Artificial intelligence

Human vs. machine

- Can machines fly?
- Can machines swim?
- Four possible goals in AI
  - Thinking rationally: the laws of thought approach
  - Thinking humanly: the cognitive modeling approach
  - Acting humanly: the Turing test approach
  - Acting rationally: the intelligent agent approach

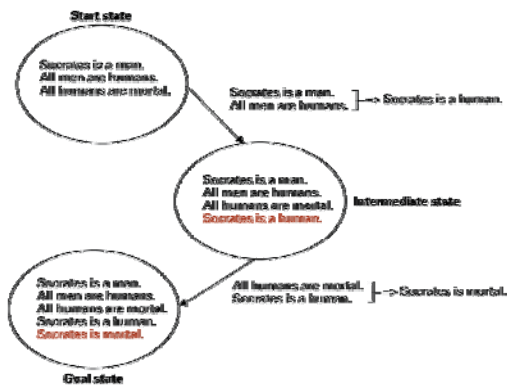| Machines that think rationally. | Machines that act like humans |
| Machines that think like humans. | Machines that act rationally |

- From "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig

Thinking rationally:
The laws of thought approach

- Rational thinking is based on logic inferences.

Logical programming: Prolog

- PROgramming in LOGic: A logic programming language for general logic problems solving.
  - Use in AI, automatically reasoning

```
1: witch(X) <= burns(X) and female(X).
2: burns(X) <= wooden(X).
3: wooden(X) <= floats(X).
4: floats(X) <= sameweight(duck, X).
5:
6: female(girl).
7: sameweight(duck,girl).
8:
9: ? witch(girl).
```
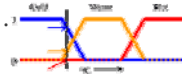Rules
Facts
Query

Resolution

--- running ---
witch(girl) yes
--- finished ---

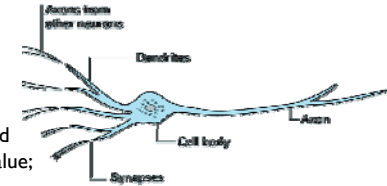## Logic and language

- Proposition logic: (命題邏輯) (=Boolean algebra)
  - A statement is true or false.
- First order logic (一階謂詞邏輯)
  - Statements with "all" or "existing".
  - FOL is undecidable. (similar idea to the halting problem.)
- Temporal logic (時間邏輯):
  - Statements with time. (It is true or false at different time.)
- Probability theory (機率):
  - Statements can have degree of belief from 0 to 1.
- Fuzzy logic (模糊邏輯):
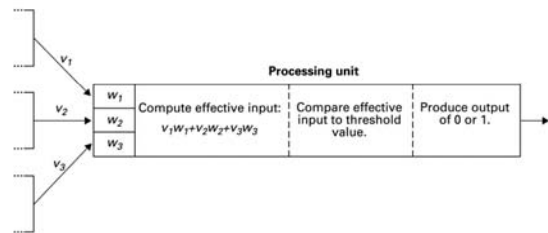 - Statements can have degree of belief, and allow ambiguity.

Thinking humanly: The cognitive modeling approach

- The interdisciplinary field of cognitive science brings together computer models from AI and experimental techniques from psychology to try to construct precise and testable theories of the workings of the human mind.
- Ex: Neuron network
  - Artificial neuron
    - Each input is multiplied by a weighting factor.
    - Output is 1 if sum of weighted inputs exceeds a threshold value; 0 otherwise.
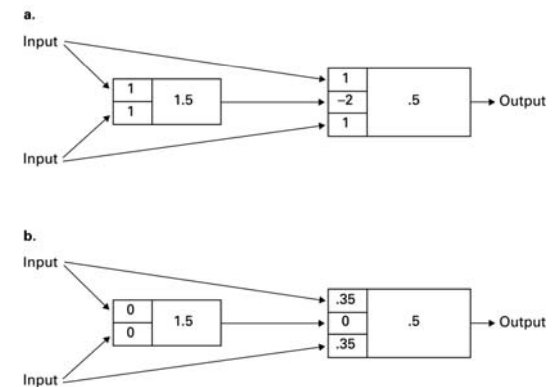 - Network is programmed by adjusting weights using feedback from examples

