UNIT 1

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Introduction

- Humankind has given itself the scientific name **Homo sapiens**—man the wise, because our mental capacities are so important to our everyday lives and our sense of self.
- The field of **Artificial Intelligence** or **AI**, attempts to understand intelligent entities.
- Thus, one reason to study it is to learn more about ourselves. But unlike philosophy and psychology, which are also concerned with intelligence.
- **Artificial Intelligence** is a branch of *Computer Science* which deals with helping machines find solutions to complex problems in a more human-like fashion.
- This generally involves borrowing characteristics from human intelligence, and applying them as algorithms in a computer friendly way.
- **AI** is generally associated with ***Computer Science***, but it has many important links with other fields such as ***Mathematics, Psychology, Cognition, Biology* and *Philosophy***, among many others. The ability to combine knowledge from all these fields will ultimately benefit the progress in the quest of creating an intelligent artificial being.

Motivation

- Computers are fundamentally well suited to performing mechanical computations, using fixed programmed rules.
- This allows artificial machines to perform simple monotonous tasks efficiently and reliably, which humans are ill-suited to.
- For more complex problems, things get more difficult.
- Unlike humans, computers have trouble understanding specific situations, and adapting to new situations.
- Artificial Intelligence aims to improve machine behavior in tackling such complex tasks.
- Together with this, much of AI research is allowing us to understand our intelligent behavior.
- Humans have an interesting approach to problem-solving, based on abstract thought, high-level deliberative reasoning and pattern recognition.
- Artificial Intelligence can help us understand this process by recreating it, then potentially enabling us to enhance it beyond our current capabilities.

What is Artificial?

- Artificial is something which is made or produced by human beings rather than occurring naturally, especially as a copy of something natural.

What is Intelligence?

- Intelligence is the ability to acquire and apply knowledge and skills to achieving the goals. It involves the ability to understand the situation and reasons about the consequences of one's action.

- It also involves learning from the experience and adapting once behavior in a dynamic environment.

- But most of all, it involves being able to make sense of the word around us and reasoning about change in this word.

What is Artificial Intelligence?

- Artificial Intelligence is used for "*Building programs that enable computers to do what humans can do*."
- For example: read, walk around, drive, play games, solve problems, learn, have conversations etc.

The definitions of Artificial Intelligence

The definitions of AI are organized into four categories:

1. Systems that think like human.
2. Systems that act like human.
3. Systems that think rationally.
4. Systems that act rationally

What is AI? (Some Definitions of AI, Organized into 4 Categories)

Systems that think like human	Systems that think rationally
•"The exciting new effort to make computers thinks … *machine with minds,* in the full and literal sense" (Haugeland 1985) •"The automation of activities that we associate with human thinking, activities: decision-making, problem-solving, learning…." (Bellman 1978)	•"The study of mental faculties through the use of computational models" (Charniak et al. 1985) •"The study of the computations that make it possible to perceive,reason, and act." (Winston 1992)
Systems that act like human	**Systems that act rationally**
• "The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990) • "The study of how to make computers do things at which, at the moment, people are better." (Rich&Knight 1991)	• A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkol, 1990) • "AI ….. Is concerned with intelligent behavior in artifacts." (Nilsson 1998)

History

- The name Artificial Intelligence is credited to John McCarthy(known as Father of AI) who, along with Marvin Minsky and Claude Shannon organized the Dartmouth Conference in 1956. So the modern history of AI from 1956 onwards is given below:

- **1956(The gestation of AI)**

- John McCarthy coined the term "artificial intelligence" as the topic of the Dartmouth Conference, the first conference devoted to the subject.

- Demonstration of the first running AI program, the Logic Theorist (LT) written by Allen Newell, J.C. Shaw and Herbert Simon (Carnegie Institute of Technology, now Carnegie Mellon University).

- **1957**

- The General Problem Solver (GPS) demonstrated by Newell, Shaw & Simon.

- **1952-62**

- Arthur Samuel (IBM) wrote the first game-playing program, for checkers, to achieve sufficient skill to challenge a world champion.
- Samuel's machine learning programs were responsible for the high performance of the checkers player.

- **1960’s (A dose of reality)**

- First industrial robot company, Unimation, founded.
- Dendral program (Edward Feigenbaum, Joshua Lederberg, Bruce Buchanan, Georgia. Sutherland at Stanford) demonstrated to interpret mass spectra on organic chemical compounds. First successful knowledge-based program for scientific reasoning.
- Joel Moses demonstrated the power of symbolic reasoning for integration problems in the program. First successful knowledge-based program in mathematics.
- Richard Greenblatt at MIT built a knowledge-based chess-playing program, MacHack that was good enough to achieve a class-C rating in tournament play.

- **1970’s (Knowledge based Program: the key to power)**

- Jaime Carbonell (Sr.) developed SCHOLAR, an interactive program for computer-aided instruction based on semantic nets as the representation of knowledge.

- Jane Robinson & Don Walker established influential Natural Language Processing group at SRI.

- Prolog developed by Alain Colmerauer.

- Ted Shortliffe's PhD dissertation on MYCIN (Stanford) demonstrated the power of rule-based systems for knowledge representation and inference in the domain of medical diagnosis and therapy. Sometimes called the **first expert system**.

- Tom Mitchell, at Stanford, invented the concept of Version Spaces for describing the search space of a concept formation program.

- Herb Simon wins the Nobel Prize in Economics for his theory of bounded rationality, one of the cornerstones of AI known as "satisficing".

• 1980's (AI becomes an industry)

- Lisp Machines developed and marketed.
- First expert system shells and commercial applications.
- Neural Networks become widely used with the Backpropagation algorithm (first described by Werbos in 1974).
- Dean Pomerleau at CMU creates ALVINN (An Autonomous Land Vehicle in a Neural Network), which grew into the system that drove a car coast-to-coast under computer control for all but about 50 of the 2850 miles.

