ARTIFICIAL INTELLIGENCE

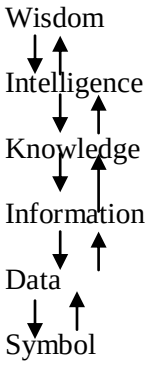
Prescribed Textbook:

Artificial Intelligence, A modern approach – 2nd edition by Stuart Russell and Peter Norvig

Definition of knowledge –

- Large collection of symbols is called as data.
- Large collection of data is called as information.
- If you have lot of information it is knowledge.
- If you have lot of knowledge then you are an intelligent.
- If you are an intelligent person then you have wisdom.
- Knowledge is defined as the piece of information that helps in decision-making.
- Intelligence can be defined as the ability to draw useful inferences from the available knowledge.

Knowledge Relation:



The following are characteristics in a list of essential abilities for intelligence.

1. To respond to situations very flexibility.

2. To make sense out of ambiguous or contradictory messages.

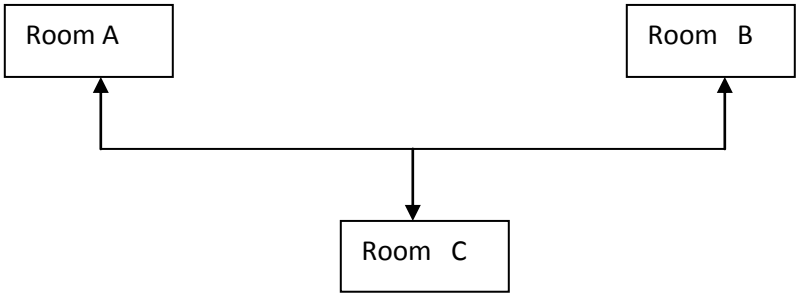
3. To recognize the relative importance of different elements of a situation.

4. To find similarities between situations despite differences, which may separate them.

5. To draw distinctions between situations despite similarities, which may link them.

Turing Test - Turing proposed an 'imitation game' which was later modified to Turing test. In the imitation game the players are three humans- a male, a female and an interrogator. The interrogator who is shielded from the other two, asks questions to both of them and based on their typewritten answers determines who is female. The aim of the male is to imitate the female and deceive the interrogator and the role of female is to provide replies that would inform the interrogator about her true sex.

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Turing proposed that if the human interrogator in Room C is not able to identify who is in Room A or in Room B, then the machine possesses intelligence. Turing considered this is a sufficient test for attributing thinking capacity to a machine. As of today, Turing test is the ultimate test a machine must pass in order to be called as intelligent test.

Importance of Turing test:

It gives a standard for determining intelligence.

It also helps in eliminating any bias in favor of living organism, because the interrogator focuses slowly on the content of the answers to the questions.

Definition of AI –

Study of how to make computer do things

(or)

Study of computations that is possible to perceive, reason and action

(or)

Part of Computer Science concerned with designing intelligent systems that exhibit the characteristics we associate with intelligence in human behavior.

(or)

AI is defined as the study of agents that receive percepts from the environment and perform actions. Each such agent implements a function that maps percept sequences to actions.

Areas of AI research –

Expert system - An expert system is a computer program designed to act as an expert in a particular domain also known as knowledge based system. An expert system is a set of programs that manipulate encoded knowledge to solve problems in a specialized domain that normally requires human expertise. The system performs their inference through symbolic computations.

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Expert systems are currently designed to assist experts not to replace them. They have proven to be useful in diverse areas such as medical diagnosis, chemical analysis, and geological exploration and computer system configuration.

Natural Language processing - The goal of natural language processing is to enable people and computers to communicate in a natural (human) language such as English rather in a computer language.

The field of N.L.P is divided into 2 sub fields:

1. Natural language understanding which investigates methods of allowing the computer to comprehend instructions given in ordinary English so computers can understand people more easily.

2. Natural-language generations, which strives to have, computers produce ordinary English language so that people can understand computers more easily.

Speech recognition - The goal of speech recognition research is to allow computers to understand human speech so that they can hear our voice and recognize the words. We are speaking speech recognition research seeks to advance the goal of natural language processing by simplifying the process of interactive communication between people and computers.

Computer Vision - The goal of computer vision research is to give computers this same facility for understanding their surroundings.

