Artificial Intelligence (AI)

CCS-3880 – 3rd Semester 2023

CO1: Introduction to the AI

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Introduction to (AI)

CO1 Describe the fundamentals of artificial intelligence including various concepts and terminologies of intelligent agents

- Where is AI in Computer Science?
- What is Artificial Intelligence?

Where is AI in Computer Science?

Computer Science: problem solving using computers

Computer Architecture and System Software *study how to build good computers*.

Computation Theory and Complexity Theory *study what can be computed, what cannot be computed, i.e., the limits of different computing devices.*

Programming Languages *study how to use computers conveniently and efficiently.*

Algorithms and Data Structures *study how to solve popular computation problems efficiently.*

Artificial Intelligence, Databases, Networking, Security, etc., *study how to extend the use of computers.*

What is artificial intelligence?

Intelligence:

- "*the capacity to learn and solve problems*" (Websters dictionary)
- in particular,
  - the ability to solve novel problems
  - the ability to act rationally
  - the ability to act like humans

A scientific and engineering discipline devoted to:

- understanding principles that make intelligent behaviour possible in natural or artificial systems;
- developing methods for the design and implementation of useful, intelligent artifacts.

What is Intelligence then?

FAST THINKING?

A LOT OF KNOWLEDGE?

TO ACT AS A HUMAN?

TO REASON LOGICALLY?

TO LEARN?

TO PERCEIVE AND ACT UPON AN ENVIRONMENT?

TO PLAY CHESS AT GRAND-MASTER'S LEVEL?

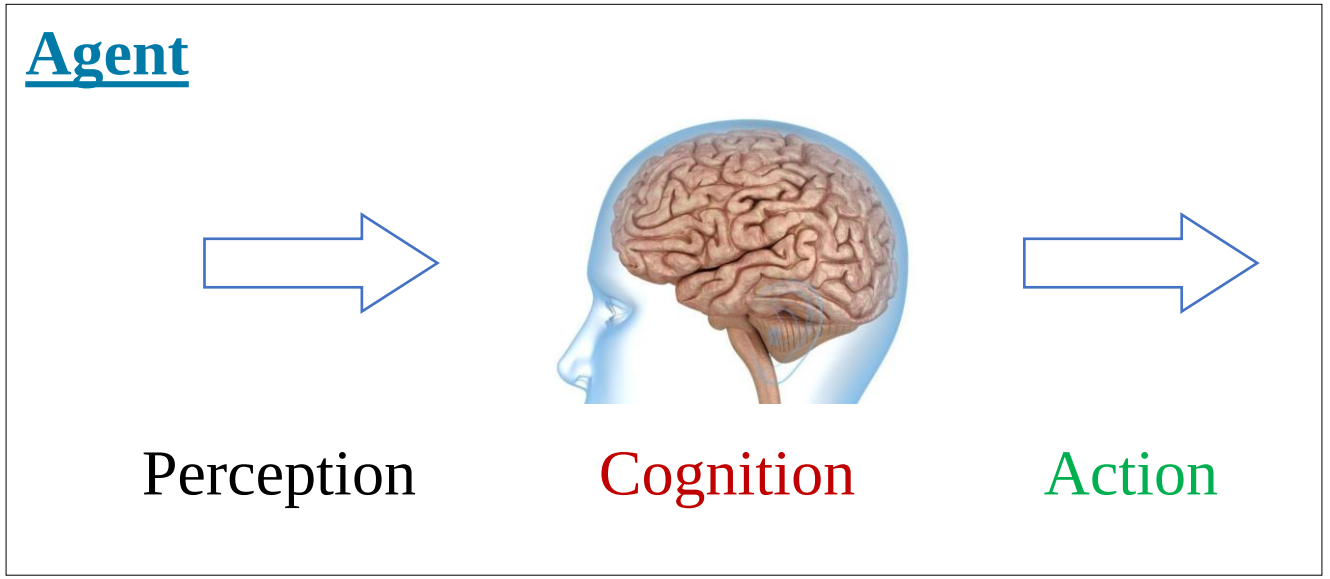
Dictionary: Intelligence

- The capacity to acquire and apply knowledge.
- The faculty of thought and reason.
- Superior powers of mind.
- *And others …*

Intelligent systems

Three key steps of a knowledge-based agent (Craik, 1943):