- **1990's (The return of neural networks)**

- NASA's pathfinder mission made a successful landing and the first autonomous robotics system, Sojourner, was deployed on the surface of Mars. (July 4, 1997)
- First official Robo-Cup soccer match (1997) featuring table-top matches with 40 teams of interacting robots and over 5000 spectators.

- **2000's (Recent events)**

- Interactive robot pets (a.k.a. "smart toys") become commercially available, realizing the vision of the 18th cen. novelty toy makers.
- Cynthia Breazeal at MIT publishes her dissertation on Sociable Machines, describing KISMET, a robot with a face that expresses emotions.
- Stanford's autonomous vehicle, Stanley, wins DARPA Grand Challenge race. (October 2005).
- The Nomad robot explores remote regions of Antarctica looking for meteorite samples.

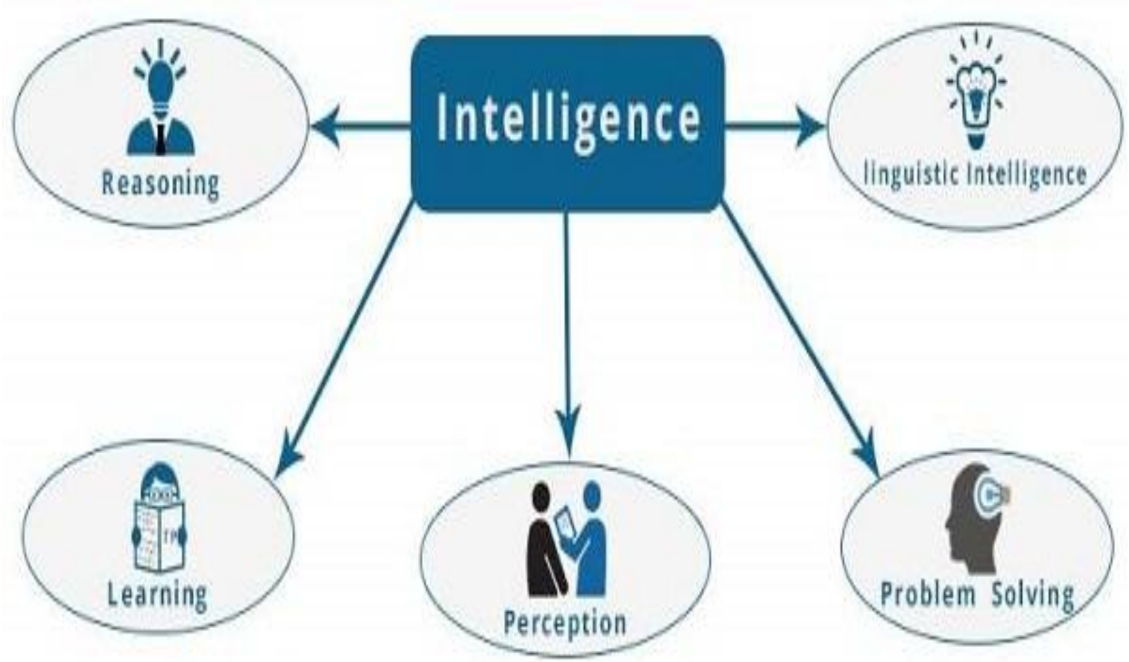
Intelligence Systems

- An intelligent system is a machine with an embedded, Internet-connected computer that has the capacity to gather and analyze data and communicate with other systems.
- Other criteria for intelligent systems include the capacity to learn from experience, security, connectivity, the ability to adapt according to current data and the capacity for remote monitoring and management.

What is Intelligence Composed of?

The intelligence is intangible.
It is composed of −

- Reasoning
- Learning
- Problem Solving
- Perception
- Linguistic Intelligence



- **Reasoning** − It is the set of processes that enables us to provide basis for judgment, making decisions, and prediction. There are broadly two types − Inductive Reasoning and Deductive Reasoning.
- **Learning** − It is the activity of gaining knowledge or skill by studying, practicing, being taught, or experiencing something. Learning enhances the awareness of the subjects of the study. The ability of learning is possessed by humans, some animals, and AI-enabled systems.
- **Problem Solving** − It is the process in which one perceives and tries to arrive at a desired solution from a present situation by taking some path, which is blocked by known or unknown hurdles. Problem solving also includes **decision making**, which is the process of selecting the best suitable alternative out of multiple alternatives to reach the desired goal are available.
- **Perception** − It is the process of acquiring, interpreting, selecting, and organizing sensory information. Perception presumes **sensing**. In humans, perception is aided by sensory organs. In the domain of AI, perception mechanism puts the data acquired by the sensors together in a meaningful manner.
- **Linguistic Intelligence** − It is one's ability to use, comprehend, speak, and write the verbal and written language. It is important in interpersonal communication.

Examples of Intelligent System

1) **Expert System**: An expert system is an intelligent system which in an interactive setting asks a person for information and, based upon the response, draws conclusions or gives advice.

2) **Intelligent Agent:** An intelligent agent is an intelligent system which perceives its environment by sensors and which uses that information to act upon the environment.

3) **Virtual Personal Assistants:** Siri, Google Now, and Cortana are all intelligent digital personal assistants on various platforms (iOS, Android, and Windows Mobile). In short, they help find useful information when you ask for it using your voice; you can say "Where's the nearest Chinese restaurant?", "What's on my schedule today?", "Remind me to call Jerry at eight o'clock," and the assistant will respond by finding information, relaying information from your phone, or sending commands to other apps.

1) **Security Surveillance**: With supervised training exercises, security algorithms can take input from security cameras and determine whether there may be a threat—if it "sees" a warning sign, it will alert human security officers.

2) **Smart Home Devices**: Many smart home devices now include the ability to learn your behavior patterns and help you save money by adjusting the settings on your thermostat or other appliances in an effort to increase convenience and save energy. For example, turning your oven on when you leave work instead of waiting to get home is a very convenient ability. A thermostat that knows when you're home and adjusts the temperature accordingly can help you save money by not heating the house when you're out.

