Introduction
Textbook for this lecture

人工知能:
AIの基礎から知的探索へ

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Web pages

• Web page of Qiangfu ZHAO
  – http://www.u-aizu.ac.jp/~qf-zhao/

• Web page of this lecture
  – http://web-ext.u-aizu.ac.jp/~qf-zhao/TEACHING/AI/AI.html

• Web page of homework answers
  – You may also find corrections for the textbook in this web page.
Topics of this lecture

• A brief review of AI history
• What is artificial intelligence?
• Related research fields
• Scope of this course
Early work (Around 1900)

- Representatives
  - George Boole
  - Alfred North Whitehead
  - Bertrand A. W. Russell

- Main contributions
  - Boolean algebra
  - Principia Mathematica

PM was an attempt to describe a set of axioms and inference rules in symbolic logic from which all mathematical truths could in principle be proven.

However, in 1931, Gödel's incompleteness theorem proved definitively that PM could never achieve this lofty goal.

(from Wikipedia)
Early work (1930~)

- Representatives
  - Alan Turing
  - Claude Shannon
  - John von Neumann

- Main contributions
  - Theory of computation, Turing Machine
  - Turing test (to distinguish machine from human)
  - Information theory, application of Boolean algebra
  - von Neumann model of computing machines

I am ZHAO. You can ask any questions, and see if I am the real person.
The first wave (1950~)

- Representatives
  - John McCarthy
  - Marvin Lee Minsky
  - Herbert Alexander Simon
  - Allen Newell
  - Edward Albert Feigenbaum

- Main contributions
  - LISP
  - Semantic network and frame
  - General problem solver and Expert systems

The term AI was proposed by these persons in the well-known Dartmouth Artificial Intelligence conference (1956)
The second wave (1980~)

- Representatives
  - David Rumelhart
  - Lotfi Zdeh
  - John Holland
  - Lawrence Forgel
  - Ingo Rechenber
  - John Koza

- Main contributions
  - Learning of MLP
  - Fuzzy logic
  - Genetic algorithms
  - Evolutionary programming
  - Evolution strategy
  - Genetic programming

Soft computing
Human like computing and natural computing
The third wave (2000～)

- Representative technologies
  - Internet
    - Tim Berners-Lee, WWW inventor, 1989
  - Internet of things
    - Kevin Ashton, MIT Auto-ID Center, 1999
  - Cloud computing
    - Main frame (1950s), virtual machine (1970s), cloud (1990s)
  - Big data
    - John R. Masey, SGI, 1998
  - Deep learning
    - Geoffrey Hinton, UoT, 2006
A brief summary

• Early work
  – Theoretic foundations
• First wave:
  – Reasoning with given knowledge
• Second wave
  – Learning-based knowledge acquisition
• Third wave
  – Learn in the cyber-space

The same as learning inside the brain. Each brain has a “natural intelligence” that can learn using the sensor data captured by different parts of the body.
Current status of AI

- In March 2016, Alpha-Go of DeepMind defeated Lee Sedol, who was the strongest human GO player at that time.
- This is a big news that may have profound meaning in the human history.
Do you think AI is good or evil?

Super-intelligence should be a tool for unifying the human beings, support them, and lives together with them!

https://www.ideapod.com/idea/When-Super-AI-Intelligence-Arrives-Will-Religion-Be-Eradicated/55cc10d8c976415e508bcc2d

After all, what is intelligence?
(from Wikipedia)

• Intelligence is an umbrella term used to describe a property of the mind that encompasses many related abilities, such as the capacities
  – to reason,
  – to plan,
  – to solve problems,
  – to think abstractly,
  – to comprehend ideas,
  – to use language, and
  – to learn.
Intelligence can be defined as the ability for solving problems

• Problem solving is to find the “best” solution in the problem space.
• Reasoning is to interpret or justify solutions or sub-solutions.
• Planning is to find ways for solving the problem.
• Thinking abstractly is to simulate the problem solving process inside the system (brain).
• Idea/language comprehension is a way (or means) for data/problem/knowledge representation;
• Learning is the process to find better ways for solving a problem (or a class of problems).
What is AI?

- Textbooks often define artificial intelligence as “the study and design of computing systems that perceives its environment and takes actions like human beings”.
- The term was introduced by John McCarthy in 1956 in the well-known Dartmouth Conference.
- In my study, an AI is defined as a system that possesses at least one (not necessarily all) of the abilities mentioned in the previous page.