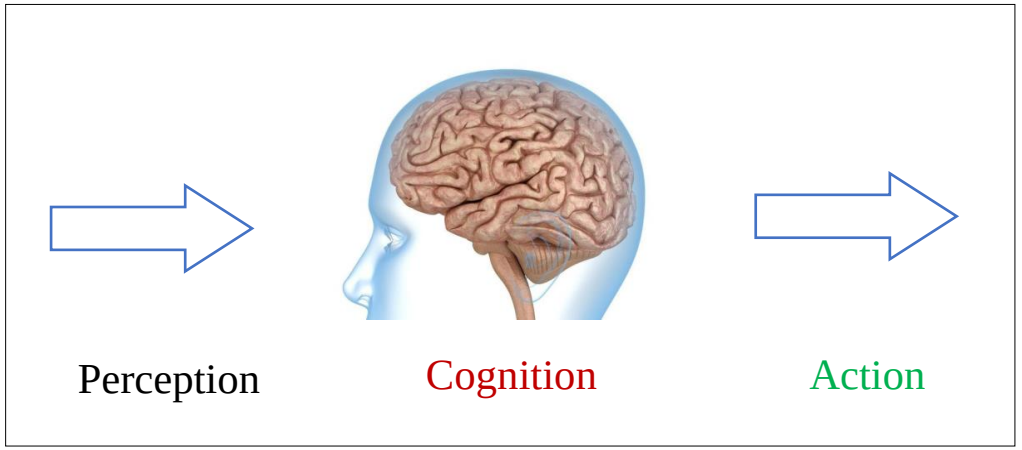
1. A thing must be translated into an internal representation
2. The representation is manipulated by cognitive processes.
3. The results of cognitive processes are, in turn, translated into action.



Representation

- All AI problems require some form of representation.
- A major part is representing the problem space as to allow efficient search for the best solution (s)
- Sometimes the representation is the output, e.g., discovering “patterns”.
- The output action can be complex.

- Chess board
- Maze
- Text
- Object
- Room
- Sound
- Visual scene

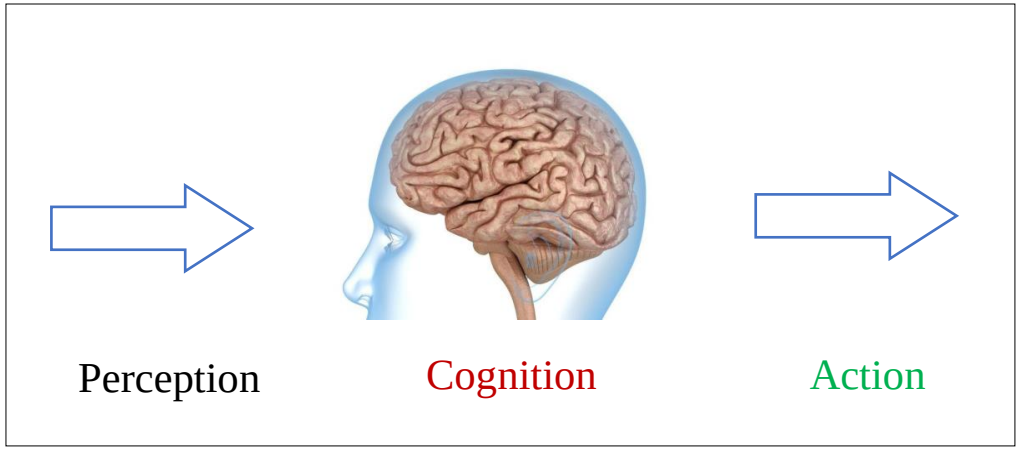


- Next move
- Label
- Movement
- *other actions …*

Thinking

What do you do once you have a representation? This requires a goal.

Rational behavior: choose actions that maximize goal achievement based on the given available information