Foundations of AI

- **Philosophy (428B.C.-Present):** Aristotle (384-322 B.C.) was the first to formulate a precise set of laws governing the rational part of the mind. He developed an informal system of syllogisms for proper reasoning, which allowed one to generate conclusions mechanically, given initial premises.

- **Mathematics (c. 800-Present):** The Great Contribution of mathematics to AI is in three fundamental areas: Logic, Computation and probability.

- **Economics (1776-Present):** Work in economics and operational research has contributed much to our notion of rational agents. Herbert Simon(1916-2001), the pioneering AI researcher, won the Nobel prize in economics in 1978 for his early work showing that model based on satisficing- making decisions that are good enough.

- **Psychology (1879- Present):** The origin of scientific psychology are traced back to the wok if German physiologist Hermann von Helmholtz(1821-1894) and his student Wilhelm Wundt(1832 – 1920). In 1879, Wundt opened the first laboratory of experimental psychology at the university of Leipzig. In US,the development of computer modeling led to the creation of the field of

- **cognitive science**. The field can be said to have started at the workshop in September 1956 at MIT.

- **Neuroscience (1861- Present):** Neuroscience is the study of the nervous system, particularly the brain. Neuroscience has contributed a lot because AI is trying to mimic the human brain.

- **Control theory and Cybernetics (1948- Present):** Ktesibios of Alexandria (c. 250 B.c.) built the first self-controlling machine: a water clock with a regulator that kept the flow of water running through it at a constant, predictable pace. Modern control theory, especially the branch known as stochastic optimal control, has as its goal the design of systems that maximize an **objective function** over time.

- **Linguistics (1957- Present):** Modem linguistics and AI, then, were "born" at about the same time, and grew up together, intersecting in a hybrid field called **computational linguistics** or **natural language processing.**

- **Computer engineering (1940-Present):** For artificial intelligence to succeed, we need two things: intelligence and an artifact. The computer has been the artifact of choice. **AI** also owes a debt to the software side of computer science, which has supplied the operating systems, programming languages, and tools needed to write modern programs.

Sub areas of AI

- AI now consists of many sub areas, few of them include:

    1. Artificial Neural Networks
    2. Robotics
    3. Expert Systems
    4. Speech Processing
    5. Natural Language Processing
    6. Machine Learning
    7. Vision Recognition
    8. Evolutionary and Genetic Computing

Applications of AI :

Research Areas	Examples	Research Areas	Examples
Artificial Neural Networks	• Stock Market Prediction • Loan Prediction • Character Recognition • Security • Medicine and Security	Natural Language Processing	• Spelling amendment, syntax checking • Speech appreciation • text to speech • Enhances search engines
Robotics	• Galaxy Robotics • Subaquatic Robotics • Rechargeable Mobility	Machine Learning	• Face detection • Image classification • Speech recognition • Anti-virus • Anti-spam • genetics
Expert Systems	• DENDRAL • MYCIN • Online Ticket Booking	Vision Recognition	• Navigation, i.e. Autonomous vehicle • Monitoring Process • Military, i.e. discovering enemy soldiers, vehicles and missile guidance.
Evolutionary and Genetic Computing	• Involving of Biomimetic • DNA Test		

Intelligent Agent

- Agents and Environments
- The Structure of Agents

Intelligent Agent

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.
- A human agent has eyes, ears, and other organs for sensors and hands, legs, vocal tract, and so on for actuators.
- A robotic agent might have cameras and infrared range finders for sensors and various motors for actuators.
- A software agent receives keystrokes, file contents, and network packets as sensory inputs and acts on the environment by displaying on the screen, writing files, and sending network packets.

- This simple idea is illustrated in Figure.

