Artificial Intelligence

Introduction

Ko, Youngjoong

http://nlp.skku.edu

Course Logistics

Please, Check out the other slide!

Ch 1. Artificial Intelligence

What is intelligence?

1.1 Definition of AI

1.2 AI techniques

1.3 Criteria for success

1.4 AI application areas

AI

https://youtu.be/nh1T8KeCBxY

What is intelligence?

Can a machine think?

- '*Thinking'* is not equal to '*Calculating.*'
- All current computers are not '*a thinking machine*' but '*a fast calculation machine*.'
- We hope that the current computer can evolve into a different type of computer with intelligence like human.

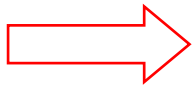
What is intelligence?

- the combination of many abilities such as memorization, learning, computing, creativity and so on.
- "the ability to understand and learn from experience OR the ability to adapt effectively to the environment, either by making a change in oneself or by changing the environment or finding a new one." from Webster's New World Dictionary

What is intelligence?

A problem to use intelligence

A	B	C
C	B	A



B	A	C
C	A	B

B	C	A
B	A	C

?	?	?
?	?	?

Rule: A → B, B → A, C → C

What is intelligence?

Symbol processing system

- The originality of intelligence is to create abstract symbols and to handle or process them effectively.
- Computer is a machine to process symbols (language characters or words) in a broad sense
  - Current computers have been focused on processing “numerical letters”
  - But intelligent computers can handle ‘string.’
  - It means they can manipulate the meaning of words.
  - It makes them to infer something new.

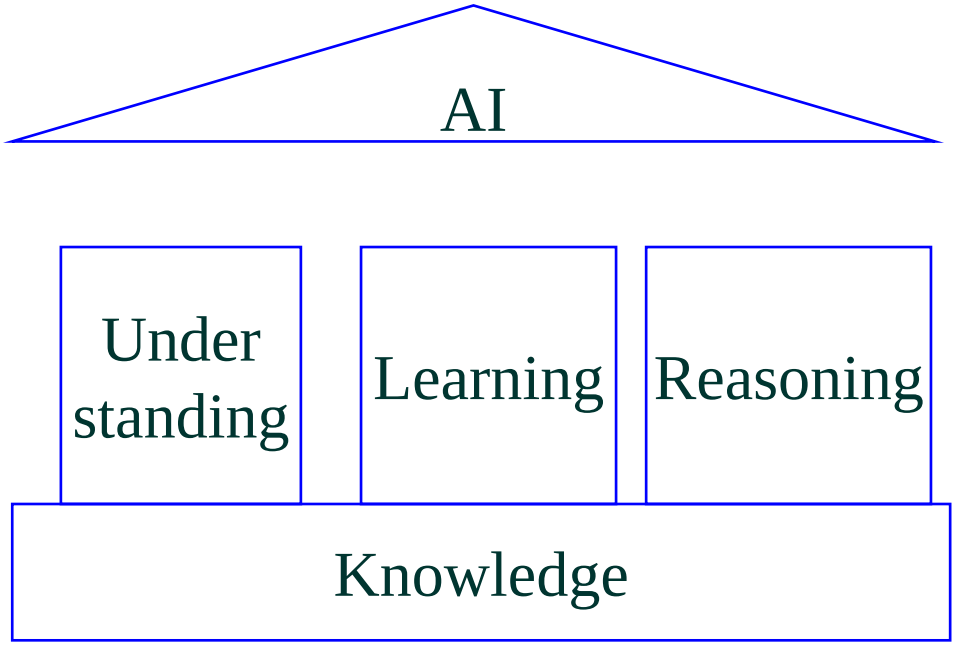
What is intelligence?

Artificial intelligence

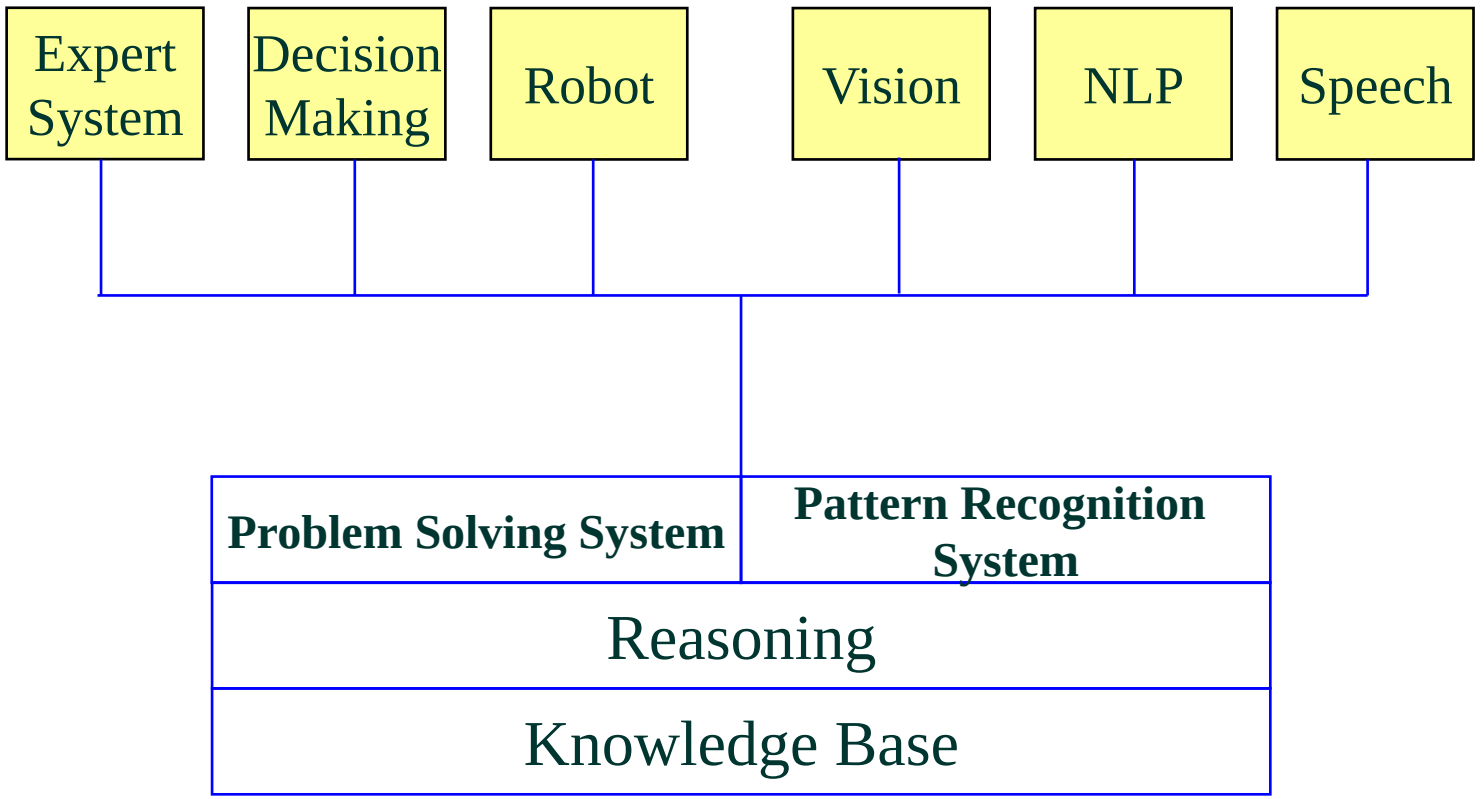
- Human intelligence
  - Understanding ability:
    - Problem recognition and understanding
    - AI) pattern recognition system: it serves as human's eyes and ears.
  - Knowledge acquisition ability by learning:
    - Learning and memorizing knowledge which is obtained from experience. (understanding ability is used to get experience.)
    - AI) Machine Learning such as Neural Networks
  - Inference ability using knowledge:
    - Solving and inferring problems using experience and knowledge
    - AI) reasoning system such as an expert system

