Artificial Intelligence

Lecture 1, Chapter 1,2

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What is AI?

- (The automation of) activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)
- "The study of mental faculties through the use of computational models" (Charniak+McDermott, 1985)
- "The study of how to make computers do things at which, at the moment, people are better" (Rich+Knight, 1991)
- "The branch of computer science that is concerned with the automation of intelligent behavior" (Luger + Stubblefield, 1993)

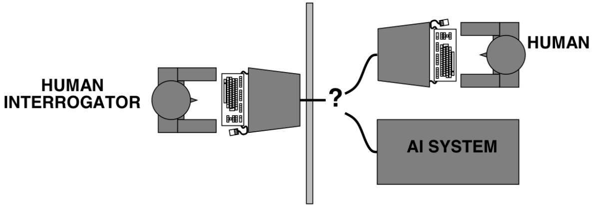
What is AI?

Views of AI fall into four categories:

Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

- Suggested major components of AI: knowledge, reasoning, language understanding, learning.

Acting Humanly: Turing Test



- Turing (1950) "Computing machinery and intelligence":
- "Can machines think?" "Can machines behave intelligently?"
- The Imitation Game (2014)

Thinking Humanly: Cognitive Modelling

- How human thinks?
- Two ways to determine a given program thinks like human (i)Through introspection , (ii)Through psychological experiments
- After defining theory, we can express it as a computer program and check if it is behaving like human

Thinking Rationally: Laws of Thought

- Normative rather than descriptive
- Aristotle was one of the first to attempt to codify "right thinking" – reasoning processing

Acting Rationally

- Rational Behavior: doing the right thing
- Right thing: maximizes our goal achievement, given the available information.
- Doesn't necessarily involve thinking – but thinking should be in the service of rational action.

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Foundation of AI

Philosophy	logic, methods of reasoning
	mind as physical system
	foundations of learning, language, rationality
Mathematics	formal representation and proof
	algorithms
	computation, (un)decidability, (in)tractability
	probability
Psychology	adaptation
	phenomena of perception and motor control
	experimental techniques (psychophysics, etc.)
Linguistics	knowledge representation
	grammar
Neuroscience	physical substrate for mental activity
Control theory	homeostatic systems, stability
	simple optimal agent designs

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history of AI

1943	McCulloch & Pitts: Boolean circuit model of brain
1950	Turing's "Computing Machinery and Intelligence"
1952–69	Look, Ma, no hands!
1950s	Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Eng
1956	Dartmouth meeting: "Artificial Intelligence" adopted
1965	Robinson's complete algorithm for logical reasoning
1966–74	AI discovers computational complexity Neural network research almost disappears
1969–79	Early development of knowledge-based systems
1980–88	Expert systems industry booms
1988–93	Expert systems industry busts: "AI Winter"
1985–95	Neural networks return to popularity
1988–	Resurgence of probabilistic and decision-theoretic methods Rapid increase in technical depth of mainstream AI "Nouvelle AI": ALife, GAs, soft computing

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Until 2010, AIMA 3rd edition

- Robotic vehicles
- Speech recognition
- Game playing
- Autonomous planning and scheduling
- Spam fighting
- Robotics
- Machine Translation

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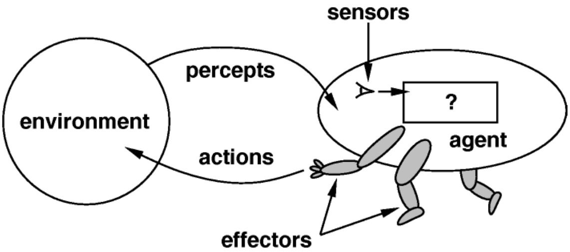
Intelligent Agents

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors.
- Our aim is to design agents.
- A rational agent is one that performs the actions that cause the agent to be most successful.



Rational Agent

- An **agent** is an entity that **perceives** and **acts**. Abstractly, an agent is a function from percept histories to actions:

$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

- Doesn't necessarily involve thinking – but thinking should be in the service of rational action.
- For any given class of environments and tasks, we seek the agent with the best performance
- Target is to design best program for given machine resources.