- Next move
- Label
- Movement
- *other actions …*

- Chess board
- Maze
- Text
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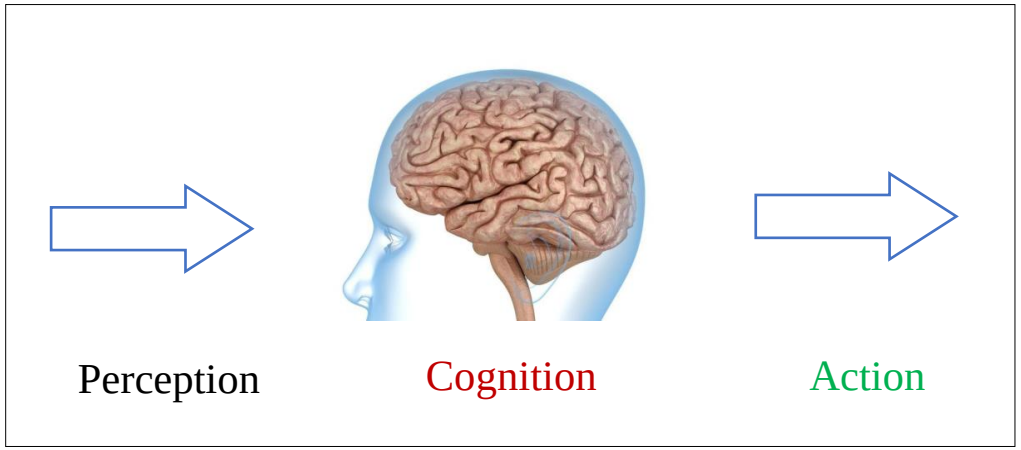
- Room
- Sound
- Visual scene

- Find best move
- Shortest path
- Semantic parsing
- Recognition
- Object localization
- Speech recognition
- Path navigation

Reasoning

- Reasoning can be thought of as constructing an accurate world model
- With uncertain info, most facts are not concrete and are not known with certainty
- Probabilistic inference: how do we give the proper weight to each observation?

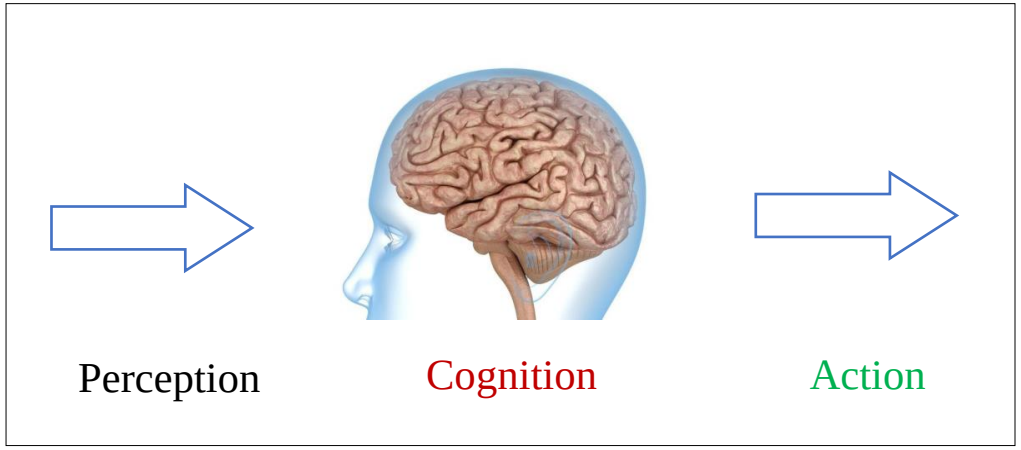


- facts
- observations
- "wet ground"
- "fever"

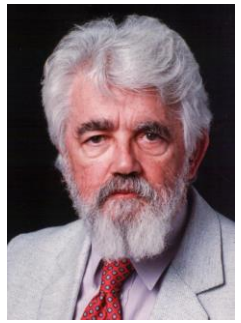
- logical consequences
- inferences
- "it may be rained"
- What causes?

Learning

- What if your world is changing? How do we maintain an accurate model?
- Adapt internal representation so that it is as accurate as possible.
- Can also adapt models of other agents



Artificial Intelligence: some definitions



John McCarthy
Stanford University

- AI *is "a branch of Science which deals with helping machines find solutions to complex problems in a more human-like fashion"*.
- AI is "*the science of making machines do things that would require intelligence if done by man*", Raphael
- The study of "*mental faculties through the use of computational models*". Charniak and McDermott, 1985
- The study of how to "*make computers do things at which, at the moment, people are better*". Rich & Knight, 1991

Strong AI vs. Weak AI vs. Superintelligence

- **Weak AI (Narrow)** — Today's AI

  Machines with weak Artificial Intelligence are made to respond to specific situations, but can not think for themselves