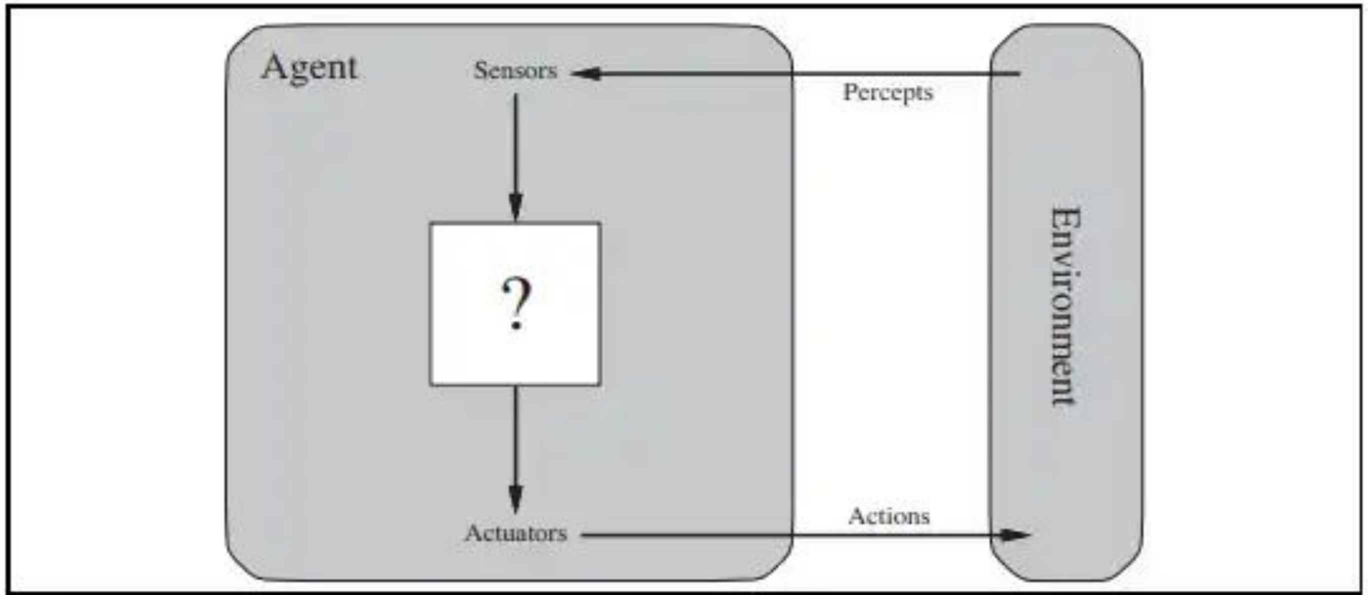
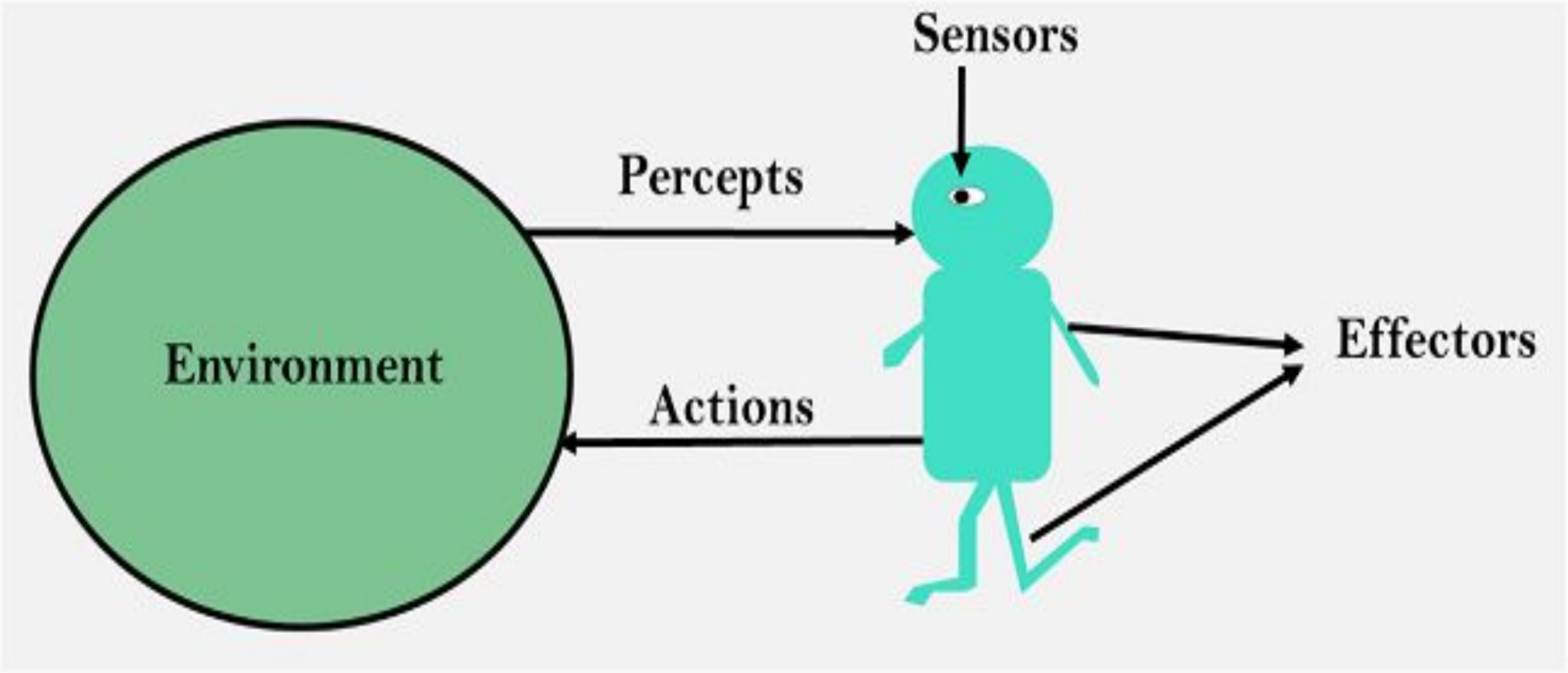


Figure 2.1 Agents interact with environments through sensors and actuators.

- **Sensor:** Sensor is a device which detects the change in the environment and sends the information to other electronic devices. An agent observes its environment through sensors.
- **Actuators:** Actuators are the component of machines that converts energy into motion. The actuators are only responsible for moving and controlling a system. An actuator can be an electric motor, gears, rails, etc.
- **Effectors:** Effectors are the devices which affect the environment. Effectors can be legs, wheels, arms, fingers, wings, fins, and display screen.


Sensors
Percepts
Environment
Actions
Effectors

- The term percept is used to refer to the agent’s perceptual inputs at any given instant.
- An agent’s percept sequence is the complete history of everything the agent has ever perceived.
- In general, an agent’s choice of action at any given instant can depend on the entire percept sequence observed to date, but not on anything it hasn’t perceived.

- Mathematically speaking, an agent’s behavior is described by the agent function that maps any given percept sequence to an action.
- Given an agent to experiment with, we can, in principle, construct a table by trying out all possible percept sequences and recording which actions the agent does in response.
- The table is, of course, an external characterization of the agent. Internally, the agent function for an artificial agent will be implemented by an agent program.
- It is important to keep these two ideas distinct. The agent function is an abstract mathematical description; the agent program is a concrete implementation, running within some physical system

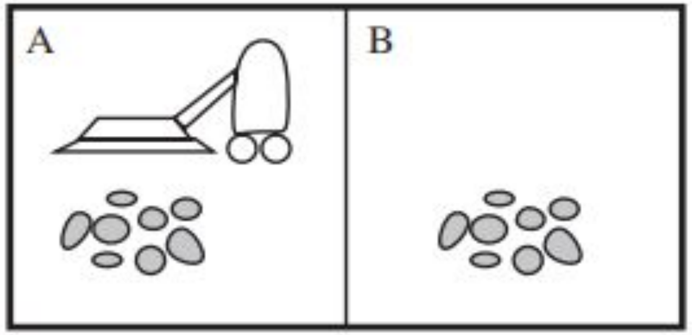


Figure 2.2 A vacuum-cleaner world with just two locations.