Robotics - A robot is an electro mechanical device that can be programmed to perform manual tasks. The robotic industries association formally defines a robot as "a re - programmable multi functional manipulator designed to move material, parts, roots or specialized devices through variable programmed motions for the performance of a variety of tasks".

A robot that performs only the actions it has been pre programmed to perform is considered to be a 'dumb' robot processing no more intelligence.

An intelligent robot includes some kind of sensory apparatus such as a camera that allows it to respond to changes in its environment, rather than just to allow instructions 'mindlessly'.

Intelligent Computer Assisted Instruction - AI methods are being applied to the development of intelligent computer –assisted instruction in an attempt to create computerized "tutors" that shape their teaching techniques to fit the learning patterns of individual students.

Automatic programming - The goal of automatic programming is to create special programs that act as intelligent "tool" to assist programmers and expedite each phase of the programming process. The ultimate aim of automatic programming is computer system that could develop programs by itself, in response to and in accordance with the specifications of a program developer.

Planning and decision support - Intelligent planning programs are designed to provide active assistance in the planning process and are expected to be particularly helpful to managers with decision-making responsibilities.

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From the perspective of goals AI can be viewed as part of engineering and part of science. The engineering goal of AI is to solve real world problems using AI as an armamentarium of ideas about presenting knowledge; using knowledge and assembling system explain various sorts of intelligence.

Characteristics of AI problems:

1. The problems that AI tackles have combinational explosion of solutions.

2. AI programs manipulate symbolic information to a larger extent, in contrast to conventional programs, which deal with numeric processing.

3. To cope with the combinational explosion of solutions, AI programs use heuristics to search tree.

4. In order to classify system as an AI program, the fundamental criterion is that it must have vast quantities of knowledge must be represented in such a form that the system work on it can easily manipulate it.

5. AI programs deal with real life problems to a large extent. They assist humans in taking right decisions. Just a human expert has the capacity to handle uncertain, incomplete and irrelevant information.

6. A very vital characteristic of an AI program is its ability to learn.

Problems representation in AI:

Before a solution can be found, the prime condition is that the problem must be very precisely defined. To build a system to solve a particular problem, we need to do four things.

1. Define the problem precisely: this definition must include precise specifications of what the initial situations will be as well as what final situations constitute acceptable solutions to the problem.
2. Analyze the problem.
3. Isolate and represent the last knowledge that is necessary to solve the problem.
4. Choose the last problem solving techniques and apply it to the particular problem.

The most common methods of problem representation in AI are

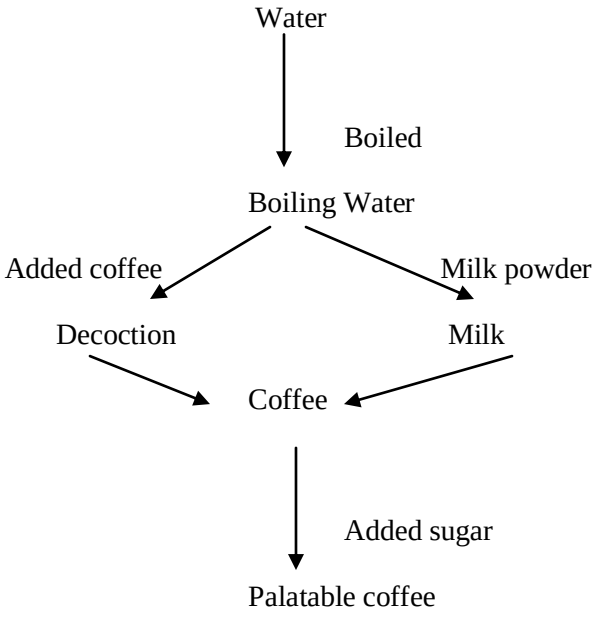
1. State space representation
2. Problem reduction

State space representation:

A set of all possible states for a given problem is known as the state space of the problem. State space representations are highly beneficial in AI because they provide all possible states, operations and goals. If the entire state space representation for a problem is given, it is possible to trace the path from the initial state to the Goal State and identify the sequence of operators necessary for doing it. The major

deficiency of this method is that it is not possible to visualize all states for a given problem. To overcome the deficiencies of this method, problem reduction technique comes handy.

