UNIT I

Introduction:

- Artificial Intelligence is concerned with the design of intelligence in an artificial device. The term was coined by John McCarthy in 1956.
- Intelligence is the ability to acquire, understand and apply the knowledge to achieve goals in the world.
- AI is the study of intellectual/mental processes as computational processes.
- AI program will demonstrate a high level of intelligence to a degree that equals or exceeds the intelligence required of a human in performing some task.
- AI is unique, sharing borders with Mathematics, Computer Science, Philosophy, Psychology, Biology, Cognitive Science and many others.
- Although there is no clear definition of AI or even Intelligence, it can be described as an attempt to build machines that like humans can think and act, able to learn and use knowledge to solve problems on their own.

Intelligence might be defined as the ability to learn and perform suitable techniques to solve problems and achieve goals, appropriate to the context in an uncertain, ever-varying world. A fully pre-programmed factory robot is flexible, accurate, and consistent but not intelligent.

Artificial Intelligence (AI), a term coined by emeritus Stanford Professor John McCarthy in 1955, was defined by him as “the science and engineering of making intelligent machines”. Much research has humans program machines to behave in a clever way, like playing chess, but, today, we emphasize machines that can learn, at least somewhat like human beings do.

Foundations of Artificial Intelligence:

- **Philosophy**
  e.g., foundational issues (can a machine think?), issues of knowledge and believe, mutual knowledge
- **Psychology and Cognitive Science**
  e.g., problem solving skills
- **Neuro-Science**
  e.g., brain architecture
- **Computer Science And Engineering**

e.g., complexity theory, algorithms, logic and inference, programming languages, and systembuilding.

- **Mathematics and Physics**

  e.g., statistical modeling, continuous mathematics,

- **Statistical Physics, and Complex**

Systems. Sub Areas of AI:

1) **Game Playing**

   Deep Blue Chess program beat world champion Gary Kasparov

   (Deep Blue versus Garry Kasparov was a pair of six-game chess matches between then-world chess champion Garry Kasparov and an IBM supercomputer called Deep Blue. Kasparov won the first match, held in Philadelphia in 1996, by 4–2. Deep Blue won a 1997 rematch held in New York City by 3½–2½.)

2) **Speech Recognition**

   PEGASUS spoken language interface to American Airlines' EAASY SABRE reservation system, which allows users to obtain flight information and make reservations over the telephone. The 1990s hasseen significant advances in speech recognition so that limited systems are now successful.

3) **Computer Vision**

   Face recognition programs in use by banks, government, etc. The ALVINN system from CMU autonomously drove a van from Washington, D.C. to San Diego (all but 52 of 2,849 miles), averaging63 mph day and night, and in all weather conditions. Handwriting recognition, electronics and manufacturing inspection, photo interpretation, baggage inspection, reverse engineering to automatically construct a 3D geometric model.

4) **Expert Systems**

   Application-specific systems that rely on obtaining the knowledge of human experts in an area and programming that knowledge into a system.

   a. **Diagnostic Systems** : MYCIN system for diagnosing bacterial infections of the blood and suggesting treatments. Intellipath pathology diagnosis system (AMA approved). Pathfindermedical diagnosis system, which suggests tests and makes diagnoses. Whirlpool customer assistance center.

   b. **System Configuration**

      DEC's XCON system for custom hardware configuration. Radiotherapy treatment planning.

c. **Financial Decision Making**

Credit card companies, mortgage companies, banks, and the U.S. government employ AIsystems to detect fraud and expedite financial transactions. For example, AMEX credit check.

d. **Classification Systems**

Put information into one of a fixed set of categories using several sources of information. E.g., financial decision making systems. NASA developed a system for classifying very faint areas in astronomical images into either stars or galaxies with very high accuracy by learning from human experts' classifications.

5) **Mathematical Theorem Proving**

Use inference methods to prove new theorems.

6) **Natural Language Understanding**

AltaVista's translation of web pages. Translation of Catepillar Truck manuals into 20 languages.

7) **Scheduling and Planning**

Automatic scheduling for manufacturing. DARPA's DART system used in Desert Storm and Desert Shield operations to plan logistics of people and supplies. American Airlines rerouting contingencyplanner. European space agency planning and scheduling of spacecraft assembly, integration and verification.