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*
$\vdots$	$\vdots$
$[A, Clean], [A, Clean], [A, Clean]$	*Right*
$[A, Clean], [A, Clean], [A, Dirty]$	*Suck*
$\vdots$	$\vdots$

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

The Structure of Agents

- The job of AI is to design an agent program that implements the agent function— the mapping from percepts to actions.
- We assume this program will run on some sort of computing device with physical sensors and actuators—we call this the architecture:
- agent = architecture + program .
- The program we choose has to be one that is appropriate for the architecture.
- action ---- Walk, the architecture had better have legs.
- The architecture might be just an ordinary PC, or it might be a robotic car with several onboard computers, cameras, and other sensors.
- In general, the architecture makes the percepts from the sensors available to the program, runs the program, and feeds the program's action choices to the actuators as they are generated.

Agent programs

- The agent programs take the current percept as input from the sensors and return an action to the actuators.
- The agent program takes just the current percept as input because nothing more is available from the environment;
- if the agent's actions need to depend on the entire percept sequence, the agent will have to remember the percepts.

Sample Agent program

```
function TABLE-DRIVEN-AGENT(percept) returns an action
  persistent: percepts, a sequence, initially empty
              table, a table of actions, indexed by percept sequences, initially fully specified

  append percept to the end of percepts
  action ← LOOKUP(percepts, table)
  return action
```

Figure 2.7 The TABLE-DRIVEN-AGENT program is invoked for each new percept and returns an action each time. It retains the complete percept sequence in memory.

- Designers must construct a table that contains the appropriate action for every possible percept sequence.
- Let P be the set of possible percepts and let T be the lifetime of the agent (the total number of percepts it will receive). The lookup table will contain $\sum_{t=1}^{T} |p|^t$ entries.
- Despite all this, TABLE-DRIVEN-AGENT does do what we want: it implements the desired agent function.
- The key challenge for AI is to find out how to write programs that, to the extent possible, produce rational behavior from a smallish program rather than from a vast table.

Four basic kinds of agent programs

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

Simple reflex agents

- The simplest kind of agent is the simple reflex agent. These agents select actions on the basis of the current percept, ignoring the rest of the percept history.
- For example, the vacuum agent is a simple reflex agent, because its decision is based only on the current location and on whether that location contains dirt.

function REFLEX-VACUUM-AGENT([*location*,*status*]) **returns** an action

if *status* = *Dirty* **then return** *Suck*
else if *location* = *A* **then return** *Right*
else if *location* = *B* **then return** *Left*

Figure 2.8 The agent program for a simple reflex agent in the two-state vacuum environment. This program implements the agent function tabulated in Figure 2.3.

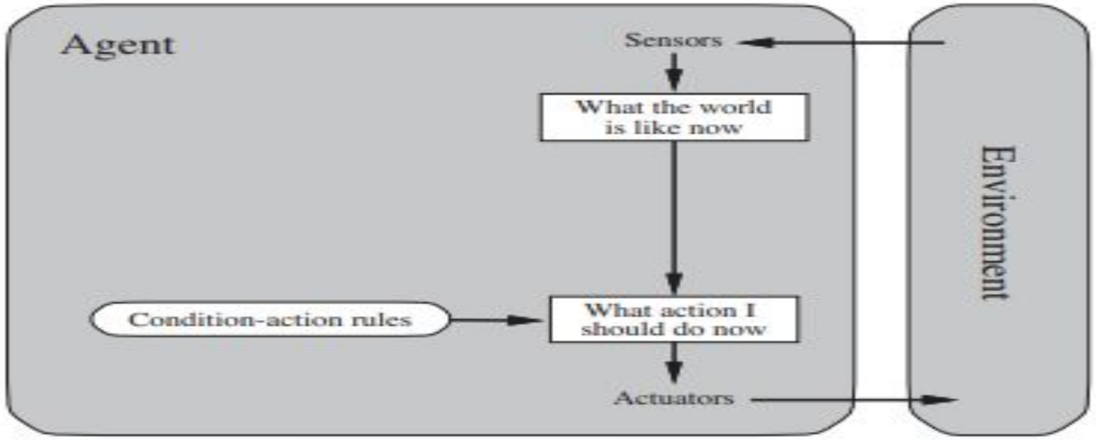


Figure 2.9 Schematic diagram of a simple reflex agent.

function SIMPLE-REFLEX-AGENT(*percept*) **returns** an action
  persistent: *rules*, a set of condition–action rules

  $state \leftarrow$ INTERPRET-INPUT(*percept*)
  $rule \leftarrow$ RULE-MATCH(*state*, *rules*)
  $action \leftarrow rule$.ACTION
  return *action*

Figure 2.10 A simple reflex agent. It acts according to a rule whose condition matches the current state, as defined by the percept.

- Rectangles denote the current internal state of the agent’s decision process, and ovals to represent the background information used in the process.
- The INTERPRET-INPUT function generates an abstracted description of the current state from the percept, and the RULE-MATCH function returns the first rule in the set of rules that matches the given state description.
- The agent shown in Figure will work only if the correct decision can be made on the basis of only the current percept—that is, only if the environment is fully observable.
- Even a little bit of unobservability can cause serious trouble.

Model-based reflex agents

- The most effective way to handle partial observability is for the agent to keep track of the part of the world it can't see now.
- That is, the agent should maintain some sort of internal state that depends on the percept history and thereby reflects at least some of the unobserved aspects of the current state.
- Updating this internal state information requires two kinds of knowledge to be encoded in the agent program.
- First, we need some information about how the world evolves independently of the agent.
- Second, we need some information about how the agent's own actions affect the world

- This knowledge about “how the world works”—whether implemented in simple Boolean circuits or in complete scientific theories—is called a model of the world.

- An agent that uses such a model is called a model-based agent.

