COMP 421 Artificial Intelligence

MACAO POLYTECHNIC INSTITUTE

Before we start

Books

- Artificial Intelligence – A Modern Approach (3rd edition)

Hours

- 3 hours per week, 15 weeks

Evaluation

- Assignment: 25%
- Test (midterm): 25%
- Final Exam: 50%

Contact

Rebecca Choi

Email: rebeccachoi@ipm.edu.mo

Telephone: 8599-3335

Office: Room M509, Meng Tak Building

Computer Science

What is Computer Science

Study of theory, experimentation, and engineering

Basis for design and use of computers

Scientific and practical approach to computation and its applications

Variety of theoretical and practical disciplines

Areas of Computer Science

Theoretical computer science

- Mathematical and abstract in spirit
- Motivation derived from practical and everyday computation
- Aims at understand nature of computation and provide more efficient methodologies
- Mathematical, logic and formal concepts and methods

Applied computer science

- Aims at identifying certain computer science concepts in solving real world problems

Theoretical Computer Science

Theory of computation

- "What can be (efficiently) automated?"
- Answering about
  - What can be computed
  - What amount of resources are required to perform those computations (computational complexity theory)
- P = NP?

Algorithms and data structures

- Study of computational methods and their efficiency

Programming language theory

- Deals with design, implementation, analysis, characterization, and classification of programming languages

Theoretical Computer Science

Information and coding theory

- Information theory
  - Quantification of information
  - Find fundamental limits on signal processing operations
- Coding theory
  - Study of codes and fitness for specific application
  - Used for data compression, cryptography, error detection and correction
  - For purpose of designing efficient and reliable data transmission methods

Applied Computer Science

Computer networks

- Manage networks between computers worldwide

Databases

- Easily organize, store, and retrieve large amounts of data
- DBMS store, create, maintain, and search data
  - through database models and query languages

Software engineering

- Study of designing, implementing, and modifying software
- Not only creation or manufacture of new software
  - Organizing and analyzing of software - internal maintenance

Applied Computer Science

Computer security and cryptography

- Computer security
  - protection of information from unauthorized access, disruption, or modification
- Cryptography
  - encryption and decryption of information

Computer graphics and visualization

- Study of digital visual contents
- Involves synthesis and manipulation of image data
- Heavily applied in fields of special effects and video games

Artificial Intelligence

- Synthesize goal-orientated processes such as problem-solving, decision-making found in humans

Relationship between CS and AI

Mathematical logic (a study area of CS)

- Important tool for inference in AI

Computability theory of CS

- Simulates human being's thinking process (AI)

Complexity theory of CS

- Quantifies how complicated to solve a problem (complexity in AI)

AI apply CS concepts and theories in solving problems

Artificial Intelligence

What is Artificial Intelligence

Many definitions

- No universal agreement
- Based on different point of view, a different definition

Human ⟷ Ideal

Thought ↕ Behavior

"The exciting new effort to make computers think … *machines with minds*, in the full and literal sense" (Haugeland, 1985)	"The study of mental faculties through the use of computational models" (Charniak and McDermott, 1985)
"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning …" (Bellman, 1978)	"The study of the computations that make it possible to perceive, reason, and act" (Winston, 1992)
"The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990)	"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkoff, 1990)
"The study of how to make computers do things at which, at the moment, people are better" (Rich and Knight, 1991)	"The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield, 1993)

Figure 1.1 Some definitions of AI. They are organized into four categories:

Systems that think like humans.	Systems that think rationally.
Systems that act like humans.	Systems that act rationally.

Different AI Systems

System thinks or acts humanly

- Methods employed by human
- Unreliable, sometimes human does irrationally

System thinks or acts rationally

- Reliable
- Not care methods, only care correctness of result
- Usually employ mathematical and logical models

System 1 – Acting Humanly

Computer act humanly → behave intelligently

Intelligently

- Achieve human-level performance in all cognitive tasks

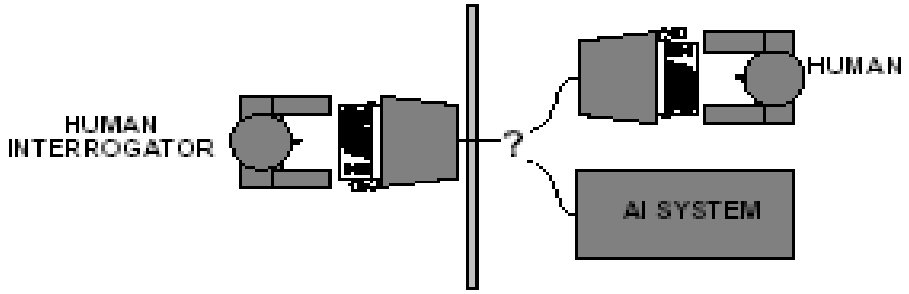
Cognitive tasks include:

- *Natural language processing*
  - Communication with human
- *Knowledge representation*
  - Store information effectively & efficiently
- *Automated reasoning*
  - Conclude answer or result for questions using stored information / knowledge
- *Machine learning*
  - Able answer unseen questions after training

System 1 – Acting Humanly

To judge if a system act humanly

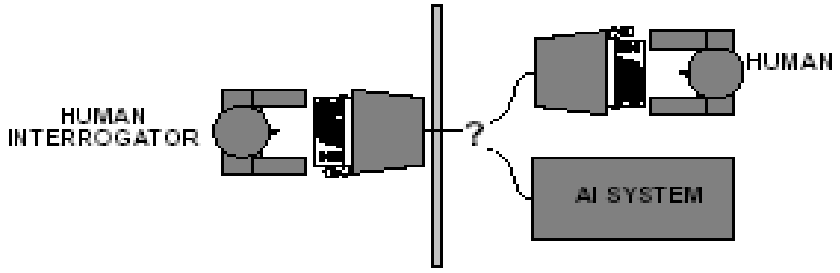
- The Turing Test (From Alan Turing)
- Human questioner cannot distinguish whether a computer or a human is answering his question, via teletype (remote communication)



Turing Test

Test a machine's ability to exhibit intelligent behavior

- equivalent to or indistinguishable from that of human



The most important problem is:

- How to model human acting ?
- What are the logics / algorithms within our brains?

System 2 – Thinking Humanly

To enable computer thinking like a human

The *cognitive modeling* approach

- Need a precise theory of mind, NOT available
- *Cognitive Science* deals with theory of mind
  - Brings AI and psychology theories together
- Cannot build human models

System 3 – Thinking Rationally

Thinking humanly is difficult

- How about thinking mathematically or logically? (rationally)

Logic

- Laws of thought
- Governs and manages mind operation
- Usually takes premises as inputs and deduces a conclusion
- Example: If (X and Y) then Z. ($X \wedge Y \Rightarrow Z$)

Only thinking

- No action is made upon the environment

System 4 – Acting Rationally

Acting rationally computer (rational agent)

- Given facts (inputs)
  - Computer acts (outputs) to achieve given goals
- Agent
  - Perceives and outputs correct actions upon the environments
  - Similar to a program: get inputs and perform some outputs
    - In-between algorithm? By the designer
    - How? Using Logic?

System 4 – Acting Rationally

Logic is good but…

- Only *part* of a rational agent, not *all* of rationality
  - Sometimes logic cannot express a correct conclusion
- At that time, some *specific human knowledge* or information is used