8) **Artificial Neural Networks: Machine Learning**

1) **Application of AI:**

AI algorithms have attracted close attention of researchers and have also been applied successfully to solve problems in engineering. Nevertheless, for large and complex problems, AIalgorithms consume considerable computation time due to stochastic feature of the search approaches

1) Engineering: check design, offer suggestions to create new product, expert systems for all engineering problems
2) Manufacturing: assembly, inspection and maintenance
3) Medicine: monitoring, diagnosing
4) Education: in teaching
5) Fraud detection
6) Object identification
7) Information retrieval
8) Space shuttle scheduling
9) Business; financial strategies

History of AI:

Important research that laid the groundwork for AI:

- In 1931, Goedel layed the foundation of Theoretical Computer Science**1920-30s**:

  He published the first universal formal language and showed that math itself is eitherflawed or allows for unprovable but true statements.
- In 1936, Turing reformulated Goedel’s result and church’s extension thereof.
- In 1956, John McCarthy coined the term "Artificial Intelligence" as the topic of the **Dartmouth Conference**, the first conference devoted to the subject.
- In 1957, The **General Problem Solver (GPS)** demonstrated by Newell, Shaw & Simon
- In 1958, John McCarthy (MIT) invented the Lisp language.
- In 1959, Arthur Samuel (IBM) wrote the first game-playing program, for checkers, to achieve sufficient skill to challenge a world champion.
- In 1963, Ivan Sutherland's MIT dissertation on Sketchpad introduced the idea of interactive graphics into computing.
- In 1966, Ross Quillian (PhD dissertation, Carnegie Inst. of Technology; now CMU) demonstrated semantic nets
- In 1967, 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.
- In 1967, Doug Engelbart invented the mouse at SRI
- In 1968, Marvin Minsky & Seymour Papert publish Perceptrons, demonstrating limits of simple neural nets.
- In 1972, Prolog developed by Alain Colmerauer.(father of the logic programming language)
- In Mid 80’s, Neural Networks become widely used with the Back propagation algorithm (firstdescribed by Werbos in 1974).
- 1990, Major advances in all areas of AI, with significant demonstrations in machine learning, intelligent tutoring, case-based reasoning, multi-agent planning, scheduling, uncertain reasoning, data mining, natural language understanding and translation, vision, virtual reality, games, and other topics.

- In 1997, Deep Blue beats the World Chess Champion Kasparov
- In 2002,iRobot, founded by researchers at the MIT Artificial Intelligence Lab, introduced
- **Roomba**,a vacuum cleaning robot. By 2006, two million had been sold.

Building AI Systems:

1) **Perception**

   Intelligent biological systems are physically embodied in the world and experience the world through their sensors (senses). For an autonomous vehicle, input might be images from acamera and range information from a rangefinder. For a medical diagnosis system, perception is the set of symptoms and test results that have been obtained and input to the system manually.

2) **Reasoning**

   Inference, decision-making, classification from what is sensed and what the internal "model" is of the world. Might be a neural network, logical deduction system, Hidden Markov Model induction, heuristic searching a problem space, Bayes Network inference, genetic algorithms, etc.

   Includes areas of knowledge representation, problem solving, decision theory, planning, game theory, machine learning, uncertainty reasoning, etc.

3) **Action**

   Biological systems interact within their environment by actuation, speech, etc. All behavior is centered around actions in the world. Examples include controlling the steering of a Mars rover or autonomous vehicle, or suggesting tests and making diagnoses for a medical diagnosis system. Includes areas of robot actuation, natural language generation, and speech synthesis.

AI in The Present

Artificial intelligence is being utilized for so many things and has so much promise that it’s difficult to imagine our future without it, related to business. Artificial intelligence technologies are boosting productivity like never seen before, from workflow management solutions to trend forecasts and even the way companies buy advertisements.

Artificial Intelligence can gather and organize vast volumes of data in order to draw inferences and estimates that are outside of the human ability to comprehend manually. It also improves organizational efficiency while lowering the risk of a mistake, and it identifies unusual patterns, such as spam and frauds, instantaneously to alert organizations about suspicious behavior, among other things.

AI has grown in importance and sophistication to the point that a Japanese investment firm became the first to propose an AI Board Member for its ability to forecast market trends faster than humans. Artificial intelligence will indeed be and is already being used in many aspects of life, such as self-driving cars in the coming years, more precise weather forecasting, and earlier health diagnoses, to mention a few.