Structure of Intelligent Agents

- The job of AI is to design the **agent program:** a function that implements the agent mapping from percepts to actions. We assume this program will run on some sort of computing device call the architecture.
- The **architecture** makes the percepts from the sensors available to the agent program. runs the program and feeds the program's action choices to the effectors as they are generated.
- **agent=architecture + program**

Agent Programs

- All agent programs have roughly the same skeleton; they accept percepts from the environment and generate actions.

```
function SKELETON-AGENT( percept) returns action
   static: memory, the agent's memory of the world

   memory ← UPDATE-MEMORY(memory, percept)
   action ← CHOOSE-BEST-ACTION(memory)
   memory ← UPDATE-MEMORY(memory, action)
   return action
```

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Specifying the task environment

PEAS (Performance, Environment, Actuators, Sensors)

Must first specify the setting for intelligent agent design.
Consider, e.g., the task of designing **an automated taxi:**

- **Performance:** Safe, fast, legal, comfortable trip, maximize profits
- **Environment:** Roads, other traffic, pedestrians,customers
- **Actuators:** Steering, accelerator, brake, signal, horn, display
- **Sensors:**Cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors, keyboard

agent types and their PEAS descriptions.

Agent Type	Performance Measure	Environment	Actuators	Sensors
Medical diagnosis system	Healthy patient, reduced costs	Patient, hospital, staff	Display of questions, tests, diagnoses, treatments, referrals	Keyboard entry of symptoms, findings, patient's answers
Satellite image analysis system	Correct image categorization	Downlink from orbiting satellite	Display of scene categorization	Color pixel arrays
Part-picking robot	Percentage of parts in correct bins	Conveyor belt with parts; bins	Jointed arm and hand	Camera, joint angle sensors
Refinery controller	Purity, yield, safety	Refinery, operators	Valves, pumps, heaters, displays	Temperature, pressure, chemical sensors
Interactive English tutor	Student's score on test	Set of students, testing agency	Display of exercises, suggestions, corrections	Keyboard entry

Figure 2.5 Examples of agent types and their PEAS descriptions.

Properties of task environments: Environment types

- Fully observable (vs. partially observable): An agent's sensors give it access to the complete state of the environment at each point in time.
- Deterministic (vs. stochastic): The next state of the environment is completely determined by the current state and the action executed by the agent. (If the environment is deterministic except for the actions of other agents, then the environment is strategic)
- Episodic (vs. sequential): An agent's action is divided into atomic episodes. Decisions do not depend on previous decisions/actions.

Environment types - cont.

- Static (vs. dynamic): The environment is unchanged while an agent is deliberating. (The environment is semidynamic if the environment itself does not change with the passage of time but the agent's performance score does)
- Discrete (vs. continuous): A limited number of distinct, clearly defined percepts and actions. How do we represent or abstract or model the world?
- Single agent (vs. multi-agent): An agent operating by itself in an environment. Does the other agent interfere with my performance measure?

Task and Environment

Task Environment	Observable	Agents	Deterministic	Episodic	Static	Discrete
Crossword puzzle	Fully	Single	Deterministic	Sequential	Static	Discrete
Chess with a clock	Fully	Multi	Deterministic	Sequential	Semi	Discrete
Poker	Partially	Multi	Stochastic	Sequential	Static	Discrete
Backgammon	Fully	Multi	Stochastic	Sequential	Static	Discrete
Taxi driving	Partially	Multi	Stochastic	Sequential	Dynamic	Continuous
Medical diagnosis	Partially	Single	Stochastic	Sequential	Dynamic	Continuous
Image analysis	Fully	Single	Deterministic	Episodic	Semi	Continuous
Part-picking robot	Partially	Single	Stochastic	Episodic	Dynamic	Continuous
Refinery controller	Partially	Single	Stochastic	Sequential	Dynamic	Continuous
Interactive English tutor	Partially	Multi	Stochastic	Sequential	Dynamic	Discrete

Figure 2.6 Examples of task environments and their characteristics.

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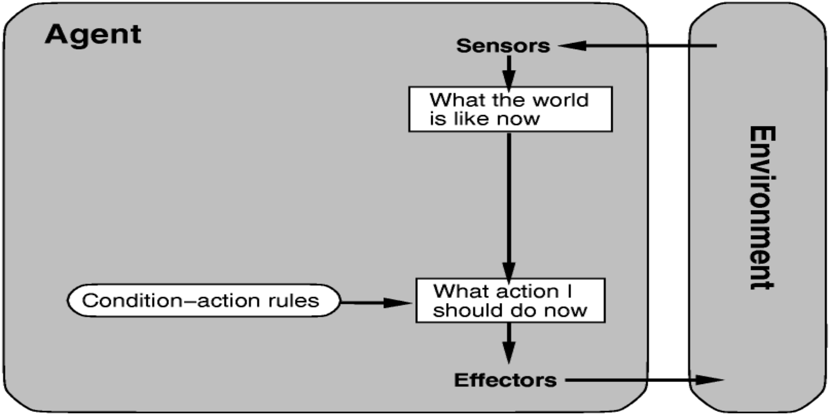
kinds of Agent Programs

Four basic kinds of agent programs that embody the principles underlying almost all intelligent systems:

- Simple reflex agents;
- Model-based reflex agents;
- Goal-based agents;
- Utility-based agents.