Thus, rational agent = Logic + knowledge

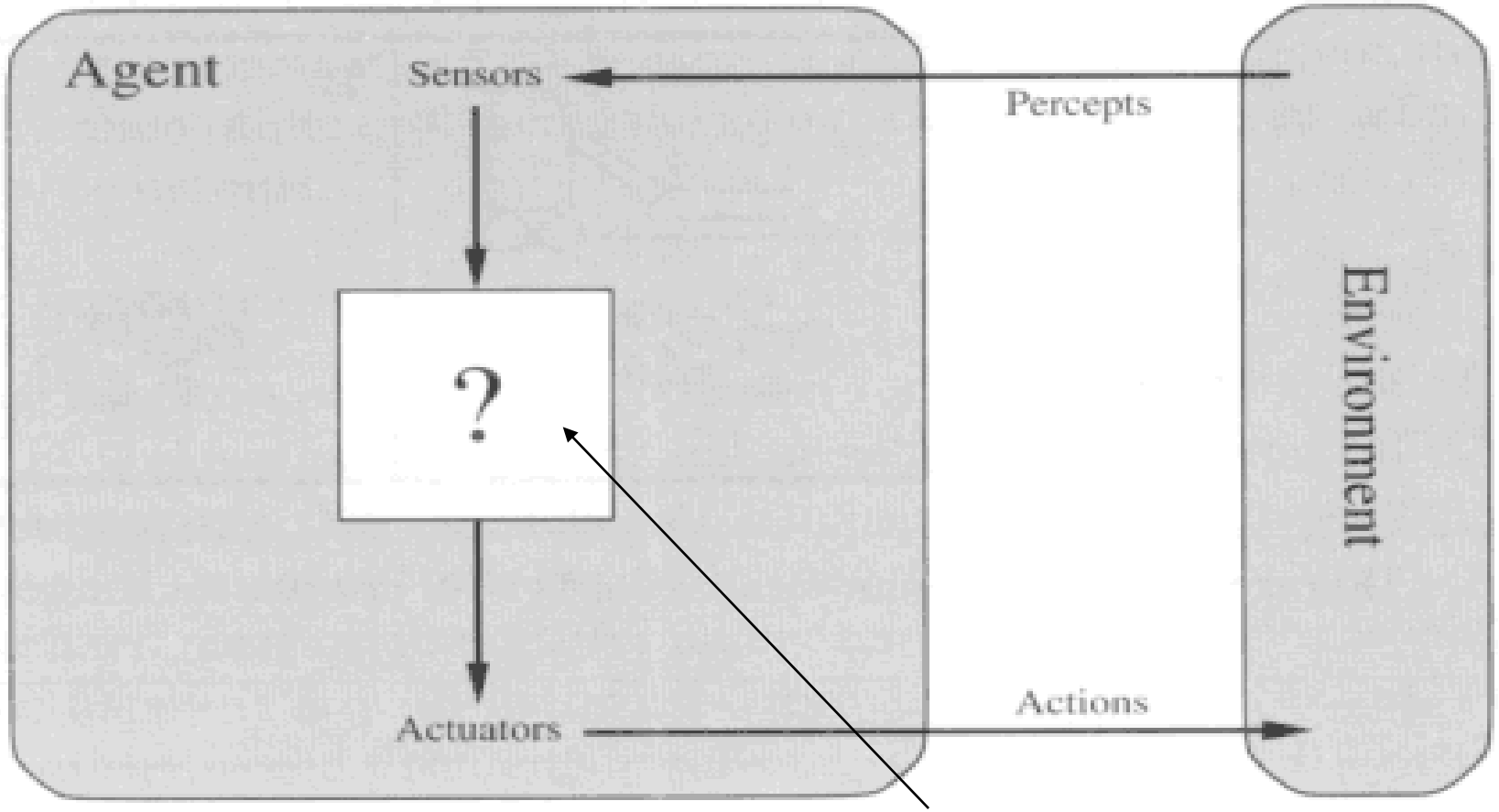
- Covers more generally different situations of problems
- Compensates the incorrectly reasoned conclusion from Logic
- Allows extension of the approach with more scientific methodologies

Agent

Agents

- Agent is anything (human / robot)
  - Perceives its environment through sensors (input)
  - Acts upon that environment through actuators (output)
- Human is an agent
- A robot is also an agent
  - with cameras and motors

Diagram of an agent

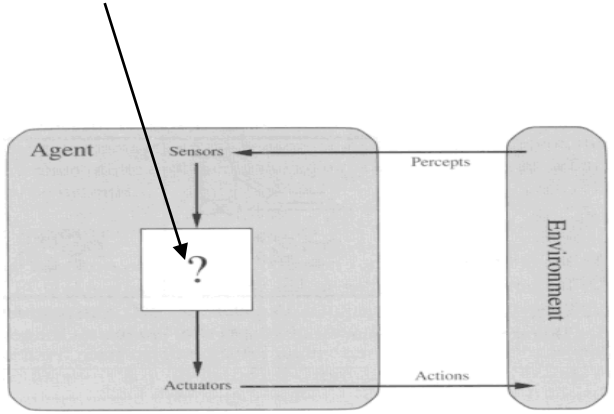


Agent function & program

"?" = Agent's processing

- Agent function
  - When mathematically described
  - A function mapping (like a lookup table)
  - Any given percept sequence → an action
- Agent program
  - Algorithm / program code
  - Real implementation

Percept sequence	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean], [A, Clean]	Right
[A, Clean], [A, Dirty]	Suck
⋮	⋮
[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck
⋮	⋮