AI in The Future

It has been suggested that we are on the verge of the 4th Industrial Revolution, which will be unlike any of the previous three. From steam and water power through electricity and manufacturing process, computerization, and now, the question of what it is to be human is being challenged.

Smarter technology in our factories and workplaces, as well as linked equipment that will communicate, view the entire production process, and make autonomous choices, are just a few of the methods the Industrial Revolution will lead to business improvements.

One of the most significant benefits of the 4th Industrial Revolution is the ability to improve the world's populace's quality of life and increase income levels. As robots, humans, and smart devices work on improving supply chains and warehousing, our businesses and organizations are becoming "smarter" and more productive.

The difference between strong AI and weak AI:

Strong AI makes the bold claim that computers can be made to think on a level (at least) equal to humans.

Weak AI simply states that some "thinking-like" features can be added to computers to make them more useful tools... and this has already started to happen (witness expert systems, drive-by-wire cars and speech recognition software).

AI Problems:

AI problems (speech recognition, NLP, vision, automatic programming, knowledge representation, etc.) can be paired with techniques (NN, search, Bayesian nets, production systems, etc.).AI problems can be classified in two types:

1. Common-place tasks(Mundane Tasks)
2. Expert tasks

Common-Place Tasks:

1. *Recognizing* people, objects.
2. Communicating (through *natural language*).
3. *Navigating* around obstacles on the streets.

These tasks are done matter of fatly and routinely by people and some other animals.

Expert tasks:

1. Medical diagnosis.
2. Mathematical problem solving
3. Playing games like chess

These tasks cannot be done by all people, and can only be performed by skilled specialists.

Clearly tasks of the first type are easy for humans to perform, and almost all are able to master them. The second range of tasks requires skill development and/or intelligence and only some specialists can perform them well. However, when we look at what computer systems have been able to achieve to date, we see that their achievements include performing sophisticated tasks like medical diagnosis, performing symbolic integration, proving theorems and playing chess.

1. Intelligent Agent's:

Agents and environments:

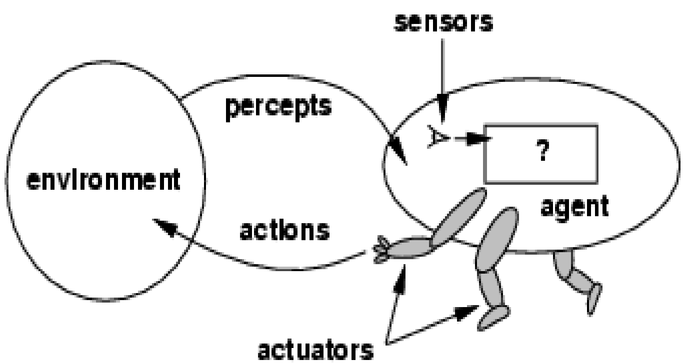

Fig 2.1: Agents and Environments

Agent:

An *Agent* is anything that can be viewed as perceiving its environment through sensors and actingupon that environment through actuators.

- ✓ A *human agent* has eyes, ears, and other organs for sensors and hands, legs, mouth, andother body parts for actuators.
- ✓ A *robotic agent* might have cameras and infrared range finders for sensors and variousmotors 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.

Percept:

We use the term percept to refer to the agent's perceptual inputs at any given instant.

PerceptSequence:

An agent's percept sequence is the complete history of everything the agent has ever perceived.

Agent function:

Mathematically speaking, we say that an agent's behavior is described by the agent function that maps any given percept sequence to an action.

Agent program

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 on the agent architecture.

To illustrate these ideas, we will use a very simple example-the vacuum-cleaner world shown in Fig 2.1.5. This particular world has just two locations: squares A and B.

The vacuum agent perceives which square it is in and whether there is dirt in the square. It can choose to move left, move right, suck up the dirt, or do nothing. One very simple agent function is the following: if the current square is dirty, then suck, otherwise move to the other square. A partial tabulation of this agent function is shown in Fig 2.1.6.