As a research area, AI studies theories and technologies for obtaining systems that are partially or fully intelligent.
A rough classification of AI
(from “Artificial Intelligence: A Modern Approach”)

<table>
<thead>
<tr>
<th>Systems that think like humans</th>
<th>Systems that think rationally</th>
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<tr>
<td><img src="image1" alt="Image of person thinking" /></td>
<td><img src="image2" alt="Image of Sir Isaac Newton" /></td>
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</table>

<table>
<thead>
<tr>
<th>Systems that act like humans</th>
<th>Systems that act rationally</th>
</tr>
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<tr>
<td><img src="image3" alt="Image of robot" /></td>
<td><img src="image4" alt="Image of Noah's Ark" /></td>
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Related research fields

- Search and optimization
- Knowledge representation
- Reasoning and automatic proving
- Learning and understanding
- Pattern classification / recognition
- Planning
- Problem solving
Search (探索)

- Brute-force search
  - Depth-first search
  - Breadth-first search

- Heuristic Search
  - Hill climbing search
  - Best-first search
  - A* Algorithm

- Intelligent search
  - Genetic algorithms
  - Meta-heuristics

- 機械的探索
  - 縦型（深さ優先）探索
  - 横型（幅優先）探索

- 発見的探索
  - 山登り法
  - 最良優先探索
  - A* アルゴリズム

- 知的探索
  - 遺伝的アルゴリズム
  - メターヒューリスティクス
Three MAPs for knowledge acquisition

- What is the input?
  - Map from real world to the mind model
- What is the output?
  - Map from the mind model to the real world
- What is the relation between the input and the output?
  - Abstraction of the real world

![Diagram showing the process of knowledge acquisition with MAPs](image-url)
Representation methods

• Representation of the problem
  – State space representation
  – Vector representation

• Representation of knowledge
  – Production (decision) rules
  – Semantic network and ontology
  – Predicate logic
  – Fuzzy logic
  – Neural network (for tacit knowledge)
Learning models and algorithms

- Neural network learning
  - Including MLP, SVM, deep learning, etc.
- Evolutionary learning
  - GA or meta-heuristics in general
- Reinforcement learning
- Artificial immune system
- Fuzzy logic
- Decision tree
- Hybrid system
Scope of this course

• Search
  – Problem formulation and basic search algorithms
• Expert system-based reasoning
  – Production system, semantic network, and frame
• Logic based-reasoning
  – Propositional logic and predicate logic
• Soft computing based reasoning
  – Fuzzy logic and multilayer neural network
Scope of this course

- Machine learning
  - Pattern recognition
  - Self-organization
  - Neural networks
  - Decision trees
- Intelligent search (if we have time)
  - Genetic algorithm
  - Ant colony optimization
Purpose of this course

- Learn how to use the basic search methods;
- Understand the basic methods for problem formulation and knowledge representation;
- Understand the basic idea of automatic reasoning;
- Know some basic concepts related to pattern recognition and machine learning.

Make a baby AI system after learning this course
Homework for lecture 1

• Write a report using about 500 words in English or 500 characters in Japanese to describe one of the key persons who made a great contribution to the AI world.
• You may choose one from those introduced in this lecture, or find someone in the internet.
• When you refer to any information taken from a paper, a report, a web-site, or any published material, please add a reference and cite it in the correct places in your report.
• Add your name, student ID, and date below the title of your report, create a pdf-file, and put the file under the specified directory.
How to submit the homework

• Make a sub-directory “AI” under your home directory.
• Make a sub-directory “ex_XX” under AI, where XX is the exercise number.
• Change the permissions of all newly created directories (and files under them) to 705 to allow the TA/SAs to check your homework.
• For example, for the homework of the “this” class, do as follows:
  – Under the directory AI, make a sub-directory ex_01.
  – Under the directory ex_01, edit your report answer.txt using any available editor, convert the file to answer.pdf, and change its permission to 705.
• For future homework, please do in a similar way.

Submit your answer before the exercise class of next week!
Quizzes for today
(Answer in Japanese or English, and submit after the lecture class)

• What is AI as a research area?

• What is Search?

• What are the three MAPs for knowledge acquisition?

• Write one learning model you have heard from the TV or other publications.