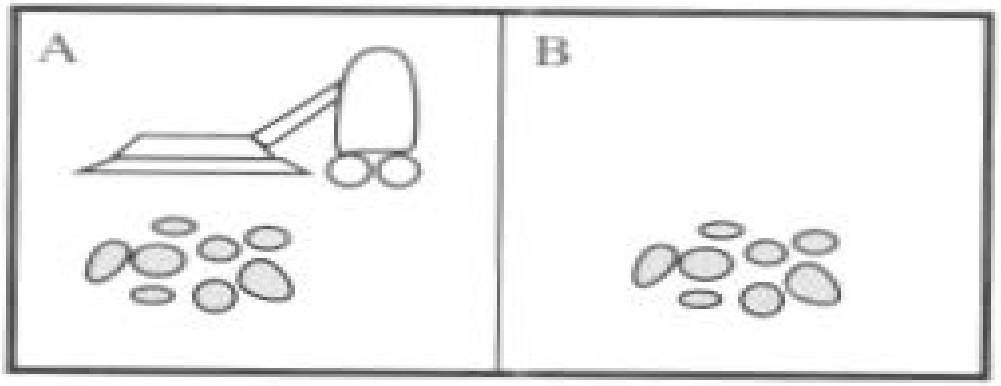
Vacuum-cleaner World Example

Perception:

- Current square is Clean or Dirty?
- Which square is it in?

Action:

- Move left
- Move right
- Suck
- Do nothing



Agent function for Vacuum-cleaner world

Percept sequence	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean], [A, Clean]	Right
[A, Clean], [A, Dirty]	Suck
⋮	⋮
[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck
⋮	⋮

Figure 2.3 Partial tabulation of a simple agent function for the vacuum-cleaner world shown in Figure 2.2.

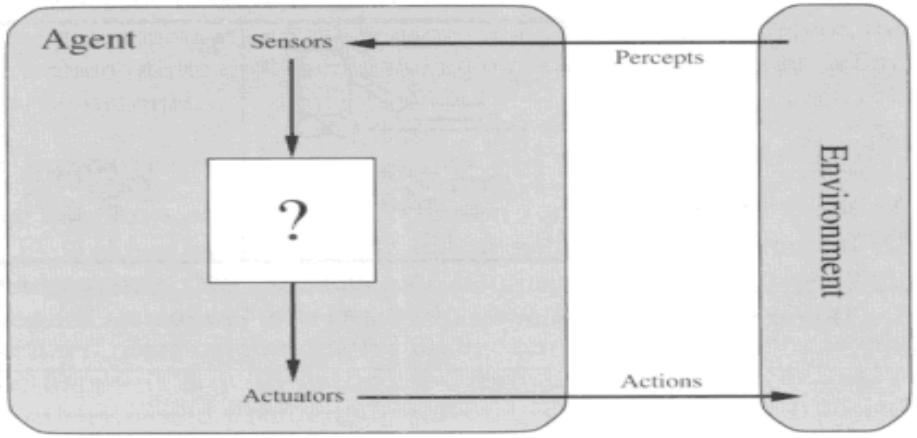
This table never ends → Impossible to construct

So *agent program* is used instead

Rational agent

For each possible percept sequence

- Rational agent select an action expected to maximize its performance
- Based on
  - Current percept and the percept sequence
  - Agent's built-in knowledge



Learning

Rational agent NOT only depend on current percept

- Also the past percept sequence
- After experiencing
  - Adjust behaviors
  - Perform better for the same job next time
    - Like riding bicycle and programming

Autonomy

Make its own decision based on current situation

NOT just relies on prior knowledge of its designer (data)

E.g. a clock, does not have autonomy

- No percepts
- Only run its own algorithm (prior knowledge)
- No learning and no experience

Omniscience

Omniscient agent

- Knows the *actual* outcome of its actions before it happens
  - No other possible outcomes, 100% sure
- Impossible in real world

Example

- Crossing a street without cars, but died of the fallen cargo door from 33,000ft
  - Action is not irrational

Omniscience

Based on the circumstance, it is rational

- Fails because out of expectation

As rationality maximizes

- *Expected* performance

Perfection/Omniscience maximizes

- *Actual* performance

Hence rational agents are not *omniscient*

Foundation of AI

Foundation of AI

Philosophy

- The idea of AI starts
  - Study theory of mind
- Initially, no formal expression in study of human intelligence
- Initiate the theory of mind
  - as a machine and its internal operations
  - similar to automata