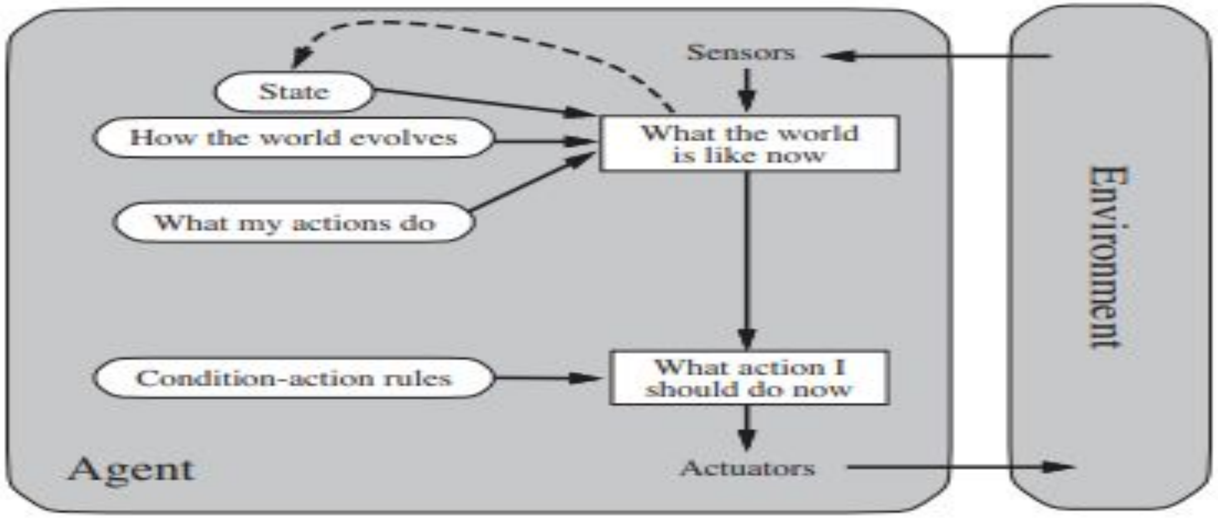


Figure 2.11 A model-based reflex agent.

function MODEL-BASED-REFLEX-AGENT(*percept*) **returns** an action
persistent: *state*, the agent's current conception of the world state
model, a description of how the next state depends on current state and action
rules, a set of condition–action rules
action, the most recent action, initially none

$state \leftarrow$ UPDATE-STATE($state, action, percept, model$)
$rule \leftarrow$ RULE-MATCH($state, rules$)
$action \leftarrow rule$.ACTION
return *action*

Figure 2.12 A model-based reflex agent. It keeps track of the current state of the world, using an internal model. It then chooses an action in the same way as the reflex agent.

Goal-based agents

- Knowing something about the current state of the environment is not always enough to decide what to do.
- For example, at a road junction, the taxi can turn left, turn right, or go straight on. The correct decision depends on where the taxi is trying to get to.
- In other words, as well as a current state description, the agent needs some sort of goal information that describes situations that are desirable—for example, being at the passenger’s destination.
- The agent program can combine this with the model to choose actions that achieve the goal.

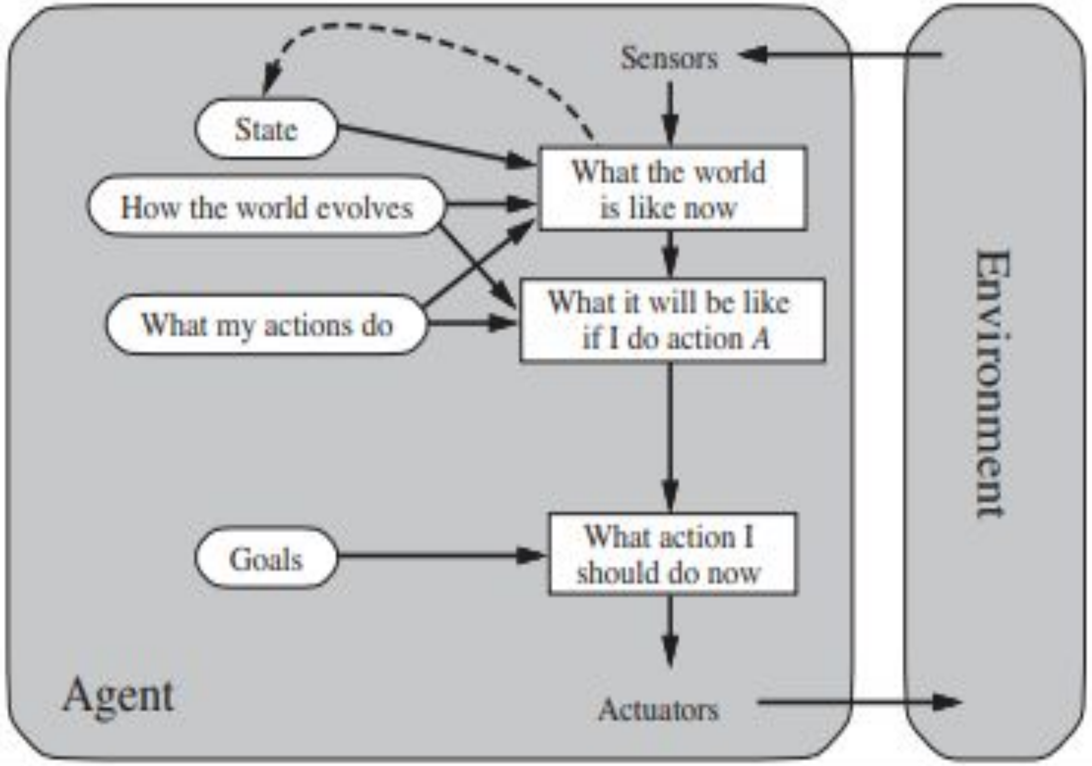


Figure 2.13 A model-based, goal-based agent. It keeps track of the world state as well as a set of goals it is trying to achieve, and chooses an action that will (eventually) lead to the achievement of its goals.