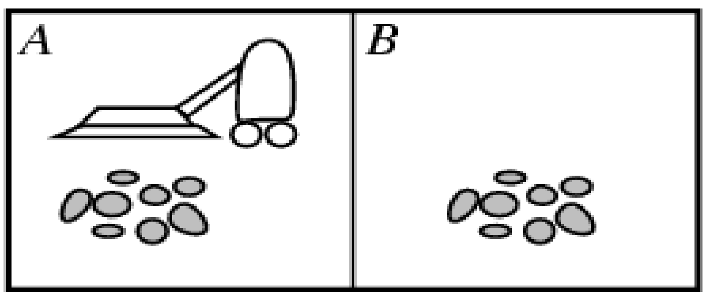

Fig 2.1.5: A vacuum-cleaner world with just two locations.

Agent function

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
…	

Fig 2.1.6: Partial tabulation of a simple agent function for the example: vacuum-cleaner

world shown in the **Fig 2.1.5**

```
Function REFLEX-VACCUM-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
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Fig 2.1.6(i): The REFLEX-VACCUM-AGENT program is invoked for each new percept (location, status) andreturns **an** action each time

Agents in Artificial Intelligence contain the following properties:

- Enrironment
- Autonomous
- Flexibility
- Reactive
- Proactiveness
- Using Response Rules

Now, let's discuss these in detail.

Environment

The agent is situated in a given environment.

Autonomous

The agent can operate without direct human intervention or other software methods. It controls its activities and internal environment. The agent independently which steps it will take in its current condition to achieve the best improvements. The agent achieves autonomy if its performance is measured by its experiences in the context of learning and adapting.

Flexibility

- Reactive: Agents must recognize their surroundings and react to the changes within them.
- Proactive: Agents shouldn’t only act in response to their surroundings but also be able to take the initiative when appropriate and effect an opportunistic, goal-directed performance.
- Social: Agents should work with humans or other non-human agents.

Reactive

- Reactive systems maintain ongoing interactions with their environment, responding to its changes.
- The program's environment may be guaranteed, not concerned about its success or failure.