The activities within a processing unit
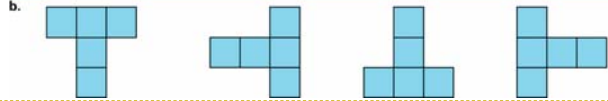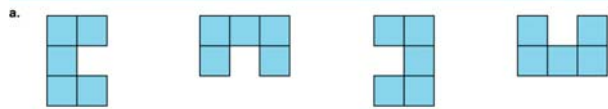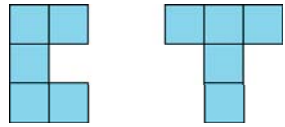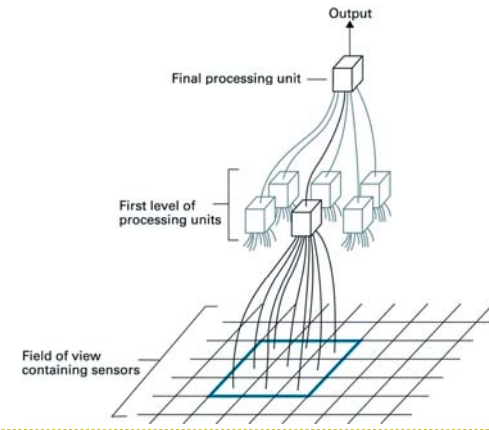

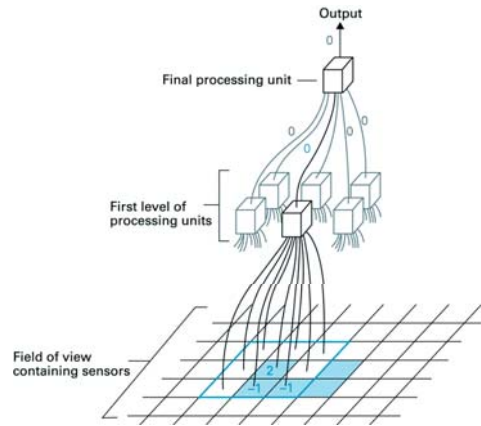Representation of a processing unit

A neural network with two programs
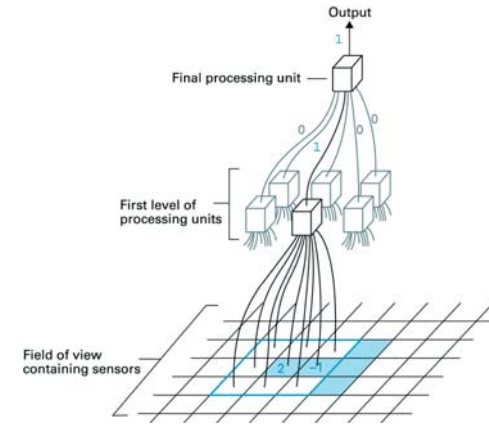
Ex: uppercase C and uppercase T

The character recognition system

The letter C in the field of view

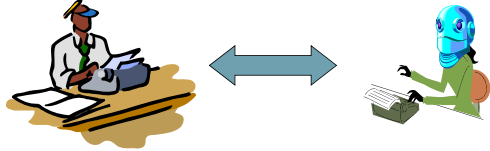## The letter T in the field of view

Acting humanly: The Turing test approach

▶ The Turing test
  ▶ Proposed by Alan Turing in 1950
  ▶ Benchmark for progress in artificial intelligence
  ▶ Test setup: Human interrogator communicates with test sbject by typewriter

  ▶ Test: Can the human interrogator distinguish whether the test subject is human or machine?
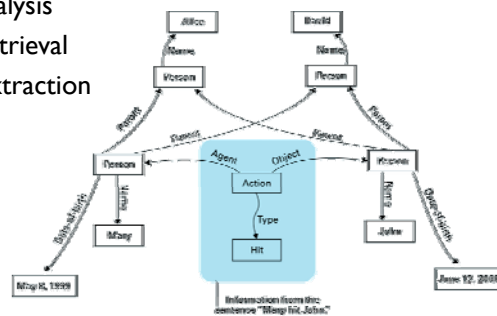
▶

Different disciplines

• Natural language processing: to enable machine to communicate in human languages
• Knowledge representation: to store information provided before or during the interrogation
• Automated reasoning: to use the stored information to answer questions and to draw new conclusions
• Machine learning: to adapt to new circumstances and to detect and extrapolate patterns.
• Computer vision: to perceive objects.
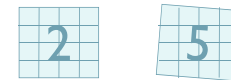• Robotics: to do action in the physical world.