What is intelligence?

Three Basic Abilities in AI



What is intelligence?



The definition of AI (1)

"AI is the study of how to make computers do things which, at the moment, people do better." (Rich)

"AI is a field of science and engineering concerned with the computational understanding of what is commonly called intelligent behavior, and with the creation of artifacts that exhibit such behavior." (Shapiro)

"AI is the study of ideas which enable computers to do things which make people seem intelligent." (Winston)

AI is the study of intelligence using the ideas and methods of computation." (Fahlman)

The definition of AI (2)

"A bridge between art and science" (McCorduck)

"Tesler's Theorem: AI is whatever hasn't been done yet." (Hofstadter)

"AI is the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit characteristics we associate with intelligent human behavior

- understanding language, reasoning, solving problems, and so on." (Barr)

AI may be defined as the branch of computer science that is concerned with automation of intelligent behavior. (Luger & Stubblefield)

The definition of AI (3)
AI as Science

Understand the working of the mind in mechanistic terms, just as medical science seeks to understand the working of the body in mechanistic terms.

Understand intelligent thought processes, including perception, motor control, communication using human languages, reasoning, planning, learning, and memory.

The definition of AI(4)
AI as Engineering

How can we make computer based systems more intelligent?

In practical terms, intelligence means

- 1. Ability to *automatically* perform tasks that currently require human operators
- 2. More *autonomy* in computer systems; less requirement for human intervention or monitoring.
- 3. *Flexibility* in dealing with variability in the environment in an appropriate manner.
- 4. Systems that are *easier* to use: able to understand what the user wants from limited instructions.
- 5. Systems that can improve their performance by learning from experience.

AI Methods

A method that uses heuristic search

A method that exploits knowledge

Two examples

- Tic-Tac-Toe
- Question-Answering

Tic-Tac-Toe(1)

1. Board Indexing Method

- Represent the board by a nine-element vector.
- Specify “Movetable” for each element.

Comments

- takes a lot of space to store the table
- do a lot of work to specify all entries in the movetable

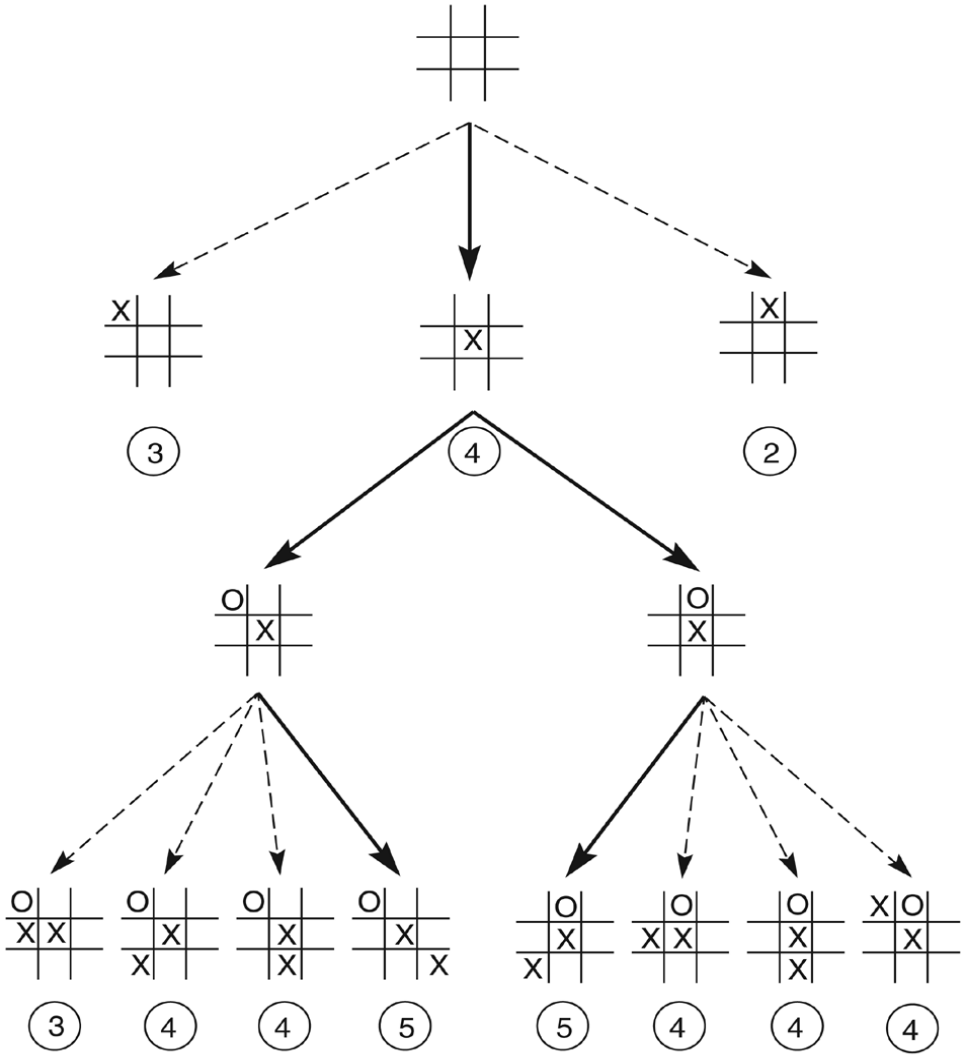
2. Algorithm Approach

- Use a nine-element vector representing board
- Specify turn by indicating which move of the game is about to be played.
- The algorithm has a built-in strategy for each move.