Simple reflex agents



Simple reflex agents Algorithm

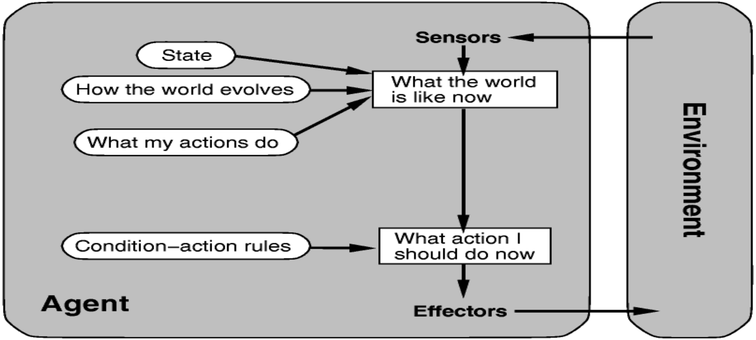
- If **condition** then **action**

```
function SIMPLE-REFLEX-AGENT(percept) returns action
   static: rules, a set of condition-action rules

   state ← INTERPRET-INPUT(percept)
   rule ← RULE-MATCH(state, rules)
   action ← RULE-ACTION[rule]
   return action
```

Model-based reflex agents

- Agents that keep track of the world(state).



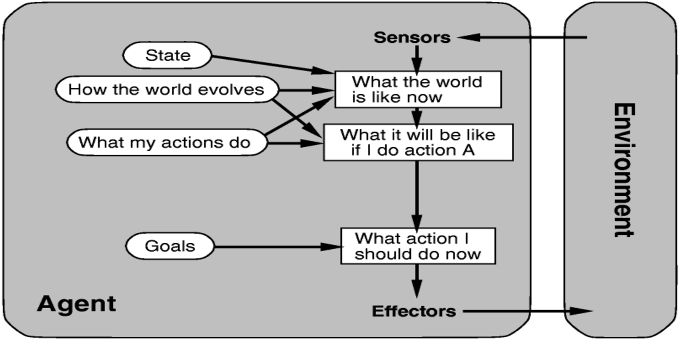
Model-based reflex agents Algorithm

```
function REFLEX-AGENT-WITH-STATE(percept) returns action
   static: state, a description of the current world state
           rules, a set of condition-action rules

   state ← UPDATE-STATE(state, percept)
   rule ← RULE-MATCH(state, rules)
   action ← RULE-ACTION[rule]
   state ← UPDATE-STATE(state, action)
   return action
```

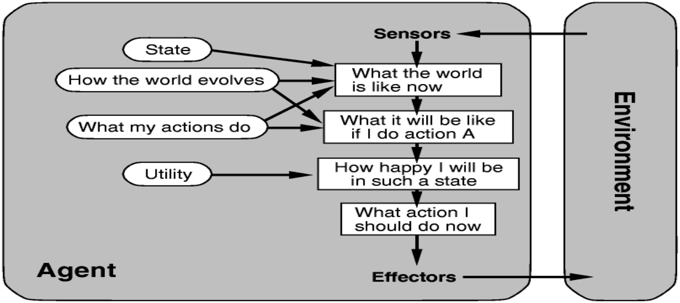
Goal-based agents

- **Search** and **Planning** are the sub fields of AI devoted to finding action sequences that achieve goals.



Utility-based agents

- Goals alone are not enough to generate high-quality behaviour. For example, there are many action sequences that will get the taxi to its destination, but some are quicker, safer, more reliable, cheaper, etc.



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Exercise Questions

- Reading Assignment
  Artificial Intelligence: A Modern Approach Textbook by Peter Norvig and Stuart J. Russell
  Chapter 1, Chapter 2
- MCQ Questions and Short Questions will have in QUIZ as well as TERM EXAM.

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