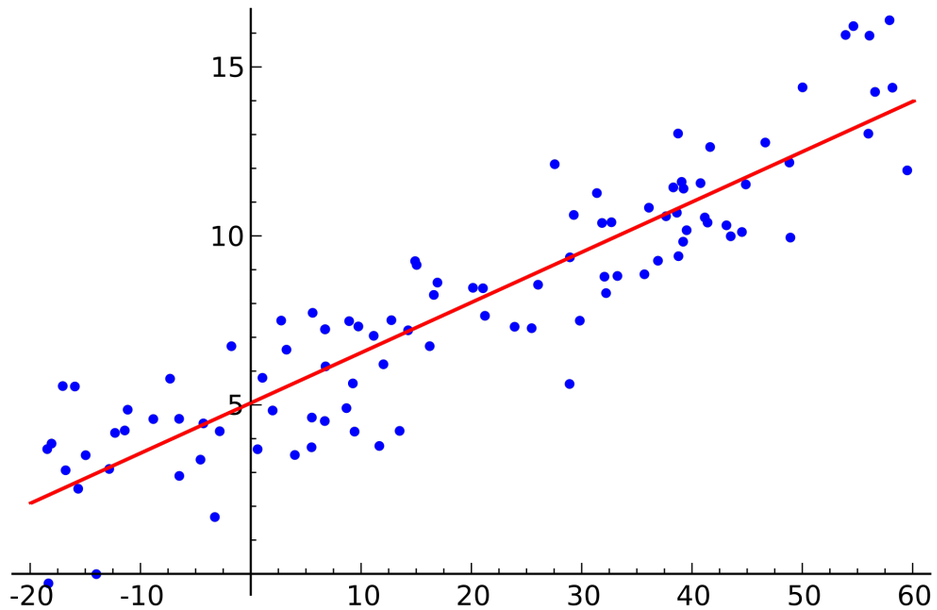
Classification

- Outputs are discrete
- Examples
  - Image classification
    - Outputs: finite categories of images
    - In hand-written digits, they are from 0 to 9
  - Whether forecast
    - Outputs: sunny, cloudy, and rainy

Supervised learning

Regression

- Outputs are continuous
  - Close if inputs are close



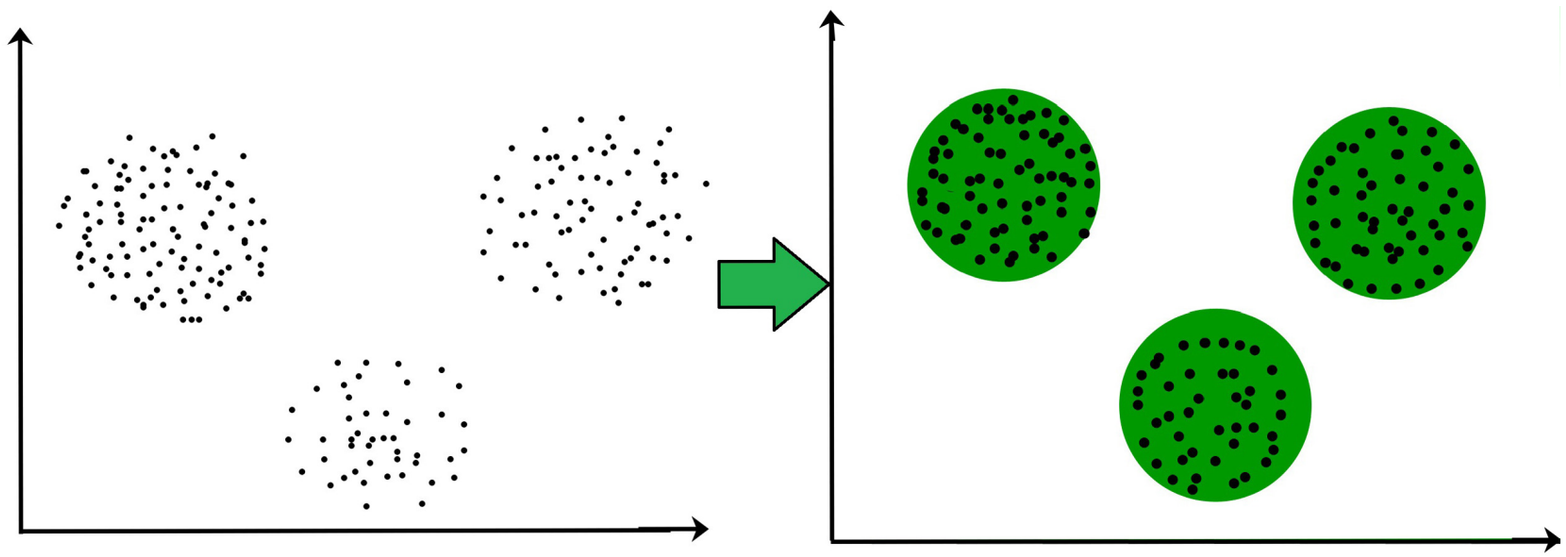
Continuous function

https://en.wikipedia.org/wiki/Regression_analysis

- Example
  - Apple pricing prediction
    - Inputs: weights of apples
    - Outputs: their prices