Comments

- Cannot generalize any program’s knowledge to a different domain

Tic-Tac-Toe(3)



Tic-Tac-Toe(2)

3. Heuristic Approach

- Use a number representing an estimate of how likely the board position is to lead to an ultimate win
- Use an algorithm called the Minimax procedure (attempts to maximize the likelihood of winning, while the opponent will try to minimize that likelihood)

- An example of AI technique
  - it uses the knowledge about game
    - evaluate the merit of each board position
    - consider only a subset of possible next moves that are reasonable.

Question Answering(1)

Mary went shopping for a new coat. She found a red one she really liked. When she got it home, she discovered that it went perfectly with her favorite dress.

Questions:

- Q1: What did Mary go shopping for?
- Q2: What did Mary find that she liked?
- Q3: Did Mary buy anything?

Question Answering(2)

1. Using Templates and Patterns

"Mary went shopping for a new coat."

Q1: Can be answered - "a new coat"

Q2: Unless the template set is very large, this question is not answerable.

Q3: No answer will be found.

Comments:

- The ability to answer the most direct questions is dependent on the exact form.

Question Answering(4)

2. Using Linguistic Knowledge

"She found a red one she really liked."

Convert the input text into a structured form representing the meaning of sentences.

Convert Questions into that form, and find answers by matching structured forms.

Q1: Can be answered - "a new coat."

Q2: Can be answered - " a red coat."

Q3: Can not be answered.

Comments:

- Less brittle than the first program with respect to exact forms.
- Some additional information is necessary to find an answer to question 3.

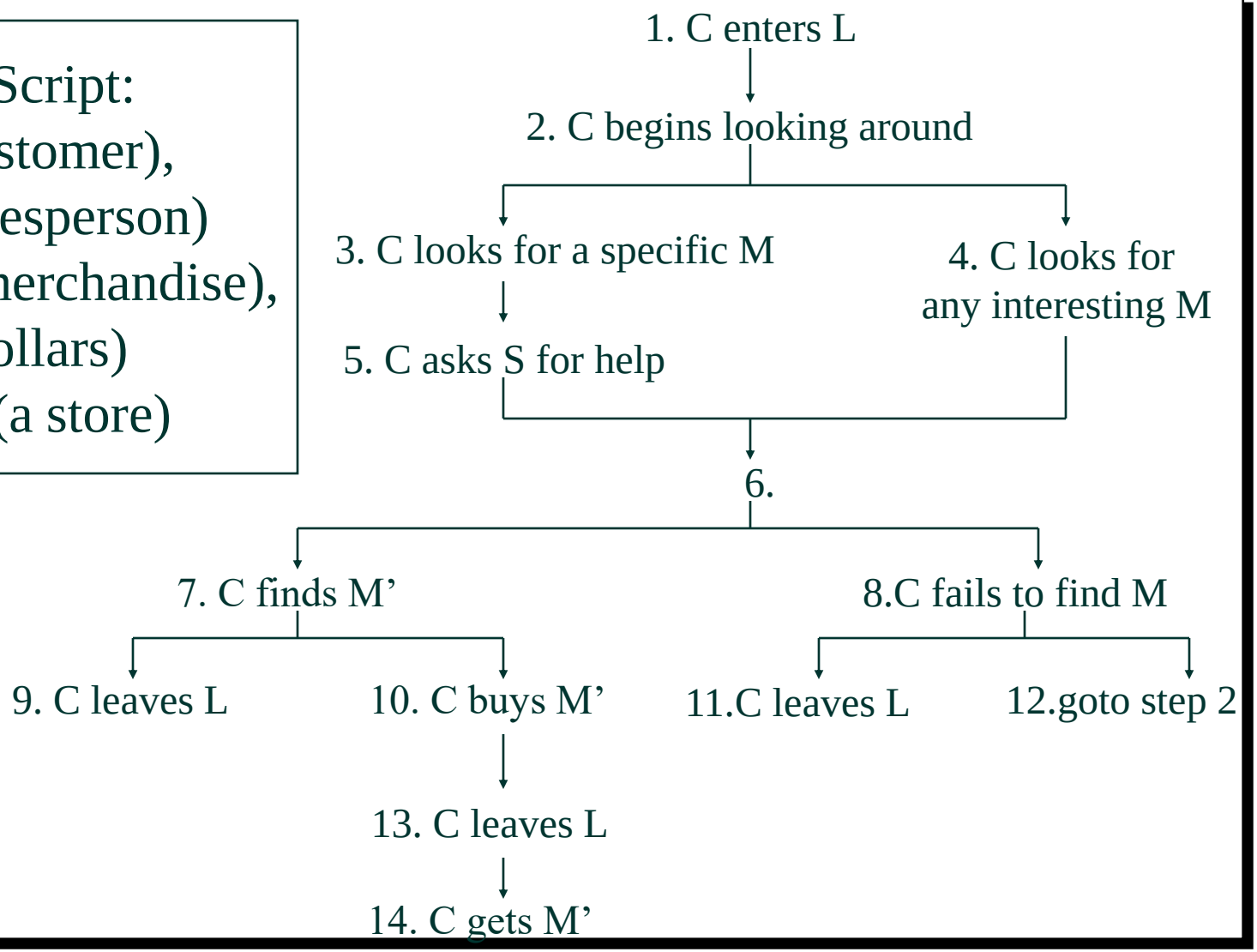
Question Answering(5)

3. Using Linguistic Knowledge and World Knowledge

   Convert input text into a structured form representing the meaning of sentences, and combine that form with other structured forms describing prior world knowledge about the objects and situations.

Question Answering(6)

Shopping Script:
roles:C(customer),
S(salesperson)
props:M(merchandise),
D(dollars)
location:L(a store)



Question Answering(7)

"When she got it home, she discovered that it went perfectly with her favorite dress."

Q1: Can be answered - "a new coat."

Q2: Can be answered - "a red coat."

Q3: "Yes, She bought a red coat."