- Most environments are dynamic, meaning that things are constantly in a state of change, and information is incomplete.
- Programs must make provisions for the possibility of failure.

Pro-Activeness

Taking the initiative to create goals and try to meet them.

Using Response Rules

The goal for the agent is directed behavior, having it do things for the user.

- Mobility: The agent must have the ability to actuate around a system.
- Veracity: If an agent's information is false, it will not communicate.
- Benevolence: Agents don't have contradictory or conflicting goals. Therefore, every Agent will always try to do what it is asked.
- Rationality: The agent will perform to accomplish its goals and not work in a way that opposes or blocks them.
- Learning: An agent must be able to learn.

Structure of an AI Agent

To understand the structure of Intelligent Agents, we should be familiar with ***Architecture* and *Agent* programs**.
Architecture is the machinery that the agent executes on. It is a device with sensors and actuators, for example, a robotic car, a camera, and a PC.
An agent program is an implementation of an agent function.
An **agent function** is a map from the percept sequence(history of all that an agent has perceived to date) to an action.

Agent = Architecture + Agent Program

Many AI Agents use the **PEAS** model in their structure. PEAS is an acronym for Performance Measure, Environment, Actuators, and Sensors. For instance, take a vacuum cleaner.

Performance: Cleanliness and efficiency

Environment: Rug, hardwood floor, living room

Actuator: Brushes, wheels, vacuum bag

Sensors: Dirt detection sensor, bump sensor

Types of Agents

Agents can be grouped into five classes based on their degree of perceived intelligence and capability :