Example1:

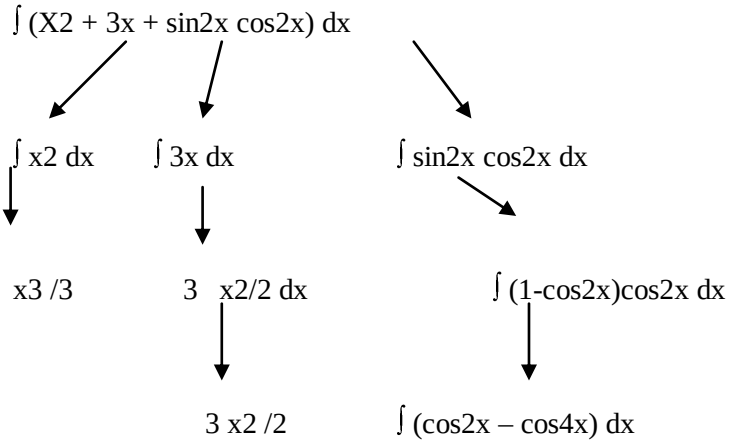


Problem Reduction: In this method a complex problem is broken down or decomposed into a set of preemptive sub problems. Solutions for these preemptive subprograms are easily obtained. The solutions for all the sub-problems collectively give the solution for the complex problem.

Example:

Evaluate $\int(x2+3x+\sin 2x\cos 2x)dx$

We can solve this by breaking down into smaller problems.



The individual values can be combined (Integrated) to get the final result.

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What is AI?

Definitions of AI vary according to "thought process and reasoning" and "behavior".

Thinking humanly - Cognitive modeling approach

Getting inside the actual working of human mind –

a) Introspection – catching our own thoughts

b) Psychological experiments.

Thinking rationally – the laws of thought approach

Laws of thought governed the operation of mind.

Acting humanly – Turing Test

While programming a computer to pass the Turing Test, it has to possess the following capabilities –

- NLP to communicate successfully in English.
- Knowledge representation to store what it knows or hears
- Automated reasoning to use stored information
- Machine learning to adapt to new circumstances

Acting rationally – The rational agent approach

An agent is something that acts, that is operating under autonomous control, perceiving their environment, persisting over a prolonged time period, adapting to change and being capable of taking on another's goals. A rational agent is one that acts so as to achieve the best expected outcome.

Study of AI as rational agent has 2 advantages –

a) It is more general than the laws of thought approach because correct inference is just one of the several possible mechanisms for achieving rationality.

b) It is more amenable to scientific development than are approaches based on human behavior or human thought because the standard of rationality is clearly defined and general.

Foundations of AI –

AI prehistory

Philosophy (428 B.C.–present)

- Can formal rules be used to draw valid conclusions?
- How does the mental mind arise from a physical brain?
- Where does knowledge come from?
- How does knowledge lead to action?

Mathematics (c. 800–present)

- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

Economics (1776–present)

- How should we make decisions so as to maximize payoff?
- How should we do this when others may not go along?
- How should we do this when the payoff may be far in the future?

Neuroscience (1861–present)

- How do brains process information?

Psychology (1879–present)

- How do humans and animals think and act?

Computer engineering (1940–present)

- How can we build an efficient computer?

Control theory and Cybernetics (1948–present)

- How can artifacts operate under their own control?

Linguistics (1957–present)

- How does language relate to thought?

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Chapter 2

An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators.

Percept – refers to the agent's perceptual inputs at any given instant.

Percept sequence – complete history of everything that the agent has perceived.