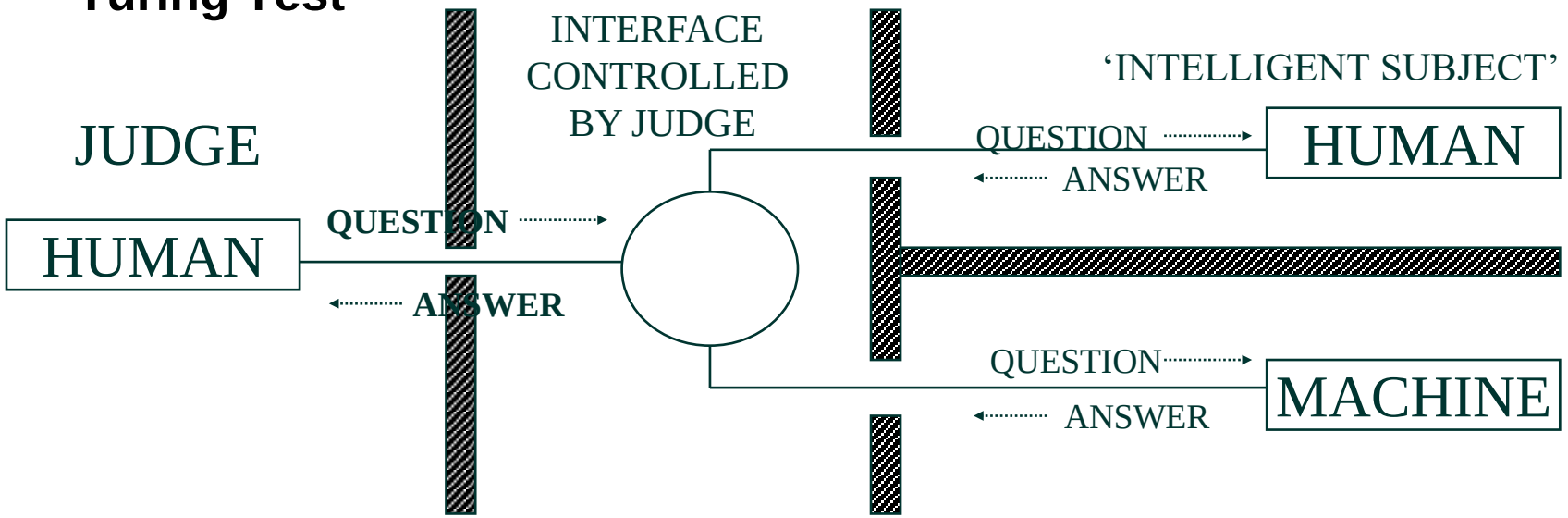
Comments:

- more powerful than the first two programs because it exploits more knowledge.
- it is exploiting AI techniques.
- a general reasoning mechanism is missing from this program.

The Evaluation Criterion of AI Success (1)

"How we know if we have succeeded?"

Turing Test



- The goal of the machine is to fool the judge into believing that it is the person.
- If the machine succeeds at this, then we will conclude that the machine can think.

The Evaluation Criterion of AI Success (2)

Blade Runner (1982)

- one of the most popular and influential science-fiction films of all time - and it has become an enduring cult classic favorite
- The film begins with a scrolling prologue …….
  - Early in the 21st Century, THE TYRELL CORPORATION advanced Robot evolution into the NEXUS phase - a being virtually identical to a human - known as a replicant.
  - ….
  - Special police squads - BLADE RUNNER UNITS - had orders to shoot to kill, upon detection, any trespassing *Replicant*.

The Basic Research Areas of AI

Knowledge Representation: represent the computer's knowledge of the world by some kind of data structures in the machine's memory

Search: a problem-solving technique that systematically explores a space of problem states

Knowledge Representation(1)

Knowledge Representation schemes

- Logical Representation Schems (e.g. Predicate Logic)
- Network Representation Schemes (e.g. Semantic Networks)
- Structured Representation Schemes (e.g. Frame)
- Procedural Representation Schemes (e.g. Production Rules)

Knowledge Representation(2) Logic

Definition - First-order Predicate Calculus

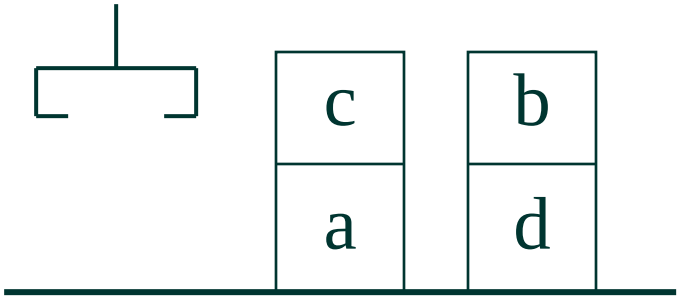
- *First-order predicate calculus* allows quantified variables to refer to objects in the domain of discourse and not to predicates or functions.

Examples of representing English sentence

- If it doesn't rain tomorrow, Tom will go to the mountains
  - $\neg$**weather(rain, tomorrow)** $\Rightarrow$ **go(tom, mountains)**
- Bisang is a Jindogae and a good dog
  - **gooddog(bisang)** $\wedge$ **isa(bisang, jindogae)**
- All basketball players are tall
  - $\forall$ **X (basketball_player(X)** $\Rightarrow$ **tall(X))**
- If wishes were horses, beggars would ride.
  - **equal(wishes, horses)** $\Rightarrow$ **ride(beggars)**.
- Nobody likes taxes
  - $\neg\exists$ **X likes(X, taxes)**

