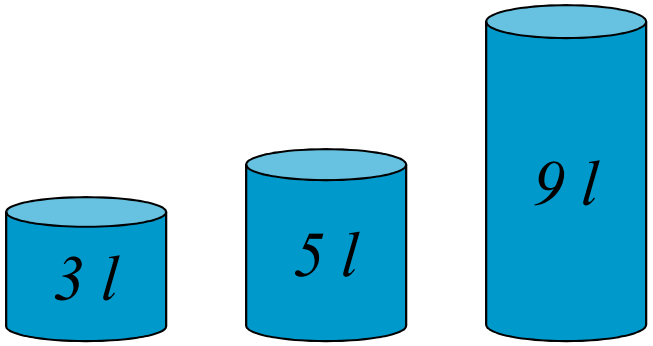
What is Intelligence?

- A very popular YouTube video of a 5 year old girl speaking about KCR and his cabinet on stage
- Solving the water jug problem on the next slide
- Solving the missionaries and cannibals problem
- Sakuntala Devi multiplying in a flash
- Following Maryada Ramanna and getting in trouble

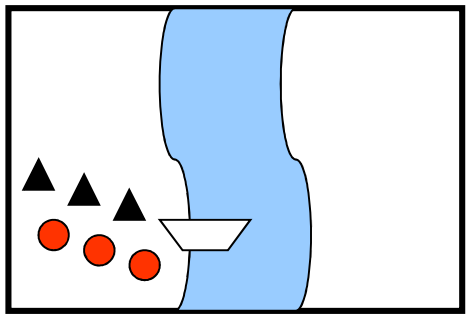
Example: Measuring problem!



- **Problem:** Using these three buckets, measure 7 liters of water.

Missionaries and Cannibals: Initial State and Actions

- Initial state:
  - all missionaries, all cannibals, and the boat are on the left bank



- Goal state :
  - all missionaries, all cannibals are on the Right bank
- Conditions
  - Boat can carry at most 2
  - Missionaries are in danger if cannibals outnumber them

What is artificial intelligence?

- There is no clear consensus on the definition of AI
- Here's one from John McCarthy, (He coined the phrase AI in 1956) - see http://www-formal.Stanford.edu/jmc/whatisai.html)

Q. What is artificial intelligence?

A. It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.

Q. Yes, but what is intelligence?

A. Intelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some machines.

Other possible AI definitions

- AI is a collection of hard problems which can be solved by humans and other living things, but for which we don't have good algorithms for solving.
  - e. g., understanding spoken natural language, medical diagnosis, learning, self-adaptation, reasoning, chess playing, proving math theories, etc.
- Definition from R & N book: a program that
  - Acts like human (Turing test)
  - Thinks like human (human-like patterns of thinking steps)
  - Acts or thinks rationally (logically, correctly)
- Hofstadter: AI is whatever hasn't been done yet.

Other possible AI definitions

- Rich & knight:
  - The study of how to make programs/computers do things that people do better
  - The study of how to make computers solve problems which require knowledge and intelligence
- Luger & Stubblefield:
  - AI may be defined as the branch of computer science that is concerned with automation of intelligent behavior.
- Marvin Minsky
  - Artificial Intelligence is a science of how to persuade computers to exhibit such a type of behaviour that conventionally requires Human Intelligence

Brief History of AI (1)

Symbolic AI	Biological AI
■ 1943: Production rules	■ 1943: McCulloch-Pitt's neurons
■ 1956: "Artificial Intelligence"	■ 1959: Perceptron
■ 1958: LISP AI language	■ 1965: Cybernetics
■ 1965: Resolution theorem proving	■ 1966: Simulated evolution
	■ 1966: Self-reproducing automata
■ 1970: PROLOG language	■ 1975: Genetic algorithm
■ 1971: STRIPS planner	
■ 1973: MYCIN expert system	■ 1982: Neural networks
■ 1982-92: Fifth generation computer systems project	■ 1986: Connectionism
■ 1986: Society of mind	■ 1987: Artificial life
■ 1994: Intelligent agents	■ 1992: Genetic programming
	■ 1994: DNA computing

AI Application Areas

- Game Playing
- Automated Reasoning and Theorem Proving
- Expert Systems
- Natural Language Understanding and Semantic Modeling
- Modeling Human Performance
- Planning and Robotics
- Machine Learning
- Neural Nets and Genetic Algorithms
- Fraud Detection

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 from their chemical formulas and mass spectrographic information about the chemical bonds present in the molecules.
    - use the heuristic knowledge of expert chemists to search into the very large possible number of molecular structures.
  - MYCIN
    - used expert medical knowledge to diagnose and prescribe treatment for spinal meningitis and bacterial infections of the blood.
    - Provided clear and logical explanations of its reasoning, used a control structure appropriate to the specific problem domain, and identified criteria to reliably evaluate its performance.