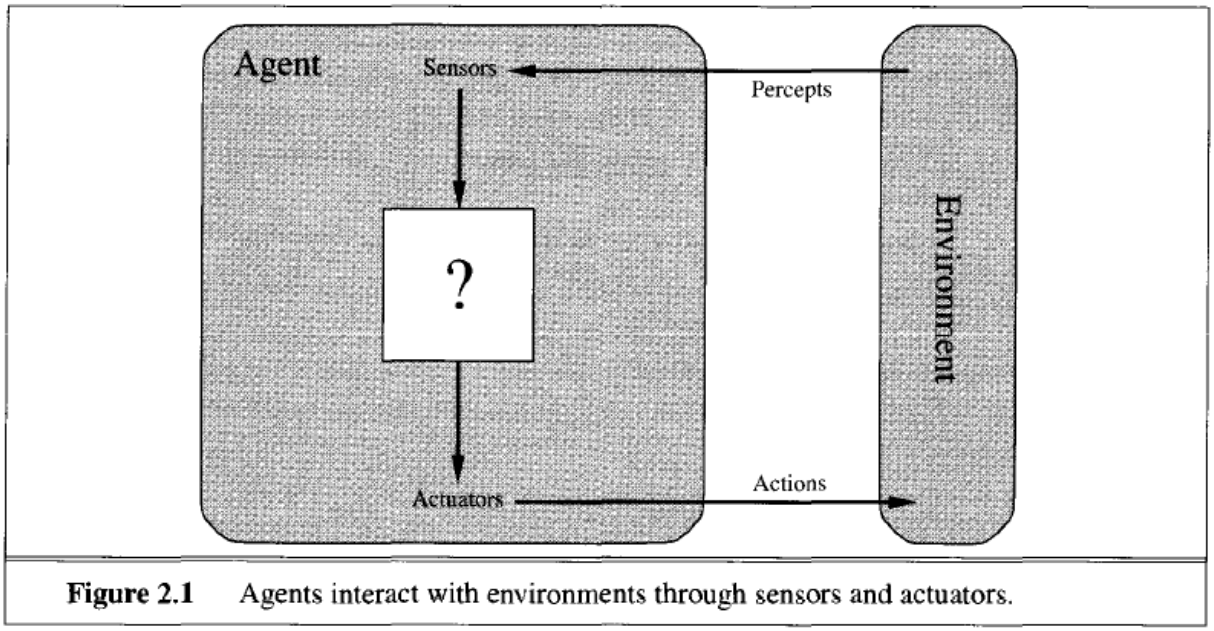


Figure 2.1 Agents interact with environments through sensors and actuators.

Agent function - Agents behavior is described by the agent function that maps any given percept sequence to an action.

Agent program – Agent function for an artificial agent will be implemented by agent program.

Agent program runs on physical architecture to produce f.

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Example:

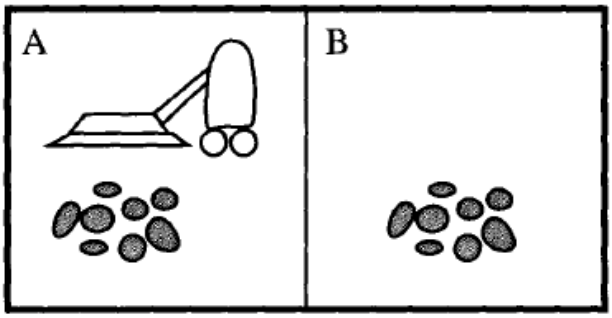


Figure 2.2 A vacuum-cleaner world with just two locations.

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*
⋮	⋮
$[A, Clean], [A, Clean], [A, Clean]$	*Right*
$[A, Clean], [A, Clean], [A, Dirty]$	*Suck*
⋮	⋮

Rational agent – chooses whichever action maximizes the expected value of performance measure given percept sequence to date.

Performance measure -
Fixed performance measure evaluates the environment sequence.

Rational ≠ omniscient (percepts do not supply relevant information)
Rational ≠ clairvoyant (action outcomes may not be as expected)
Hence Rational ≠ successful

A performance measure embodies the criterion for success of an agent's behavior.

Rationality – What is rational at any given time depends on four things –

a) The performance measure that defines the criterion of success
b) The agent's prior knowledge of the environment

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c) The actions that the agent can perform
d) The agent's percept sequence to date

This leads to a **definition of a rational agent**:

> *For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.*

Nature of environments –

Specifying the task environment:

P – performance E- environment A- actuators S- sensors

Example:

a) Designing a taxi:

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

b) Interactive English Tutor:

Interactive English tutor	Maximize student's score on test	Set of students, testing agency	Display exercises, suggestions, corrections	Keyboard entry

<u>Properties of task environments –</u>

a) Fully observable – agent's sensors can give access to complete state of environment, agent need not maintain any internal state to keep track of the world.

vs

Partially observable – noisy or inaccurate sensor

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b) Deterministic – Next state of environment is determined by current state and action executed. Ex : vacuum cleaner

Vs

Stochastic – Next state of environment is not determined by current state. Ex: taxi

Strategic – Environment is deterministic except for actions of other agents

c) Episodic – Agent's experience is divided into atomic episodes. Next episode does not depend on actions taken in previous episodes.