Foundation of AI

Mathematics

- The tools to implement mind as a machine
- Formalizes three main areas of AI
  - *Computation*, *logic*, and *probability*
  - Computation and logic
    - Analysis of problems that can be computed
    - Transform real-world problem to computable algorithm
  - Probability
    - Handles *uncertainty* (degree of belief) in real-world problems

Foundation of AI

Psychology

- Study how human think and act, not mathematically
- Study human reasoning and acting
- Provides *human reasoning models* for AI
- Strengthen the idea
  - Human = Information processing machine

Foundation of AI

Computer Engineering

- How to build an efficient computer?
  - Computer: The artifact that makes many AI applications possible
  - The power of computer makes computation of large and difficult problems more easily
- AI has also contributed its own work to computer science
  - Time-sharing, the linked list data type, etc.

Foundation of AI

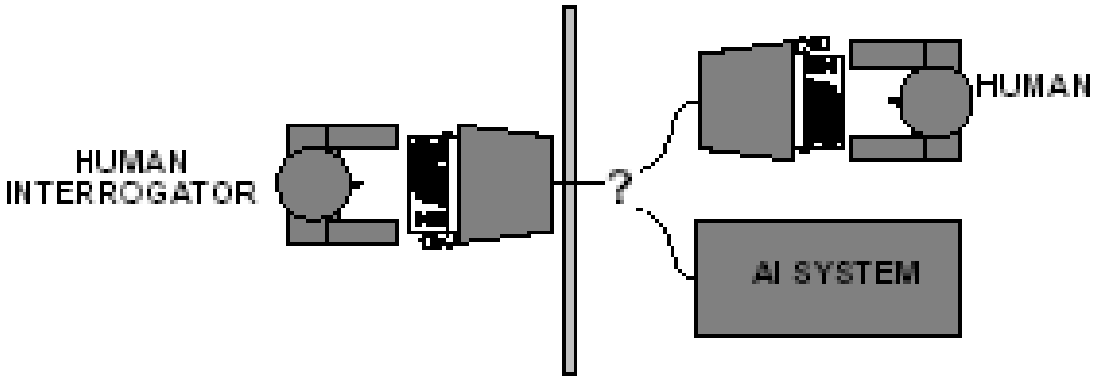
Control theory and Cybernetics

- Building a robot (computer)
  - Can operate under its own control
  - i.e. acting on its own (controlling hardware)
  - Adjust their actions
  - Do better for the environment over time
  - Based on an objective function and feedback from the environment

Foundation of AI

Linguistics

- Understanding natural languages
- Formal languages (i.e., no ambiguity)
  - Syntactic and semantic analysis
  - Knowledge representation



Applications of AI

Applications of AI

What can AI do today?

- As a mechanic: Monitoring and Recovering
  - E.g., Mars exploration of spacecraft
  - The system monitors the spacecraft for any problem
    - detecting, diagnosing, and recovering
- As a player: Game playing
  - Playing chess and other games
  - Even better than human champions

Applications of AI

- As a driver: Autonomous Control
  - The computer drives a car (a robot) across U.S. for 2,850 miles
    - Compute the best direction to steer, based on previous training
- As a doctor: Disease diagnosis
  - Based on symptoms, the machine can point out and explain the factors influencing its decision
  - Also gives the probabilities of decisions

Applications of AI

- As a planner: Logistics Planning
  - Automated logistics planning and scheduling for transportation
  - Involves up to 50,000 vehicles, cargo and people in a time
  - Reduced the planning time from weeks to hours
- As a surgical doctor: Robotics
  - Uses computer vision techniques to help analysis
  - Used in medical surgery and other areas

Applications of AI

- As a human: Language understanding and problem solving
  - Solves crossword puzzles even better than human
  - Using a large database of past puzzles, and a variety of information sources, etc.
  - Another area is machine translation
    - English ←→ Chinese ←→ Portuguese

Why study AI?

Computer program = algorithm = logic

- Sometimes incapable to solve practical problems
  - Too difficult
- Or can only solve problems inefficiently
  - Too long time or too expensive

To model human intelligence

- Impractical and difficult problems become possible

To produce smart programs

- Difficult problems become easier/faster to solve