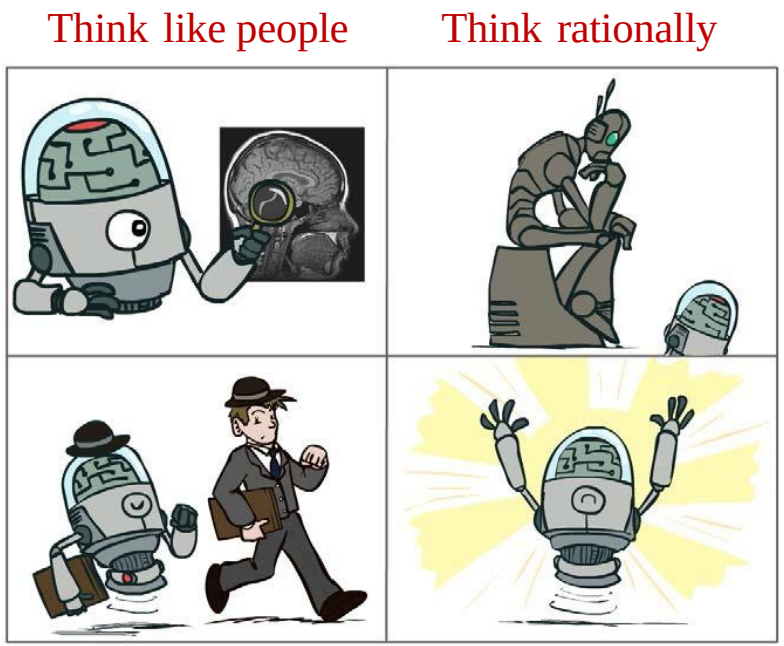
- **Strong AI (General)** — Future AI – around 2040

  A machine with strong AI can think and act just like a human. It can learn from experiences, but there are no real-life examples of strong AI yet.

- **Superintelligence** — Soon after Strong AI
  - Super AI demonstrates intelligence beyond human capabilities.
  - Super AI will surpass human intellect to accomplish any task better than its human counterparts.

Different Types of Artificial Intelligence

1. Modeling exactly how humans actually *think*
2. Modeling exactly how humans actually *act*
3. Modeling how ideal agents "should *think*"
4. Modeling how ideal agents "should *act*"



- *Modern AI focuses on the last definition*
- Success is judged by how well the agent performs

Thinking humanly: Cognitive Science

- **If we are going to say that a given program thinks like a human**, we must have some way of determining *how humans think*. We need to get *inside* the actual workings of human minds.

- **There are three ways to do this:**
  - through mind reflexion —*trying to catch our own thoughts as they go by;*
  - through psychological experiments—*observing a person in action;*
  - and through brain imaging —*observing the brain in action.*

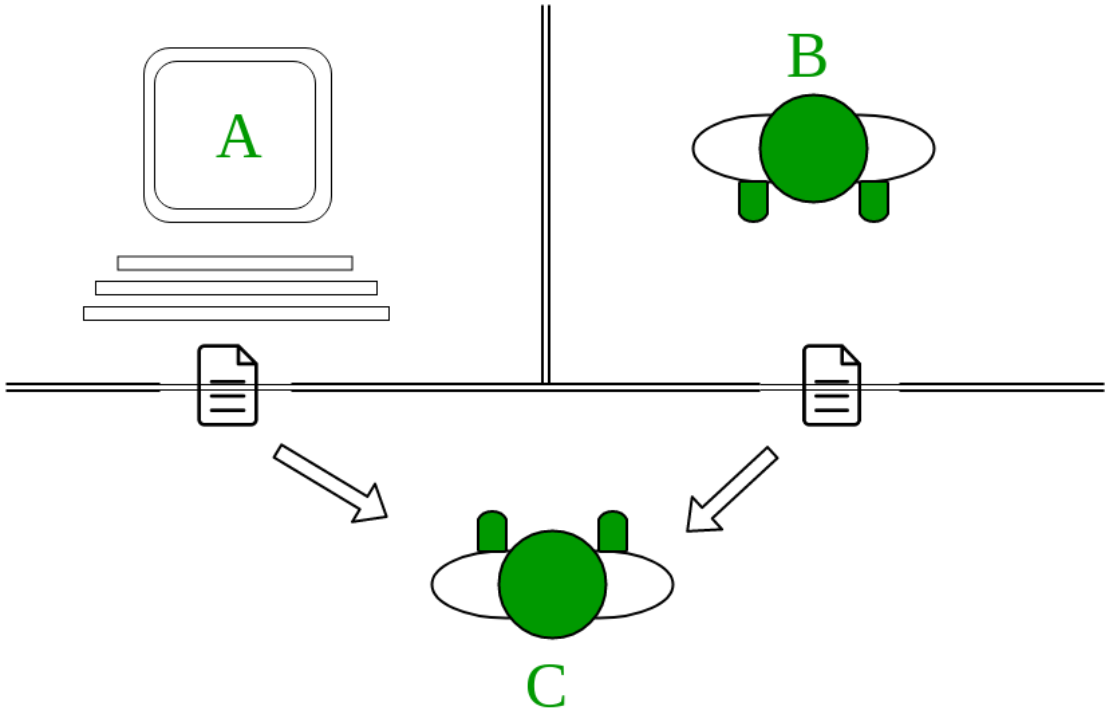
- **Once we have a sufficiently precise theory of the mind**, it becomes possible to express the theory as a computer program. If the program's input–output behavior matches corresponding human behavior, that is evidence that some of the program's mechanisms could also be operating in humans.