▶

Natural language processing

▶ Syntactic analysis
▶ Semantic analysis
▶ Contextual analysis
▶ Information retrieval
▶ Information extraction

Semantic understanding using
Semantic net: a Knowledge representation.

▶

Computer vision

▶ To understand the contents of images
  ▶ Possible images are finite ⇒ compare the different sections to prerecorded templates pixel by pixel
  ▶ Optical readers apply the similar method for image recognition (hand-writing)
  ▶ A certain degree of uniformity (size, orientation, non-overlapping) is required

  ▶ The alternative is to first extract the geometric features(1: a single vertical line) and make comparison in terms of these features

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Two-step approach

- Image processing: identify the characteristics of the image
  - Edge enhancement to clarify the boundary
  - Region (with common properties: color, …) finding for identifying objects
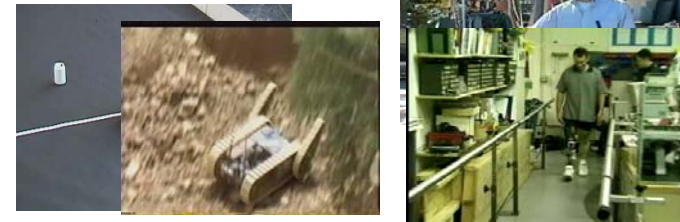 - Smoothing (removing flaws/noises in image)

- Analysis: identify the meaning of these characteristics
  - First, make assumption of what the image might be is made. Then, associate the image components with the objects conjectured to exist

Robotics

- Began as a field within mechanical and electrical engineering
- Today encompasses a much wider range of activities
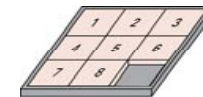 - Robocup competition
  - Evolutionary robotics

Acting rationally: The intelligent agent approach

- Classification of agents based on intelligent behaviors
  - Simple reflex agents
    - If temperature>27, turn on the air-conditioner.
  - Model-based reflex agents
    - Turn on the air-conditioner at 9:00AM. (No thermometer)
  - Goal-based agents
    - Keep people in the room comfortable.
  - Utility-based agents
    - Measure comfortable with a comfortable utility function.
    - (not just comfortable or uncomfortable.)
  - Learning agents
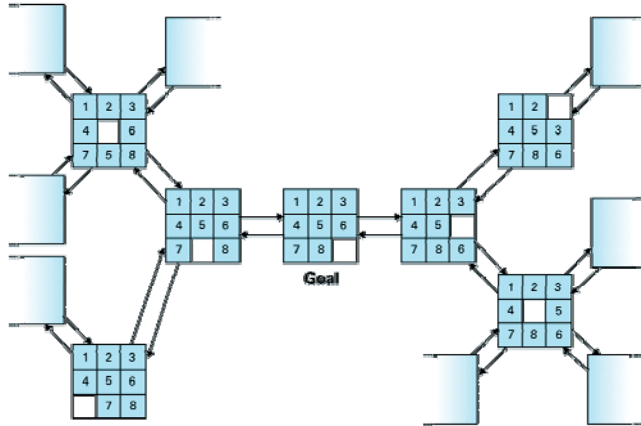   - Learn the definition of "comfortable" with some feedbacks.

Problem solving agent

- Ex: the eight-puzzle problem : to move the tiles from an initial state to the goal state
  - A state is one of all possible situations
    - The beginning (or initial) state
    - The desired (or goal) state(s) is called the goal state
  - There are 181,440 states for the eight-puzzle problem
- State graph = states, rules, and preconditions
  - Rule: operation to be performed to move from one state to another under some preconditions
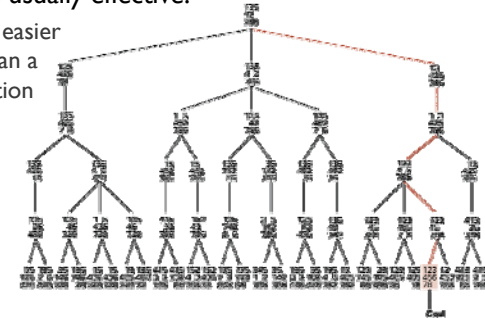 - Precondition: the conditions must be met to qualify the applicable rule

The state graph of the eight-puzzle

Search tree

- Complete search on state graph is inefficient
- Heuristics: algorithms whose correctness cannot be proven, but are usually effective.
  - Must be much easier to compute than a complete solution
  - Must provide a reasonable estimate of proximity to a goal

Example of heuristic strategies

- Use the number of moves to final position