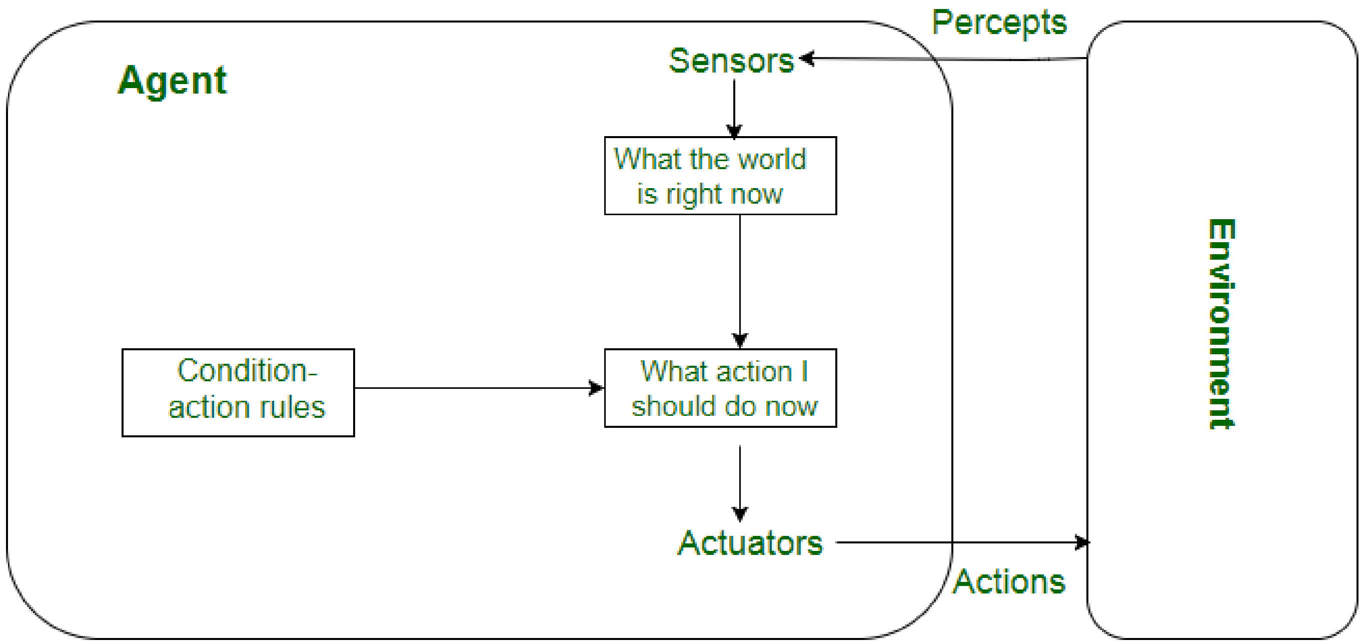
- Simple Reflex Agents
- Model-Based Reflex Agents
- Goal-Based Agents
- Utility-Based Agents

Simple Reflex Agents

- Simple reflex agents ignore the rest of the percept history and act only on the basis of the **current percept**. Percept history is the history of all that an agent has perceived to date. The agent function is based on the **condition-action rule**. A condition-action rule is a rule that maps a state i.e., a condition to an action. If the condition is true, then the action is taken, else not. This agent function only succeeds when the environment is fully observable. For simple reflex agents operating in partially observable environments, infinite loops are often unavoidable. It may be possible to escape from infinite loops if the agent can randomize its actions.
- Problems with Simple reflex agents are :
- Very limited intelligence.
- No knowledge of non-perceptual parts of the state.
- Usually too big to generate and store.
- If there occurs any change in the environment, then the collection of rules needs to be updated.

Example. The vacuum agent is a simple reflex agent because the decision is based only on the current location, and whether the place contains dirt. A simple reflex agent comprises the following parts:
Agent: The agent is the one who performs actions on the environment.

− Action depends only on immediate percepts.
− Implement by condition-action rules.
− Example: Agent: Mail sorting robot
Environment: Conveyor belt of letters
Rule: e.g. city=Edinburgh → put Scotland bag

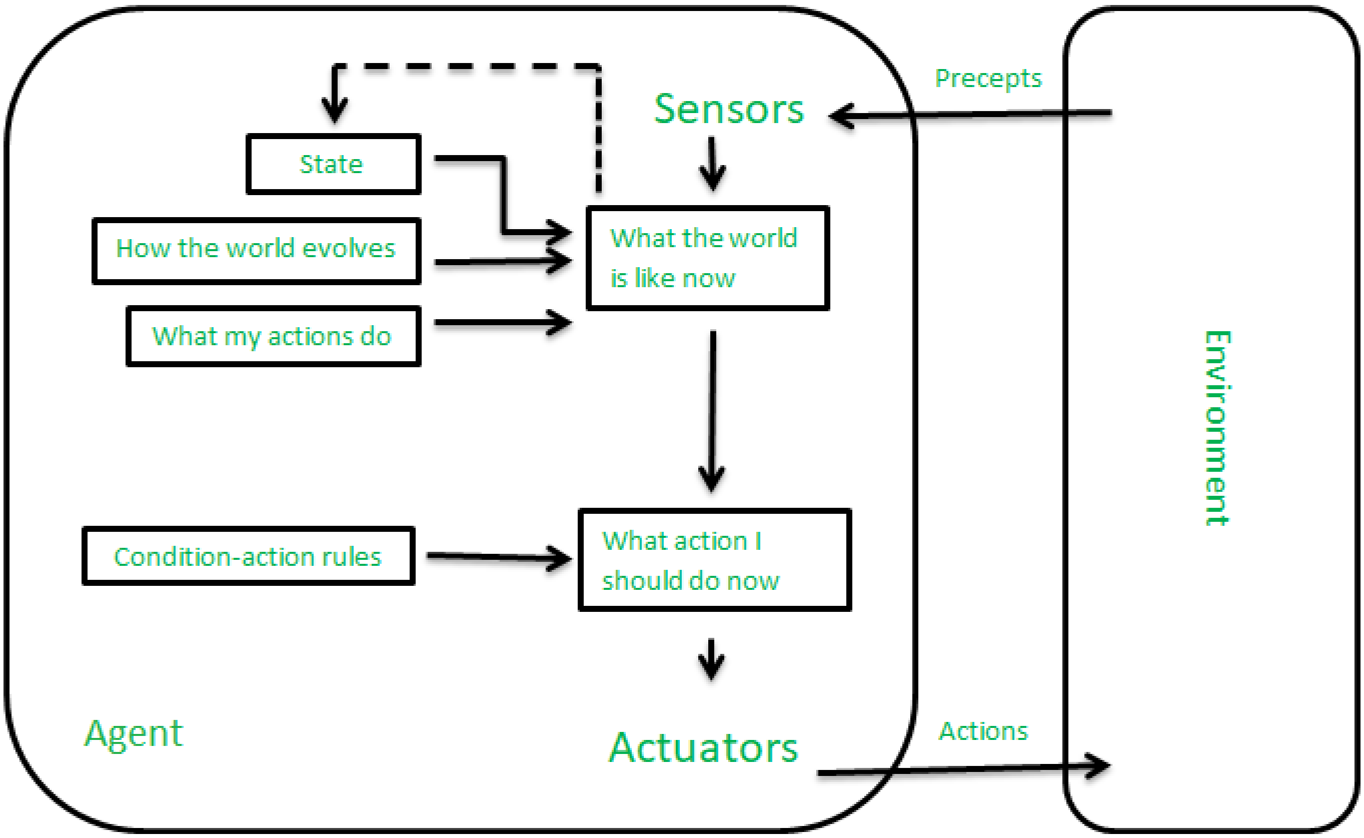


Model-Based Reflex Agents