Utility-based agents

- Goals alone are not enough to generate high-quality behavior in most environments.
- For example, many action sequences will get the taxi to its destination (thereby achieving the goal) but some are quicker, safer, more reliable, or cheaper than others.
- An agent's utility function is essentially an internalization of the performance measure.
- If the internal utility function and the external performance measure are in agreement, then an agent that chooses actions to maximize its utility will be rational according to the external performance measure.

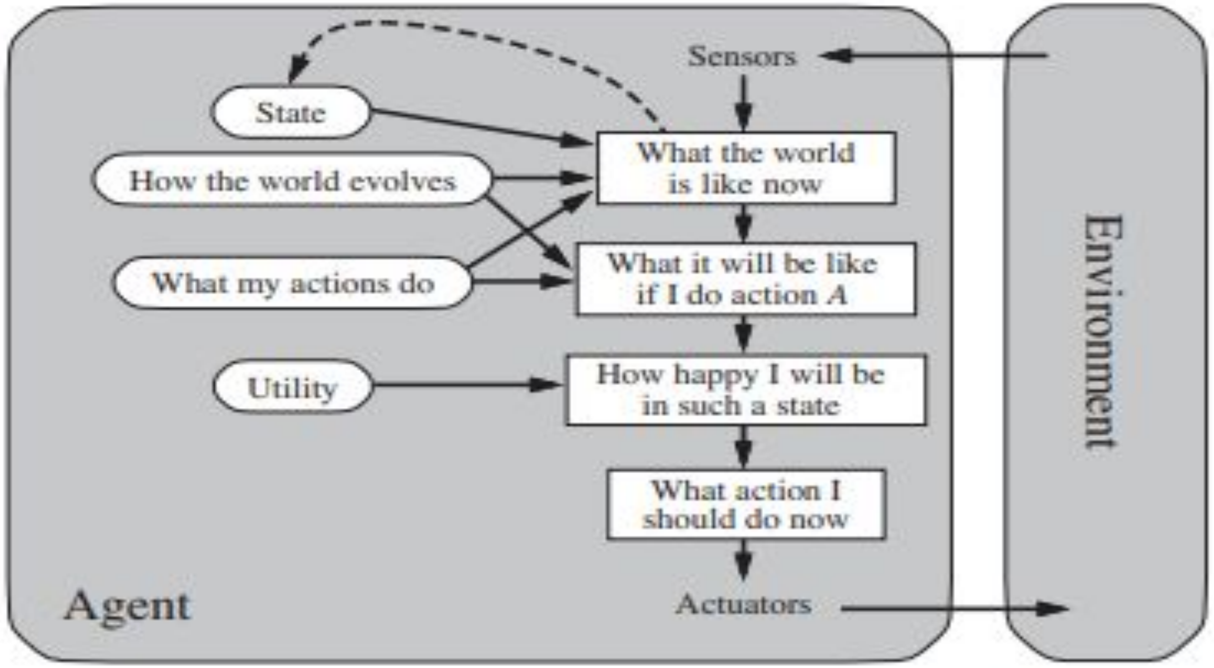


Figure 2.14 A model-based, utility-based agent. It uses a model of the world, along with a utility function that measures its preferences among states of the world. Then it chooses the action that leads to the best expected utility, where expected utility is computed by averaging over all possible outcome states, weighted by the probability of the outcome.

- A utility-based agent has many advantages in terms of flexibility and learning.
- Furthermore, in two kinds of cases, goals are inadequate but a utility-based agent can still make rational decisions.
- First, when there are conflicting goals, only some of which can be achieved (for example, speed and safety), the utility function specifies the appropriate tradeoff.
- Second, when there are several goals that the agent can aim for, none of which can be achieved with certainty, utility provides a way in which the likelihood of success can be weighed against the importance of the goals.

Learning agents

- A learning agent in AI is the type of agent that can learn from its past experiences or it has learning capabilities.
- It starts to act with basic knowledge and then is able to act and adapt automatically through learning.
- A learning agent has mainly four conceptual components, which are:
- **Learning element**: It is responsible for making improvements by learning from the environment.
- **Critic:** The learning element takes feedback from critics which describes how well the agent is doing with respect to a fixed performance standard.
- **Performance element:** It is responsible for selecting external action.
- **Problem Generator:** This component is responsible for suggesting actions that will lead to new and informative experiences.