Expert Systems(3)

- Many successful expert systems (Continued)
  - 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.

ELIZA

Person: Men are all alike.

ELIZA: In what way?

Person: They're always bugging us about something or other.

ELIZA: Can you think of a specific example?

Person: Well, my husband made me come here.

ELIZA: Your husband made you come here.

Person: He says I'm depressed much of the time.

ELIZA: I am sorry to hear you are depressed.

Person: It's true. I am unhappy.

ELIZA: Do you think coming here will help you not to be unhappy?

Person: I need some help, that much seems certain.

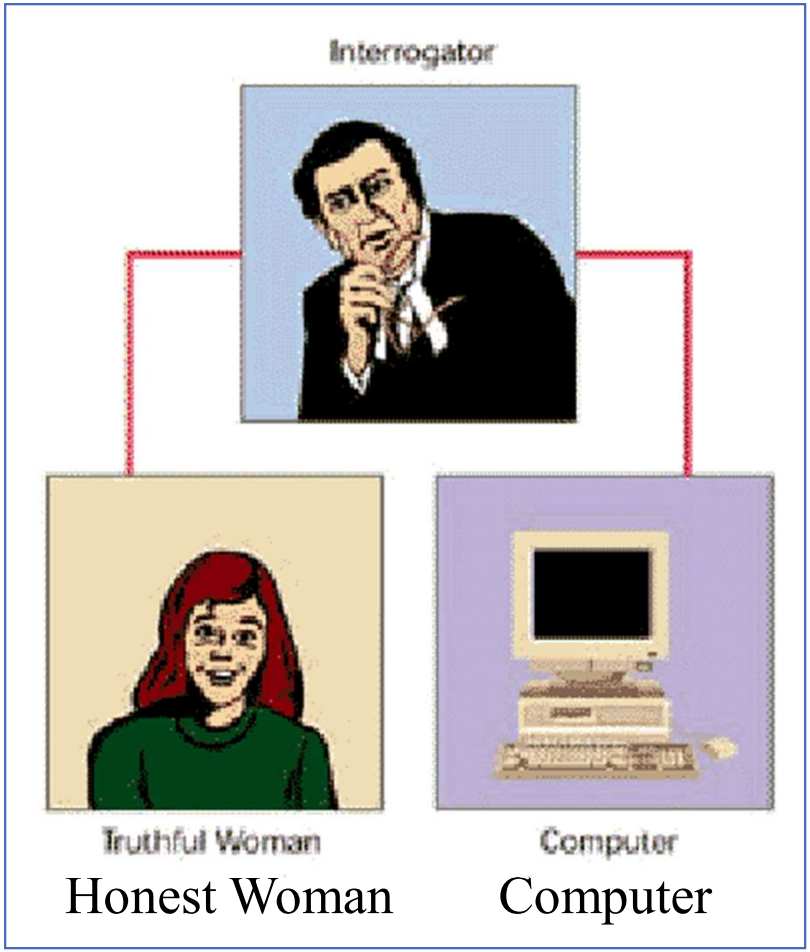
ELIZA: What would it mean to you if you got some help?

Person: Perhaps I could learn to get along with my husband.

ELIZA: Tell me more about your family.