- It works by finding a rule whose condition matches the current situation. A model-based agent can handle **partially observable environments** by the use of a model about the world. The agent has to keep track of the **internal state** which is adjusted by each percept and that depends on the percept history. The current state is stored inside the agent which maintains some kind of structure describing the part of the world which cannot be seen.
- Updating the state requires information about:
- How the world evolves independently from the agent?
- How do the agent's actions affect the world?

Self-driving cars are a great example of a model-based reflex agent. The car is equipped with sensors that detect obstacles, such as car brake lights in front of them or pedestrians walking on the sidewalk. As it drives, these sensors feed percepts into the car's memory and internal model of its environment

– Action may depend on history or unperceived aspects of the world.
– Need to maintain internal world model.

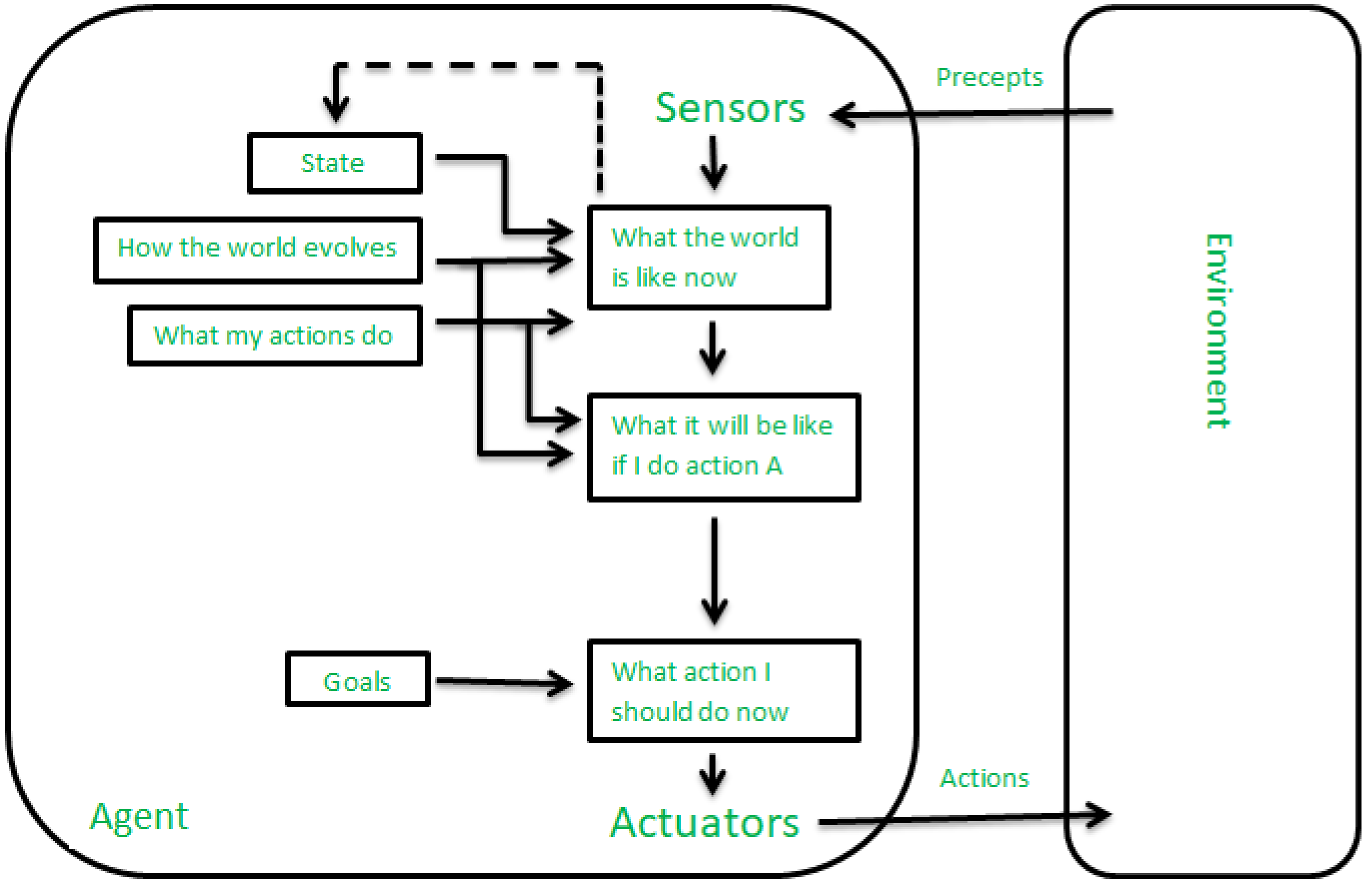


Goal-Based Agents

These kinds of agents take decisions based on how far they are currently from their **goal**(description of desirable situations). Their every action is intended to reduce their distance from the goal. This allows the agent a way to choose among multiple possibilities, selecting the one which reaches a goal state. The knowledge that supports its decisions is represented explicitly and can be modified, which makes these agents more flexible. They usually require search and planning. The goal-based agent's behavior can easily be changed.

− Agents so far have fixed, implicit goals
. − We want agents with variable goals.
− Forming plans to achieve goals.
− Example: Agent: household service robot
Environment: house & people.
Goals: clean clothes, tidy room, table laid, etc

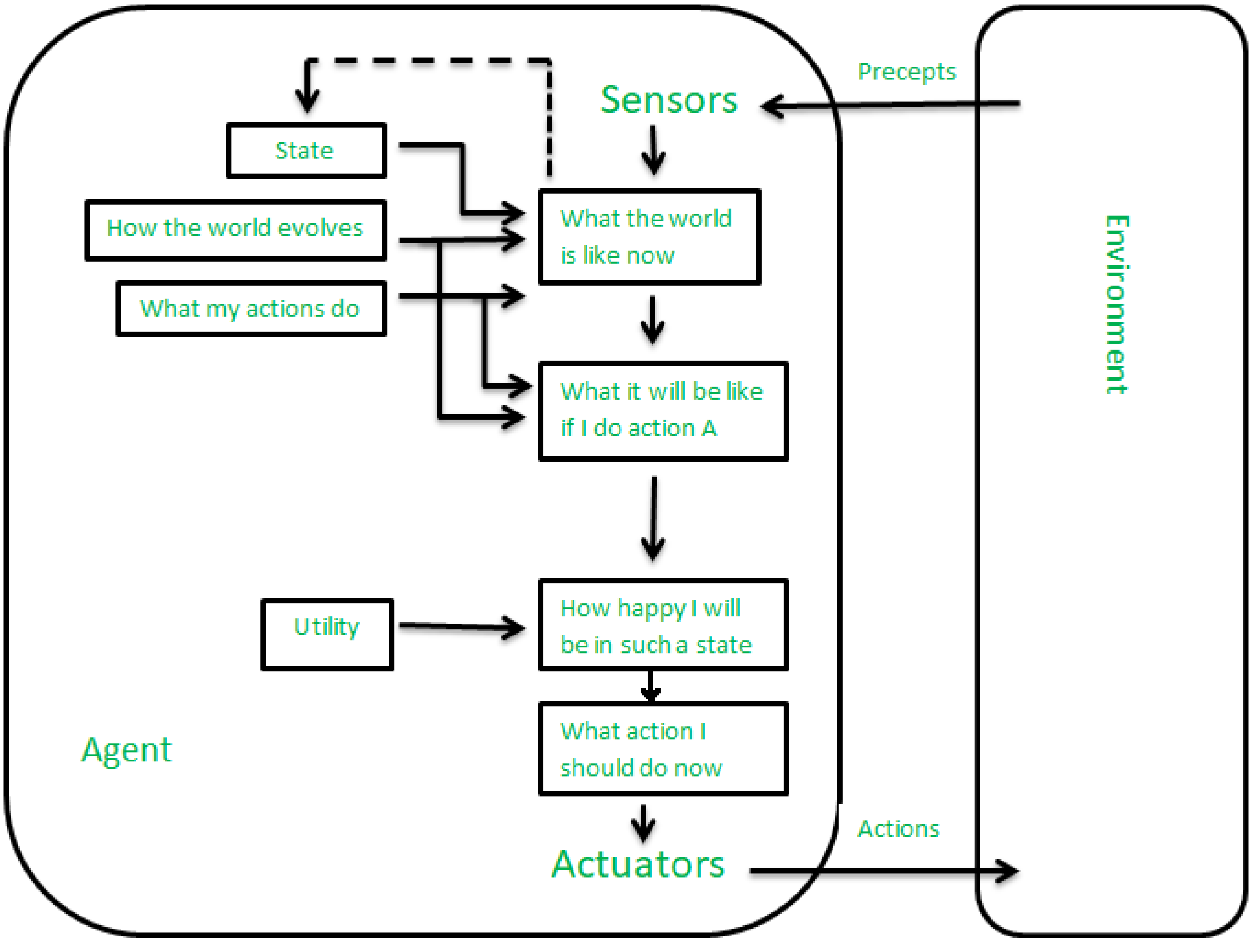