Thinking rationally: Laws of Thought

- **Problems:**
  - Not all intelligent behavior is mediated by logical deliberation (careful discussion or consideration).
  - What is the purpose of thinking? What thoughts should I have out of all the thoughts (logical or otherwise) that I could have?

- **There are two main obstacles to this approach**
  - *First*, it is not easy to take informal knowledge and state it in the formal terms required by logical notation, particularly when the knowledge is less than 100% certain.
  - *Second*, there is a big difference between solving a problem "in principle" and solving it in practice. Even problems with just a few hundred facts can exhaust the computational resources of any computer unless it has some guidance as to which reasoning steps to try first.

Acting humanly: Turing test

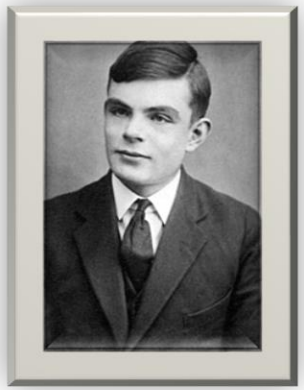


- In the 1950s Alan Turing created the Turing Test which is used to determine the level of intelligence of a computer.

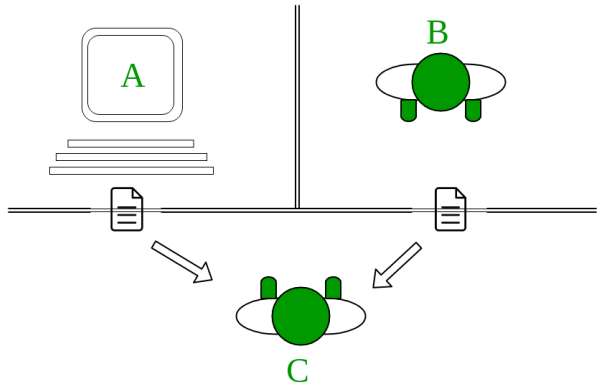
  Turing (1950) "Computing machinery and intelligence"

- **Some people disagree with the Turing Test.** They claim it does not actually measure a computer's intelligence.

- **Problem**: Turing test is not reproducible, constructive, or amenable (controllable) to mathematical analysis



Acting humanly: Turing test



Eugene Goostman is a chatbot

Ukrainian boy (13 years old)

On 7 June 2014, in a Turing test competition at the Royal Society, organised by the University of Reading to mark the 60th anniversary of Turing's death, Goostman won after 33% of the judges were convinced that the bot was human

Acting rationally: Rational agents

- **Rational behavior**
  - "doing the right thing", i.e., that which is expected to maximize goal achievement, given the available information
  - doesn't necessarily involve thinking, but thinking should be in the service of rational action
- **An agent is an entity that perceives and acts.**
- **This course is about designing rational agents**
- **The rational-agent approach has two advantages over the other approaches.**
  - First, it is more general than the "laws of thought" approach because correct inference is just one of several possible mechanisms for achieving rationality.
  - Second, it is more amenable to scientific development than are approaches based on human behavior or human thought.