Knowledge Representation(3) Logic

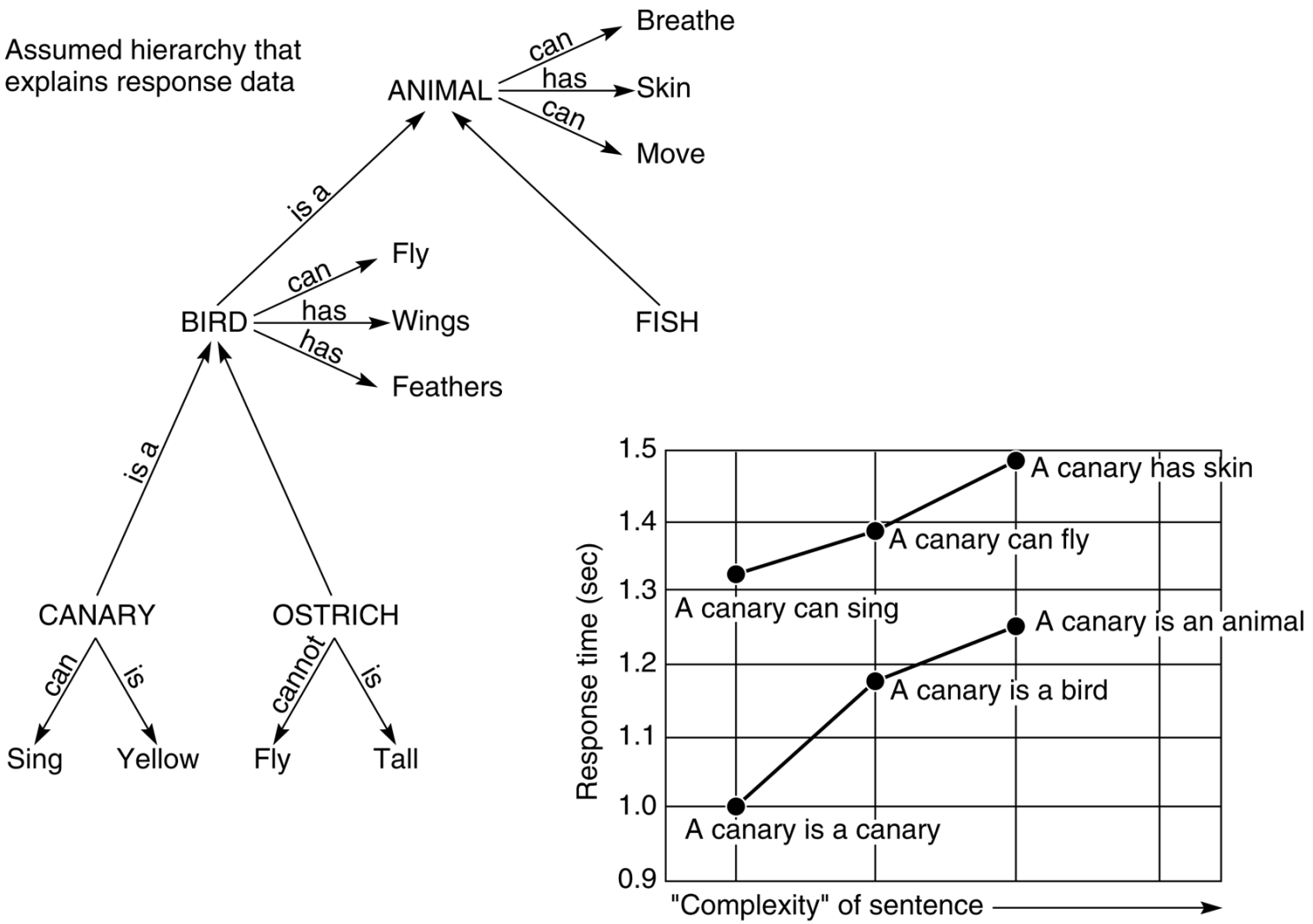
Representing a blocks world



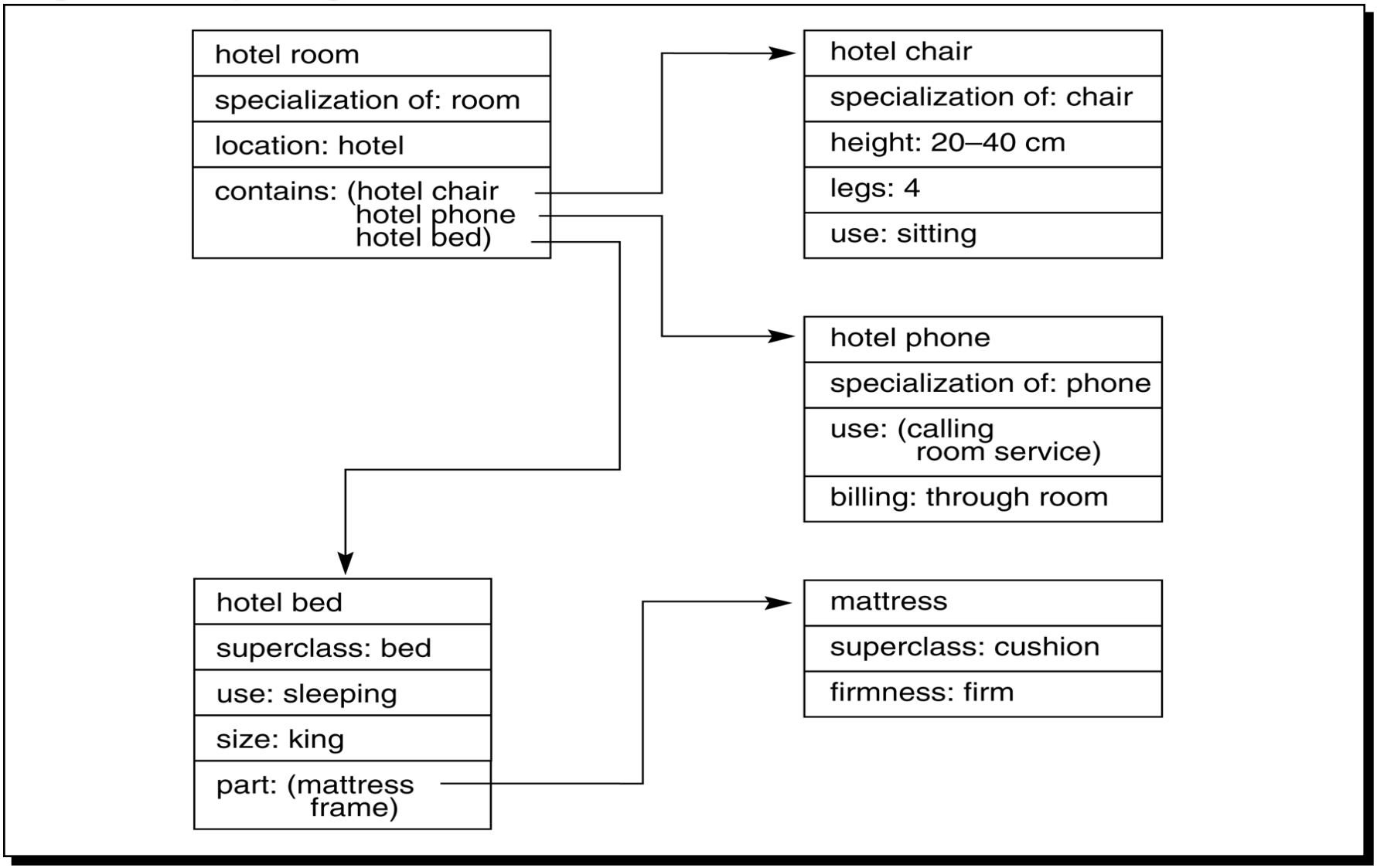

```
on(c,a).
on(b,d).
ontable(a).
ontable(d).
clear(b).
clear(c).
hand_empty.
```

- for all **X**, **X** is clear if there does not exist a **Y** such that **Y** is on **X**.
  - $\forall$ **X** ($\neg\exists$ **Y** **on**(**Y**, **X**) $\Rightarrow$ **clear**(**X**)).
- To stack **X** on **Y** first empty the hand, then clear **X**, then clear **Y**, and then **pick_up X** and **put_down X** on **Y**.
  - $\forall$ **X** $\forall$ **Y** ((**hand_empty** $\wedge$ **clear**(**X**) $\wedge$ **clear**(**Y**) $\wedge$ **pick_up**(**X**) $\wedge$ **put_down**(**X**, **Y**)) $\Rightarrow$ **stack**(**X**,**Y**)).