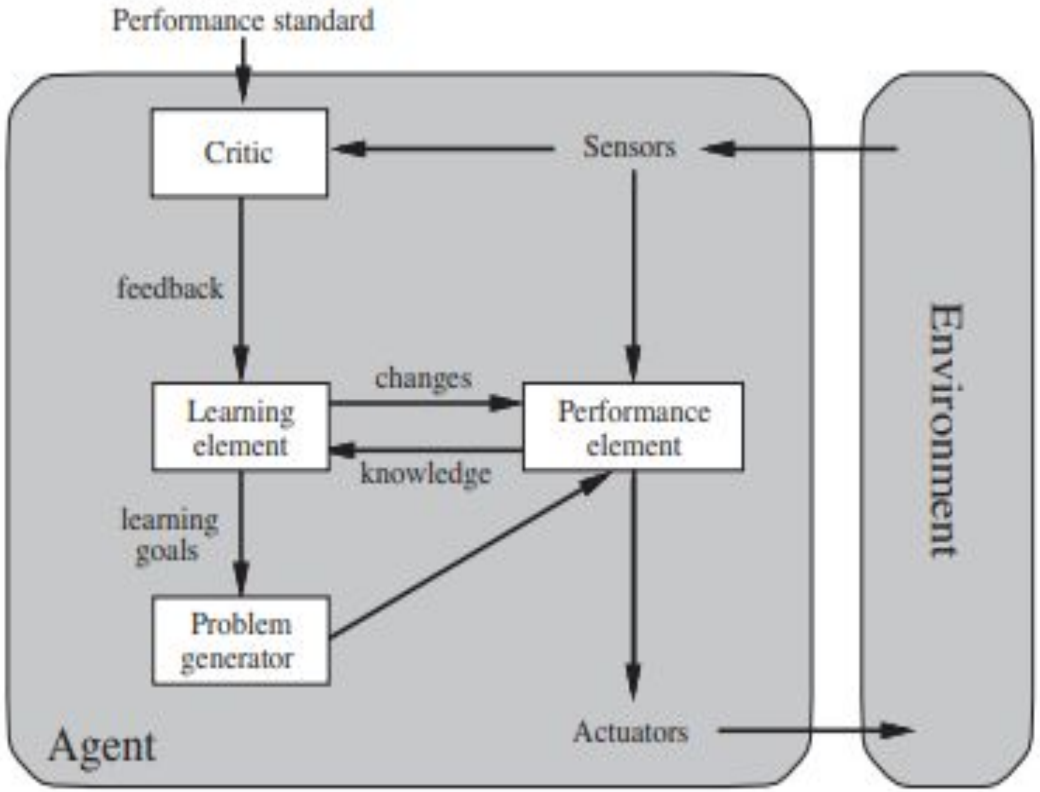


Figure 2.15 A general learning agent.

- Learning in intelligent agents can be summarized as a process of modification of each component of the agent to bring the components into closer agreement with the available feedback information, thereby improving the overall performance of the agent.

How the components of agent programs work?

- Agent programs (in very high-level terms) as consisting of various components, whose function it is to answer questions such as: “What is the world like now?” “What action should I do now?” “What do my actions do?” The next question for a student of AI is, “How on earth do these components work?”

- we can place the representations along an axis of increasing complexity and expressive power—atomic, factored, and structured.

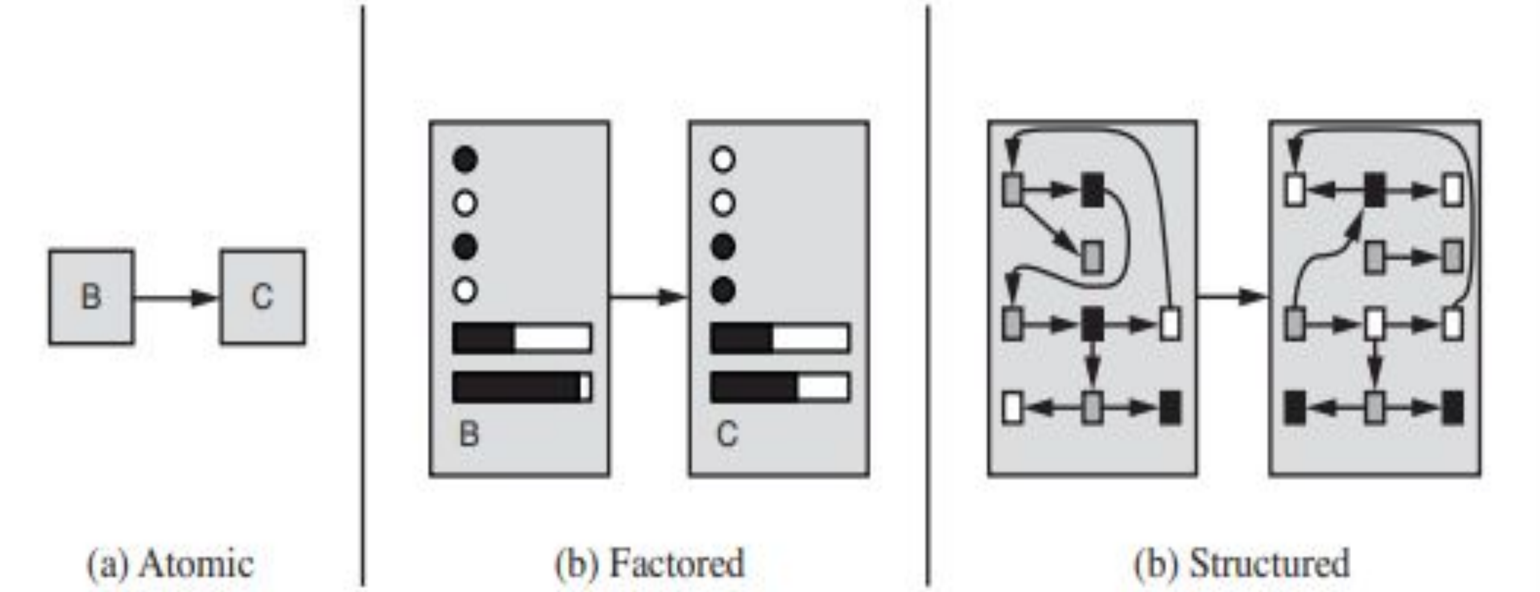


Figure 2.16 Three ways to represent states and the transitions between them. (a) Atomic representation: a state (such as B or C) is a black box with no internal structure; (b) Factored representation: a state consists of a vector of attribute values; values can be Boolean, real-valued, or one of a fixed set of symbols. (c) Structured representation: a state includes objects, each of which may have attributes of its own as well as relationships to other objects.

- In an atomic representation each state of the world is indivisible—it has no internal structure.
- The algorithms underlying search and game-playing ,Hidden Markov models, and Markov decision processes all work with atomic representations—or, at least, they treat representations as if they were atomic.
- A factored representation splits up each state into a fixed set of variables or attributes, each of which can have a value. While two different atomic states have nothing in common—they are just different black boxes—two different factored states can share some attributes (such as being at some particular GPS location) and not others (such as having lots of gas or having no gas);
- This makes it much easier to work out how to turn one state into another. With factored representations, we can also represent uncertainty—for example, ignorance about the amount of gas in the tank can be represented by leaving that attribute blank.
- Many important areas of AI are based on factored representations, including constraint satisfaction algorithms, propositional logic, planning, Bayesian networks ,and the machine learning algorithms.

- For many purposes, we need to understand the world as having things in it that are related to each other, not just variables with values.
- Structured representations underlie relational databases and first-order logic ,first-order probability models, knowledge-based learning and much of natural language understanding.
- In fact, almost everything that humans express in natural language concerns objects and their relationships.