Turing Test

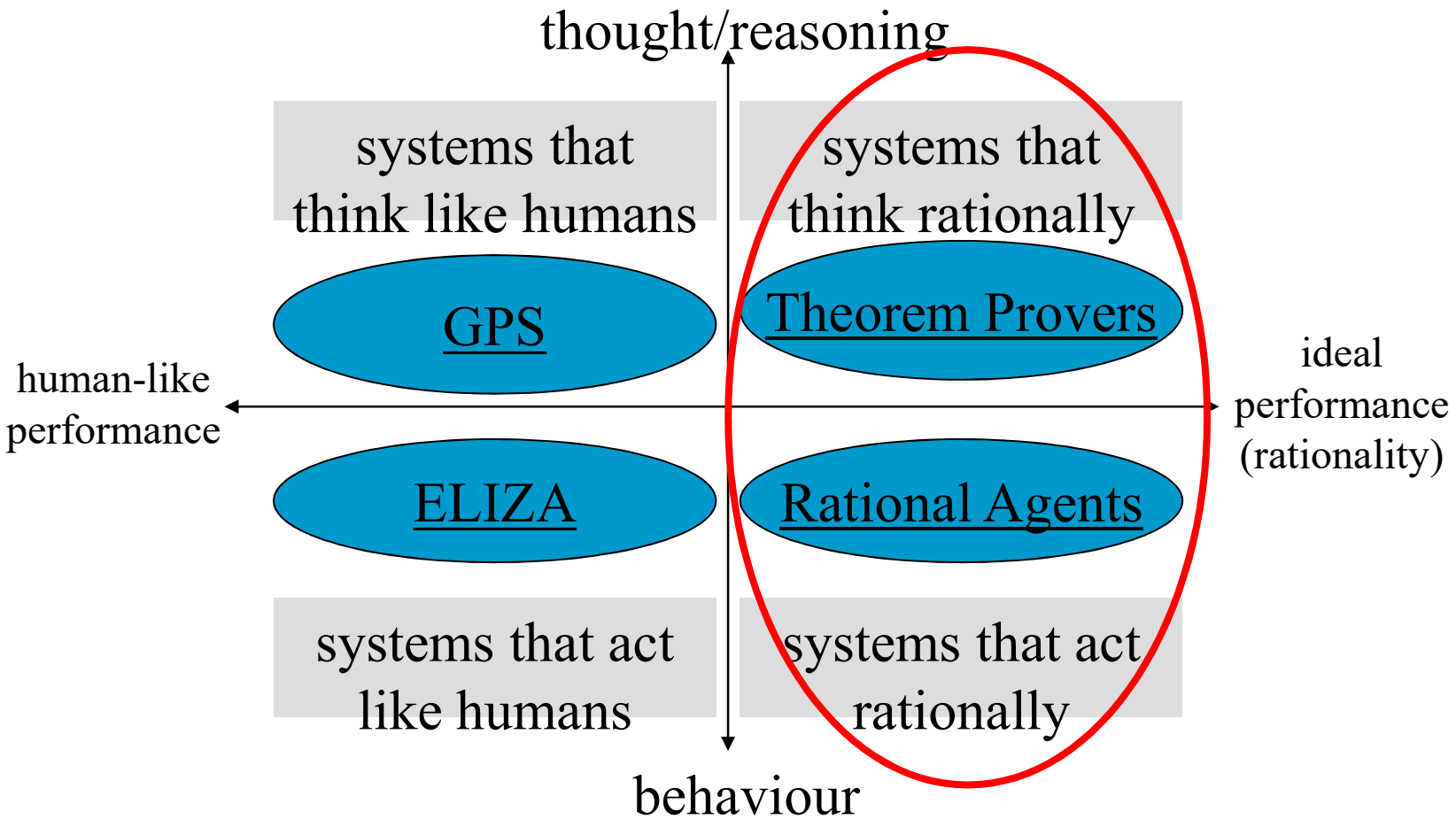
- Alan Turing (1912 - 1954)
  - Proposed a test - **Turing's Imitation Game –** in his 1950 article **Computing machinery and intelligence.**
- Turing test
  - Computer and woman separated from an interrogator.
  - The interrogator types in a question to either party.
  - By observing responses, the interrogator's goal was to identify which was the computer and which was the woman.
  - If he fails, **the computer is intelligent!**



Turing Test – how good is it ?

- Measures imitation, not intelligence
  - Does **Eliza** pass this test ? YES!
  - Does **Deep Blue** pass this test ? NO!
  - Most AI programs are shallow, they recognize "syntax" but not "semantics"
- Searle's Chinese Room
  - Room with a slot, human with huge rule book on how to translate Chinese to English
  - If someone drops a Chinese letter in the slot and the human translates it to English, does the human understand Chinese?
- Turing test is not reproducible, constructive, and amenable to mathematic analysis.

Approaches to AI



Think well

- Develop formal models of knowledge representation, reasoning, learning, memory, problem solving, that can be rendered in algorithms.
- There is often an emphasis on systems that are provably correct, and guarantee finding an optimal solution.