Search Engines: Goal-based agents also can be utilized by smart search engine algorithms that scan content on the web quickly and accurately return relevant information related to a specific query made by a user. Additionally, these same types of algorithms can create personalized experiences for users based on past searches results or profile data gathered from previous browsing behavior patterns.



Utility-Based Agents

The agents which are developed having their end uses as building blocks are called utility-based agents. When there are multiple possible alternatives, then to decide which one is best, utility-based agents are used. They choose actions based on a **preference (utility)** for each state. Sometimes achieving the desired goal is not enough. We may look for a quicker, safer, cheaper trip to reach a destination. Agent happiness should be taken into consideration. Utility describes how **"happy"** the agent is. Because of the uncertainty in the world, a utility agent chooses the action that maximizes the expected utility. A utility function maps a state onto a real number which describes the associated degree of happiness.

Utility-Based Agents − Agents so far have had a single goal.
− Agents may have to juggle conflicting goals.
− Need to optimise utility over a range of goals.
− Utility: measure of goodness (a real number).
− Combine with probability of success to get expected utility. –
Example: Agent: automatic car.
Environment: roads, vehicles, signs, etc.
Goals: stay safe, reach destination, be quick, obey law, save fuel, etc


Precepts
Sensors
State
How the world evolves
What my actions do
What the world is like now
What it will be like if I do action A
Utility
How happy I will be in such a state
What action I should do now
Agent
Actuators
Actions
Environment