Knowledge Representation(4) Semantic Network



Knowledge Representation(5) Frame



Knowledge Representation(6)

Production Rules

- Rule1
  - **IF** X has a risk of heart attack
    AND X has had a previous heart attack
    THEN give X the drug Digitalis
- Rule2
  - **IF** X has left quadratic pain
    AND X has high blood pressure
    THEN X has a risk of a heart attack
- Rule3
  - **IF** X has raised intraocular pressure
    THEN X has high blood pressure

Search(1)

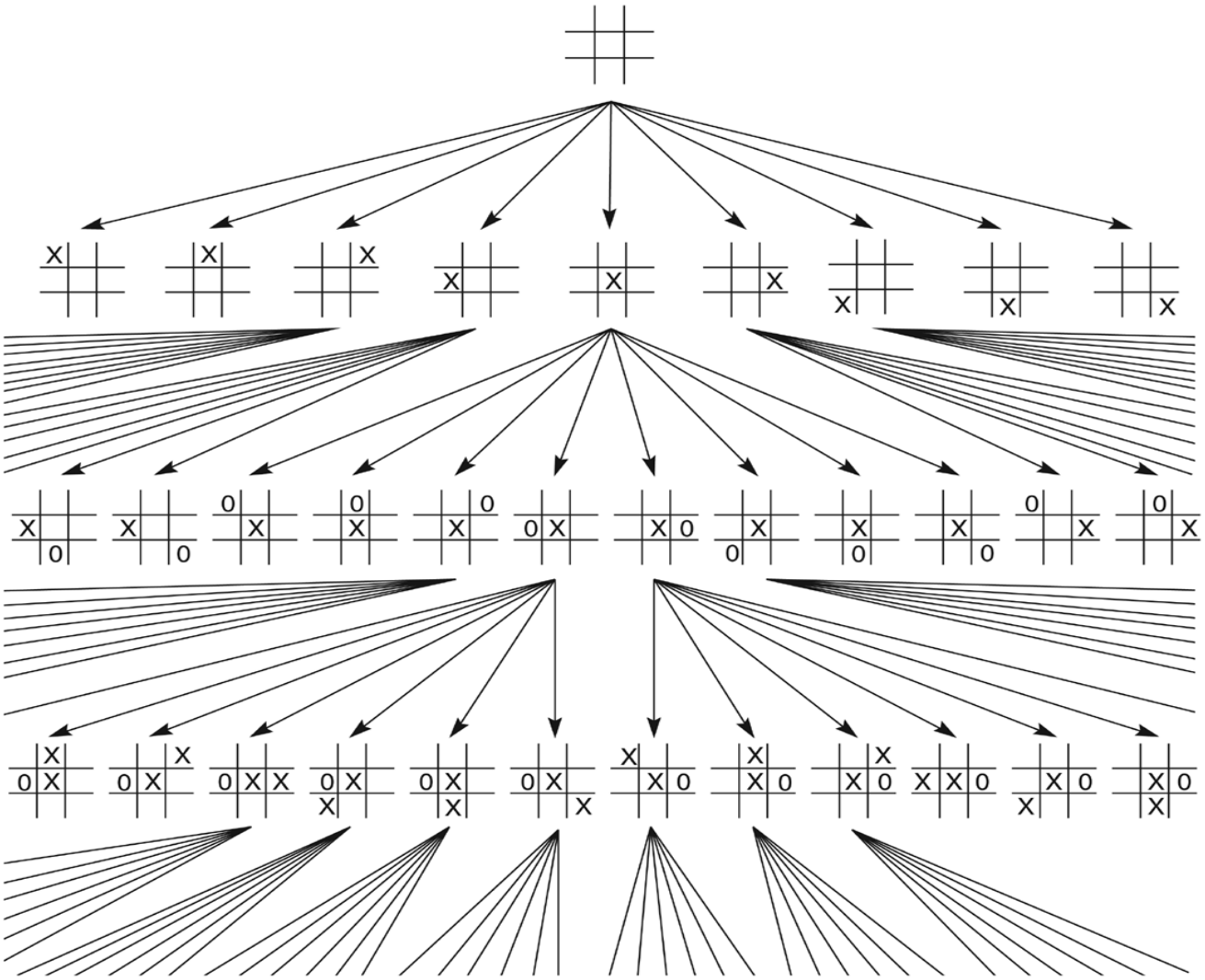
Blind Search

- Depth-First Search, Breath-First Search,

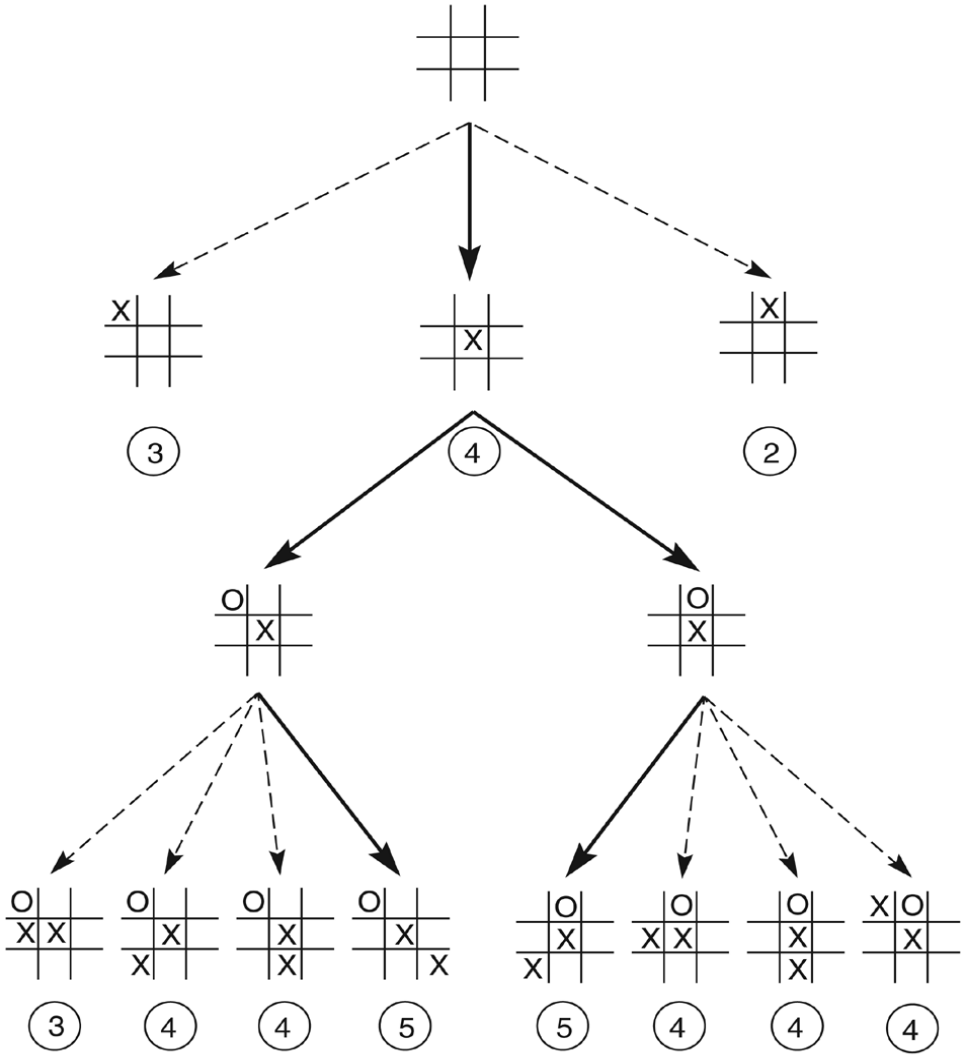
Heuristic Search

- Hill-Climbing Search, Best-First Search

Search(2)
Tic-tac-toe



Search(3)
Tic-tac-toe



The Application Areas of AI

- Game Playing
- Automatic Theorem Proving
- Expert Systems
- Natural Language Understanding
- Planning and Robotics
- Machine Learning

Game Playing(1)

Games are good vehicles for AI research because

- most games are played using a well-defined set of rules
- board configurations are easily represented on a computer

Games can generate extremely large search spaces.