Act well

- For a given set of inputs, generate an appropriate output that is not necessarily correct but gets the job done.
- A **heuristic** (**heuristic rule**, **heuristic method**) is a rule of thumb, strategy, trick, simplification, or any other kind of device which drastically limits search for solutions in large problem spaces.
- Heuristics do not guarantee optimal solutions; in fact, they do not guarantee any solution at all: **all that can be said for a useful heuristic is that it offers solutions which are good enough most of the time.**

Think like humans

- Cognitive science approach
- Focus not just on behavior and I/O
  but also look at reasoning process.
- Computational model should reflect “how” results were obtained.
- GPS (General Problem Solver): Goal not just to produce humanlike behavior (like ELIZA), but to produce a sequence of steps of the reasoning process that was similar to the steps followed by a person in solving the same task.

Act like humans

- Behaviorist approach.
- Not interested in how you get results, just the similarity to what human results are.
- ELIZA
- Exemplified by the Turing Test (Alan Turing, 1950).

Components of AI programs

- Knowledge Base
  - Facts
  - Rules
- Control Strategy
  - Which rule to apply
- Inference Mechanism
  - How to derive new knowledge from the existing information

(follows from physical symbol system hypothesis)

AI as Representation and Search

- In their Turing Award lecture, **Newell and Simon** argue that intelligent activity, in either humans or machines, is achieved thru
  1. Symbol patterns to represent significant aspects of a problem domain,
  2. Operations on these patterns to (combine and manipulate) generate potential solutions and
  3. Search to select a solution from these possibilities.
- **Physical Symbol System Hypothesis [NS'76]**:
  - A physical symbol system has the necessary and sufficient means for general intelligent action.

Physical Symbol System Hypothesis

- **Physical Symbol System Hypothesis** outlines the major foci of AI research
  1. Defining symbol structures and operations necessary for intelligent problem solving and
  2. Developing strategies to efficiently and correctly search potential solution generated by these structures and operations.
- These two interrelated issues of **Knowledge Representation** and **Search** are at the heart of AI.
- We study these two issues in detail in this course.

Example: Tic-Tac-Toe program

- Complexity
- Use of generalizations
- Clarity of knowledge
- Extensibility

1	2	3
4	5	6
7	8	9

Program 1

- Board: 9-element vector

  0 : blank, 1 : X , 2 : O

- Move table: 3^9 Rows of 9-element vectors
  - Nearly 2000 entries.
- Algorithm:

  1. transform board vector from base 3 to 10
  2. use (1) as the move table index
  3. change the board by using the vector from (2)

Move Table for Program 1

Table 1.1 Move Table

Index	Current Board Position	New Board Position
0	000000000	000010000
1	000000001	020000001
2	000000002	000100002
3	000000010	002000010
	⋮	

Comments:

- Advantages:
  - efficient in terms of time,
  - optimal game of tic-tac-toe in theory
- Disadvantages:
  - space - move table space
  - work - move table
  - error prone - move table
  - three dimension - 3^{27}, no longer work at all

Program 2

- Board: program1
  2 : blank, 3 : X, 5 : O
- Turn: game moves 1,2,3,.....
  odd-numbered move : x
  even-numbered move : o

Algorithm : *3 sub procedures*

Make2: Determines our step to have two X's in…

Posswin (p): 18 (3*3*2) for p = X
50 (5*5*2) for p = O

Go (n) : Place X in square [n]

Strategy

- Turn=1 Go (1)
- Turn=2 Go (5) or Go (1)
- Turn=3 Go (9) or Go (3)
- Turn=4 Go(Posswin(X)) or Go(Make2)
- …
- Try to win if you can, check if the opponent is winning in the next move and block him/her, else make2 move.

Comments:

- Less efficient than Program 1 (time)
- More efficient (space)
- More clarity (strategy)
- Easier to change (strategy)

- Cannot extend to three dimension

Program 3

- Board - magic square 15
- Possible win check:

  S = sum of two paired block owned by a player

  D = 15 – S

  if 0 < D < 10 and Board [D] is empty then the player can win

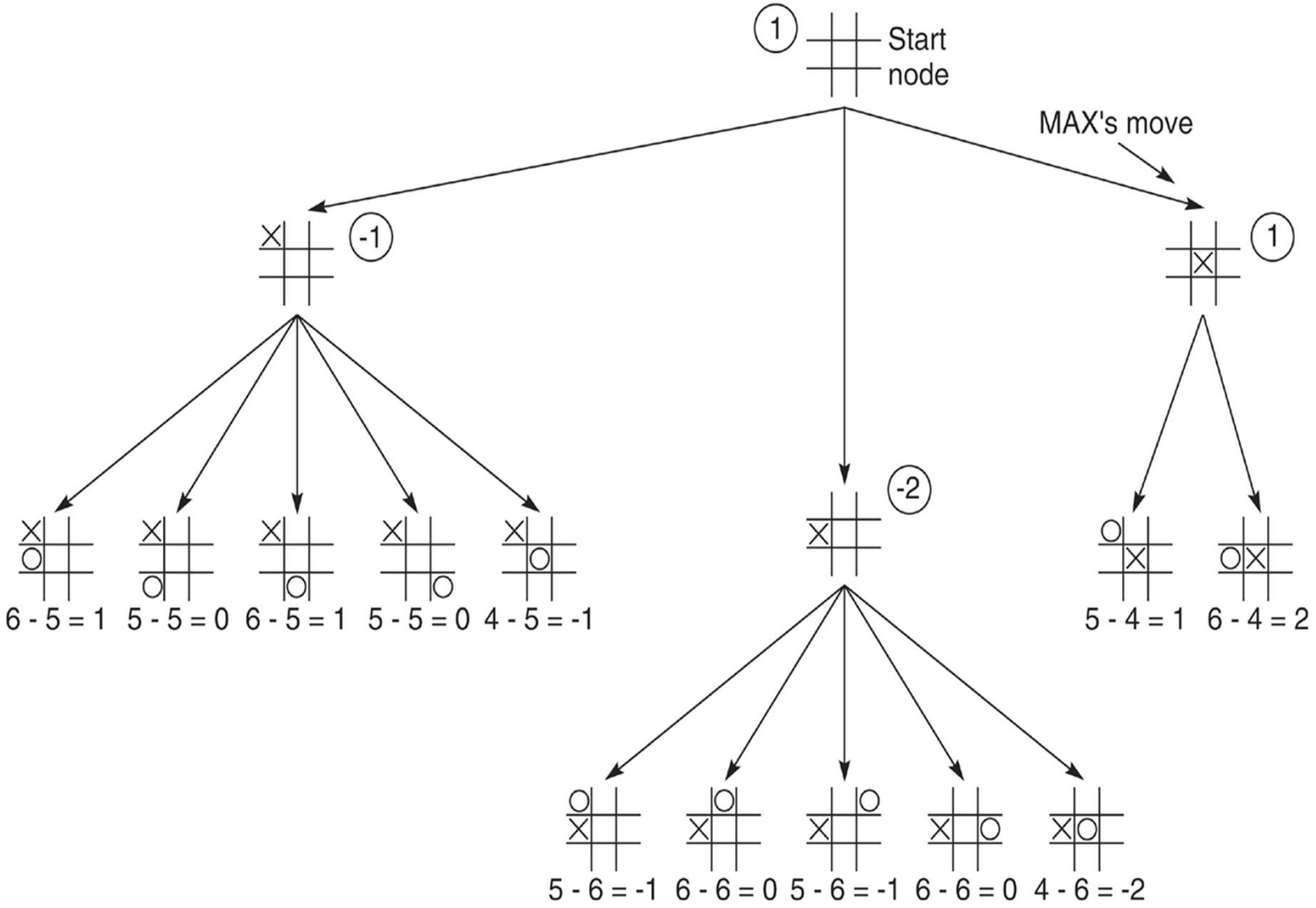
8	3	4
1	5	9
6	7	2

Program 3 - winning

Table 1.4 Status of Both Lists after Seventh Move

Player *X* (Human)
8 1 4 2
Player O (Computer)
↓
5 6 3

Program 4 : minimax



Comments

- Much more complex (time and space)
- Extendable
- AI technique

Current Trends in AI

- Traditional AI + BioSciences
- Soft Computing to deal with intractability, imprecision, uncertainty, partial truth, and approximation to achieve non-conventional solutions, robustness and low costs.
  - Fuzzy Logic (FL),
  - Artificial Neural Networks (ANN),
  - Evolutionary Computation (EC),
  - Genetic algorithms,
  - Swarm Intelligence (i.e. Ant colony optimization and Particle swarm optimization),
  - Multi-agent systems etc.