Foundation and Main Techniques of AI

Foundation is based on

- Computer Science and Engineering
- Mathematics
  - Formal logical methods, e.g., *Boolean logic & Fuzzy logic*
  - Uncertainty e.g., *Probability theory*
- Neuroscience
  - How do the brain work?
  - Neurons as information processing units
- Control Theory
  - Machines can modify their behavior in response to the environment, e.g., Water-flow
- Linguistics
  - Analysis of human language
  - Grammar, …

Techniques

- Search
- Knowledge Representation
- Formal Logics
- Neural Networks
- Genetic Algorithm

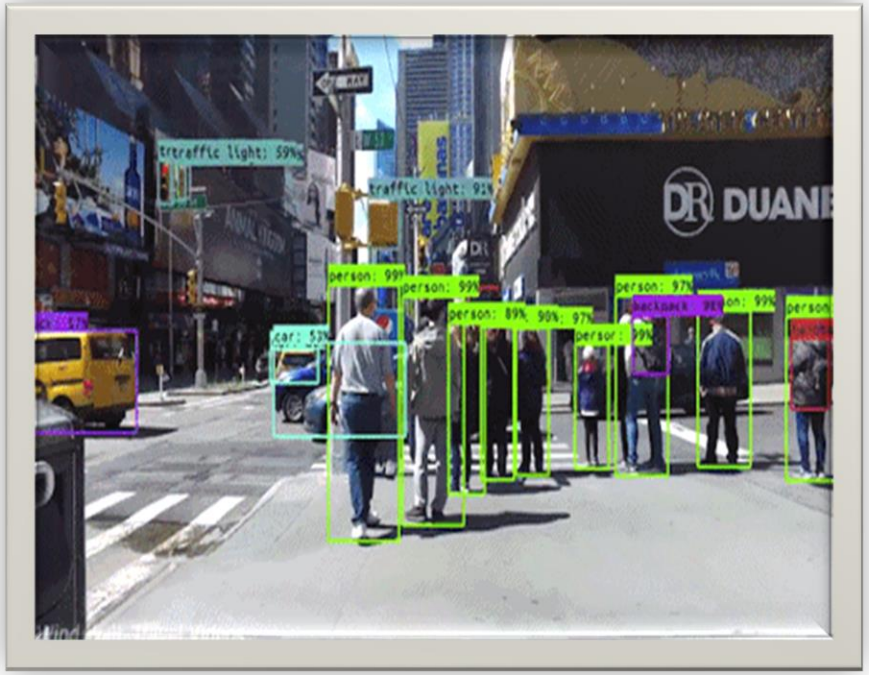
Applications of AI

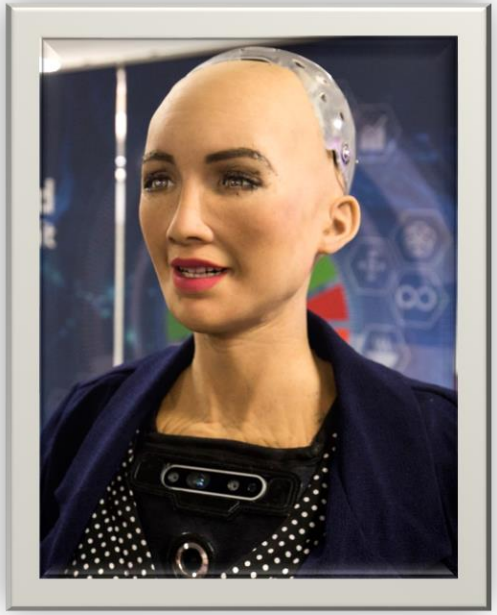
AI has been dominant in various fields such as:

- Gaming
- Natural Language Processing
- Expert Systems
- Vision Systems
- Speech Recognition
- Handwriting Recognition
- Intelligent Robots
- *Others …*

Real Life AI Examples

- Self Driving Cars
- Boston Dynamics
- Navigation Systems
- ASIMO
- Chatbots
- Human vs Computer Games
- Many More!





Contents for the next lectures

- Problem Solving and Representation
- Problem as a State Space Search
  - Problem Types
  - States
  - State Space
  - State Modification
  - Problem Solution
  - Formal Description of the Problem
  - Examples: 8 Puzzle & Traveling Salesman Problems
- State Space Search – *the basic idea*
- Search Tree
- State Space vs. Search Trees
- Comparing Problems and Algorithms
- Search Strategies (Blind Search)
  - Breadth-First Search (BFS)
  - Uniform Cost Search
  - Depth-First Search (DFS)
  - Depth-Limited Search
  - Iterative Deepening Search

Any questions?