- Search spaces are large and complex enough to require powerful techniques(heuristics) for determining what alternatives to explore in the problem space.

Two-person games are more complicated than puzzles.

- Hostility: **maximize own advantage while minimize opponent's opportunity of win**.
- Unpredictable opponent: **different knowledge of games.**
- Credit assignment is difficult.

Game Playing(2)

Various games

- chess : study the trade-off between knowledge and search
- checker
  - Samuel's program had an interesting learning component which allowed its performance to improve with experience. Ultimately, the program was able to beat its author.
    - ✓ Evaluate all states at a level with a evaluation polynomial.
      (C_1*piece advantage + C_2*advancement + C_3*center control + C_4*fork treat + C_5*mobility …)
    - ✓ If the evaluation polynomial led to a losing series of moves, the program adjusted its coefficients to improve performance.
- Go : Go is a very difficult game to play by machine since the average branching factor of the game tree is very high.
- Backgammon : a backgammon program must choose its moves with incomplete information about what may happen.
- Othello : achieved world-championship level.

Automatic Theorem Proving

Automatic Theorem Proving is the oldest branch of AI.

- **Theorem proving research was responsible for much of the early work in formalizing search algorithms and developing formal representation languages such as predicate calculus and logic programming language PROLOG.**

Variety of problems can be attacked by representing the problem description and relevant background information as logical axioms and treating problem instances as theorems to be proved.

Expert Systems(1)

Expert systems are constructed by obtaining the knowledge of a human expert and coding it into a form that a computer may apply to similar problems.

- domain expert provides the necessary knowledge of the problem domain.
- knowledge engineer is responsible for implementing this knowledge in a program that is both effective and intelligent in its behavior.

Expert Systems(2)

Many successful expert systems

- DENDRAL
  - designed to infer the structure of organic molecules.
- MYCIN
  - used expert medical knowledge to diagnose and prescribe treatment for bacterial infections of the blood.
- PROSPECTOR
  - for determining the probable location and type of ore deposits based on geological information.
- INTERNIST
  - for performing diagnosis in the area of internal medicine.
- XCON
  - for configuring VAX computers.

Deficiencies of Current Expert Systems

1. **Difficulty in capturing "deep" knowledge of the problem domain**
   - MYCIN lack any real knowledge of human physiology.
2. **Lack of robustness and flexibility**
3. **Inability to provide deep explanations**
4. **Difficulties in verification**
   - may be serious when expert systems are applied to air traffic control, nuclear reactor operations, and weapon systems.
5. **Little learning from experience**

Natural Language Understanding(1)

One of the long-standing goals of AI is the creation of programs that are capable of understanding human language

- Ability of understanding natural language seem to be one of the most fundamental aspects of human intelligence
- Successful automation would have an incredible impact on the usability and effectiveness of computers

Real understanding of natural language depends on extensive background knowledge about the domain of discourse as well as an ability to apply general contextual knowledge to resolve ambiguities.

Natural Language Understanding(2)

- **Goal of natural language understanding**
  - Common Stage: translating the original sentence into an internal representation of its meaning
- **The first stage: POS tagging**
  - The study of the sub-word units of meaning (word class)
- **The second stage: Parsing**
  - analyze the syntactic structure of sentences
    - **verify well-formed sentence & Determines a linguistic structure**
- **The third stage: Semantic Interpretation**
  - produce a representation of the meaning of the text using knowledge about the meaning of words and linguistic structure such as case roles of nouns or verbs
  - Check semantic consistency

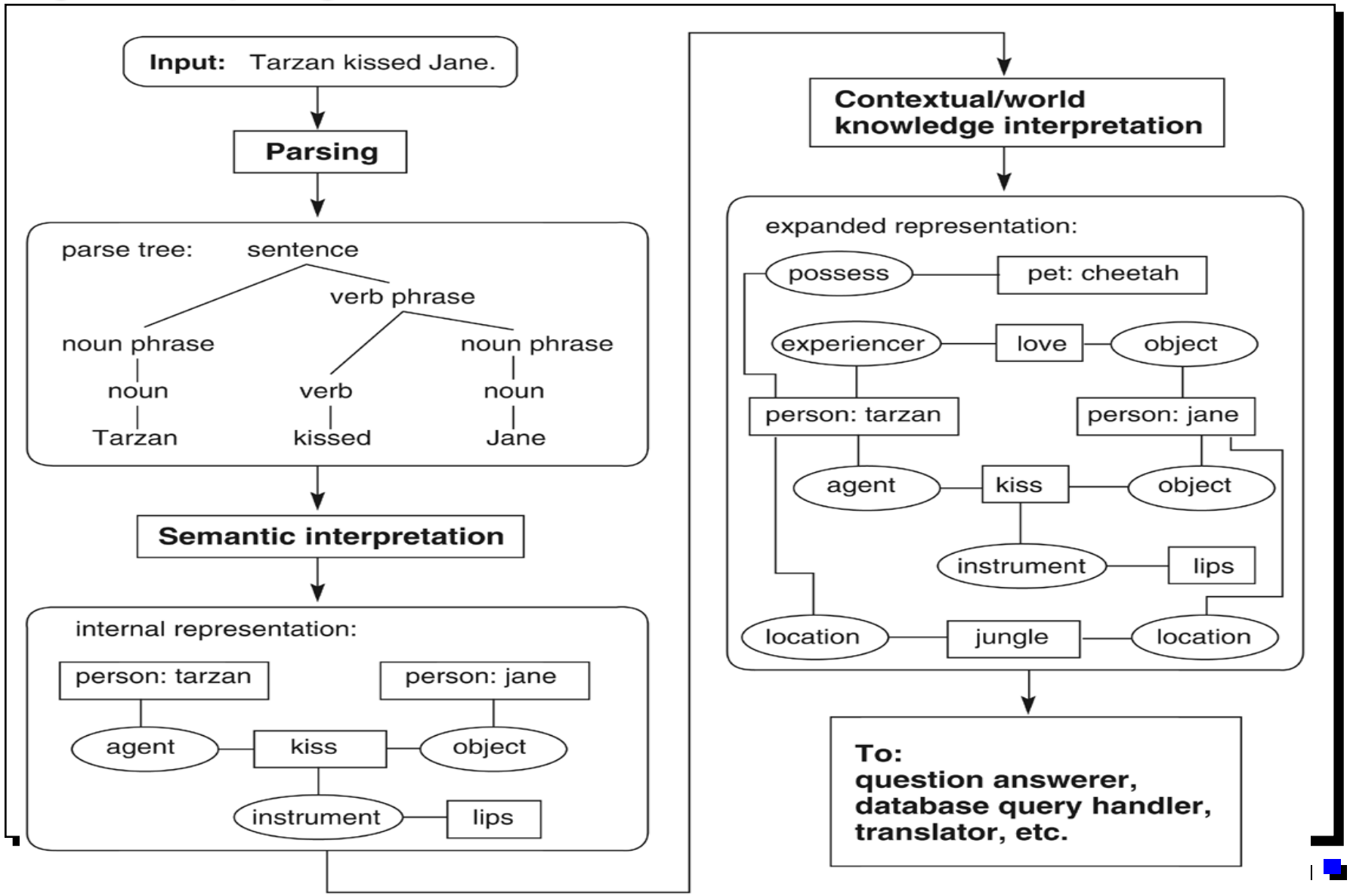
    e.g.) Tarzan kisses Jane. (O) Tarzan kisses Cheetah. (X)