Unsupervised learning

- Finding a structure of sample data
- Example: cluster analysis
  - Grouping sample data



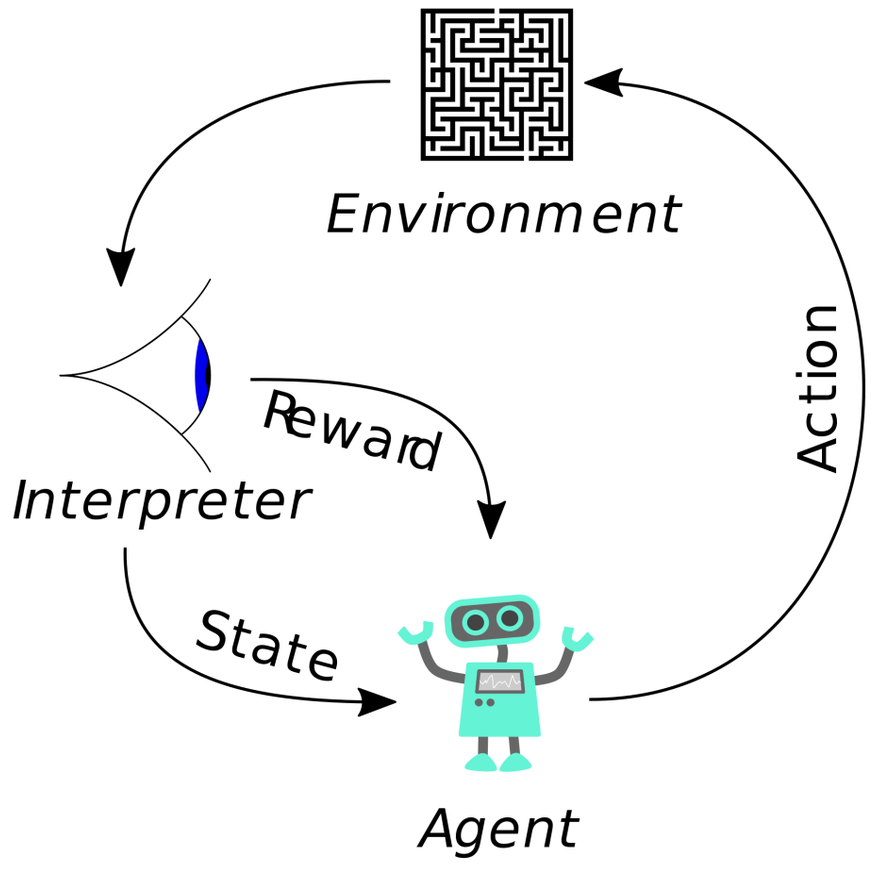
https://www.geeksforgeeks.org/clustering-in-machine-learning/

Reinforcement learning

- Learning a strategy to interact with an environment
- Example: two-player game (like chess, go, shogi)
  - Goal: learning a strategy to win the game
  - Environment: an opponent player

Reinforcement learning

- General framework



https://en.wikipedia.org/wiki/Reinforcement_learning#Algorithms_for_control_learning

Outline

1. Artificial intelligence
2. Machine learning
3. **Programming environment**

Programming environment

- Programming language: **Python**
  - Equipped with many libraries/tools suitable for programming with ML

Useful tools / libraries

- Tools
  - Jupyter notebook
    - Interactive programming in web browser
- Libraries
  - numpy
    - Data structures useful for ML
  - scikit-learn
    - ML algorithms
  - pandas / matplot
    - Data visualization

Programming environment

- Recommendation: **Anaconda**
  - Software package that contains all in one
    - Python interpreter
    - Useful tools / libraries for ML programming
  - Support for Windows / Mac OSX / Linux
  - Download URL https://www.anaconda.com/distribution/
- Others
  - pyenv, pipenv, virtualenv, etc.

References

- Book "Introduction to Machine learning with Python" by Müller & Guido, 2016 (O'Reilly Media)

- Online course “Machine learning" @ Coursera https://www.coursera.org/learn/machine-learning

- Book "Think Python 2nd Edition”
  by Downey, 2015 (O'Reilly Media)