Natural Language Understanding(3)

The fourth stage: structures from KB are added to the internal representation of the sentence to produce an expanded representation of the sentence's meaning.

- This adds the necessary world knowledge required for complete understanding.
  - e.g.) Tarzan loves Jane, Tarzan and Jane live in the jungle
- In a database front end, the extended structure would combine the representation of the query's meaning with knowledge about the organization of the database.
- In a story understanding program, this extended structure would represent the meaning of the story and be used to answer questions about it.

Natural Language Understanding(4)



Planning and Robotics

Planning attempts to order the atomic actions which robot can perform in order to accomplish some higher-level task.

Planning is a difficult problem because of vast number of potential move sequences and obstacles.

A blind robot performs a sequence of actions without responding to changes in its environment or being able to detect and correct errors in its own plan.

Machine Learning(1)

Herbert Simon defines learning as "any change in a system that allows it to perform better the second time on repetition of the same task or on another task drawn from the same population."

Programs learn on their own, either from experience, analogy, and examples or by being "told" what to do.

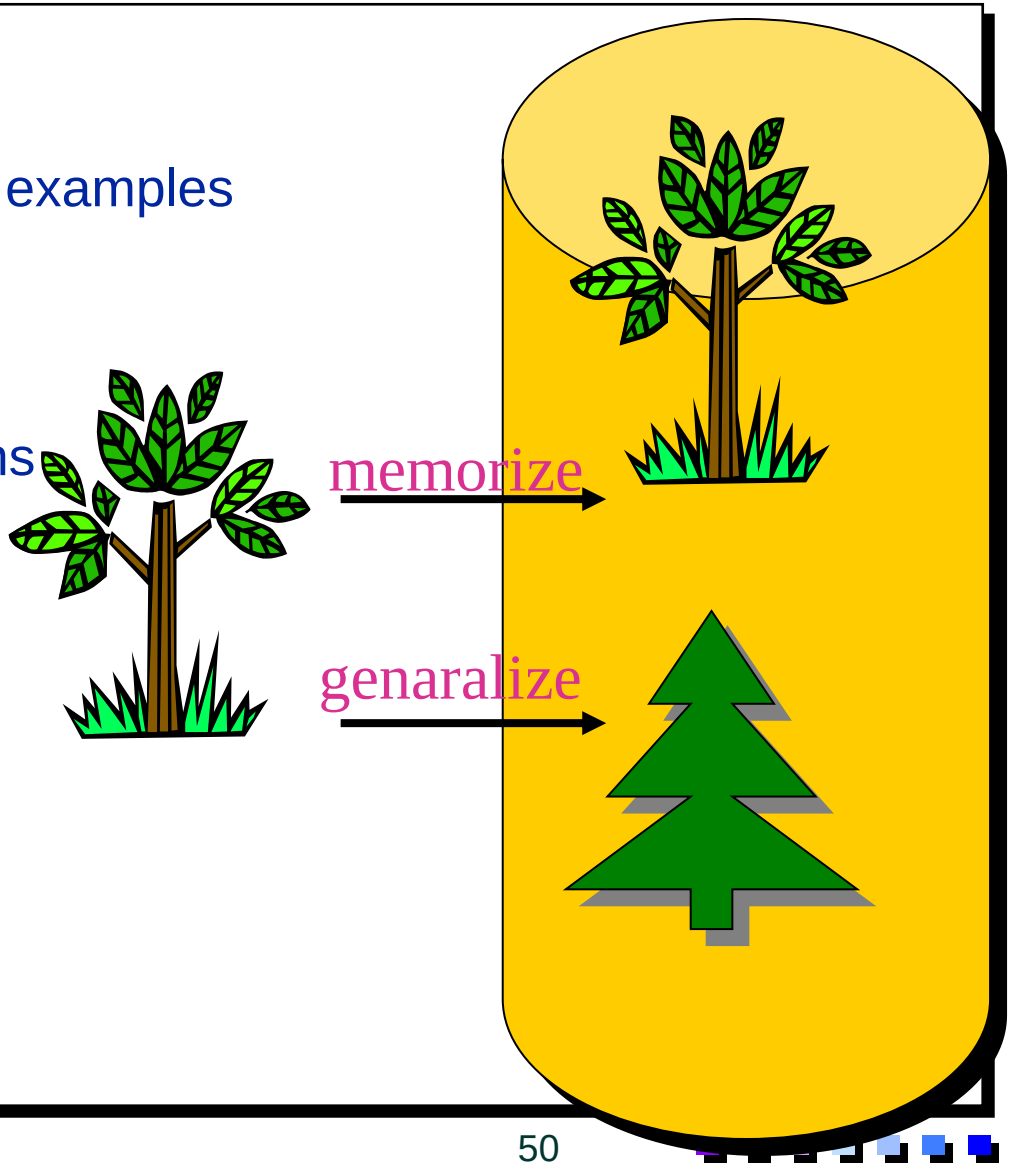
Machine Learning(2)

What it is

- Inducing a model from examples

What to do

- Generalizing patterns
- Memorizing the patterns



AI Characteristics

1. A focus on problems that do not respond to algorithmic solutions. Rely on heuristic search as an AI problem-solving technique.
2. A concern with problem solving using inexact, missing, or poorly defined information.
3. Answers that are neither exact nor optimal, but are in some sense "sufficient".
4. The use of large amounts of domain-specific knowledge in solving problems.