Vs

Sequential – Current decision affects all future decisions. Ex: Chess

d) Static – No change in the environment

Vs

Dynamic – Environment changes while agent is deliberating, continuously ask agent what to do.

Semi dynamic – environment does not change, but agent's performance score does. Ex : Chess

e) Discrete – Applied to state of environment to the way time is handles and to percepts and actions of agents. Ex : Chess

Vs

Continuos – Continuous state and time problem. Ex:Taxi

f) Single agent – Agent solving a crossword puzzle

Vs

Multi agent – Playing chess

Examples of task environments –

Task Environment	Observable	Deterministic	Episodic	Static	Discrete	Agents
Crossword puzzle	Fully	Deterministic	Sequential	Static	Discrete	Single
Chess with a clock	Fully	Strategic	Sequential	Semi	Discrete	Multi
Refinery controller	Partially	Stochastic	Sequential	Dynamic	Continuous	Single
Interactive English tutor	Partially	Stochastic	Sequential	Dynamic	Discrete	Multi

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Structure of agents –

Job of AI is to design agent program that implements agent function mapping percepts to actions. Program runs on some sort of computing device with physical sensors and actuators called architecture.

Agent = architecture + program

Agent program takes current percept as input and returns action to actuators.

Agent program takes current percept as input whereas agent function takes into account the entire percept sequence.

Four types of agents –

a) ***Simple reflex:*** Selects actions on the basis of current percept ignoring percept history.

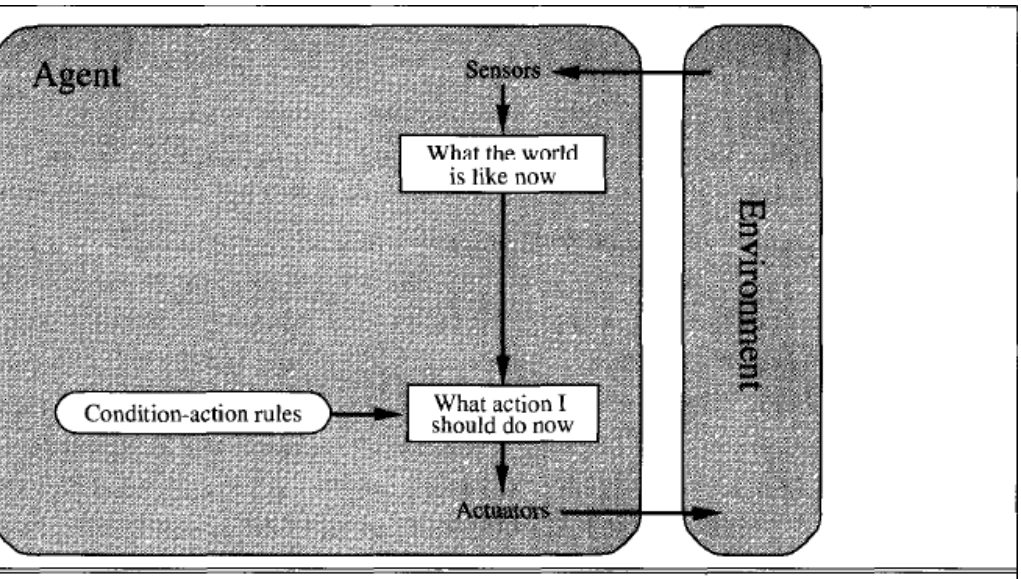


Figure 2.9 Schematic diagram of a simple reflex agent.

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

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

Rectangle is used for current internal state of agent's decision process.

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Oval is used for background information used in process.

Interpret – input function generates abstracted description of current state from percept.

Rule match returns first rule in set of rules that matches given state description.

Disadvantage – limited intelligence, environment must be fully observable.

Ex: breaking in a taxi, vacuum cleaner with only dirt sensor.

b) Model based reflex: Maintains an internal state for partially observable world. This internal state depends on percept history. So for updating this internal state information, 2 kinds of knowledge are required.

i. Environment around agent changes independent of the agent.

ii. Agent's own actions affecting the world.

Using this knowledge is called modeling the world. Agent using this model is called model based agent.

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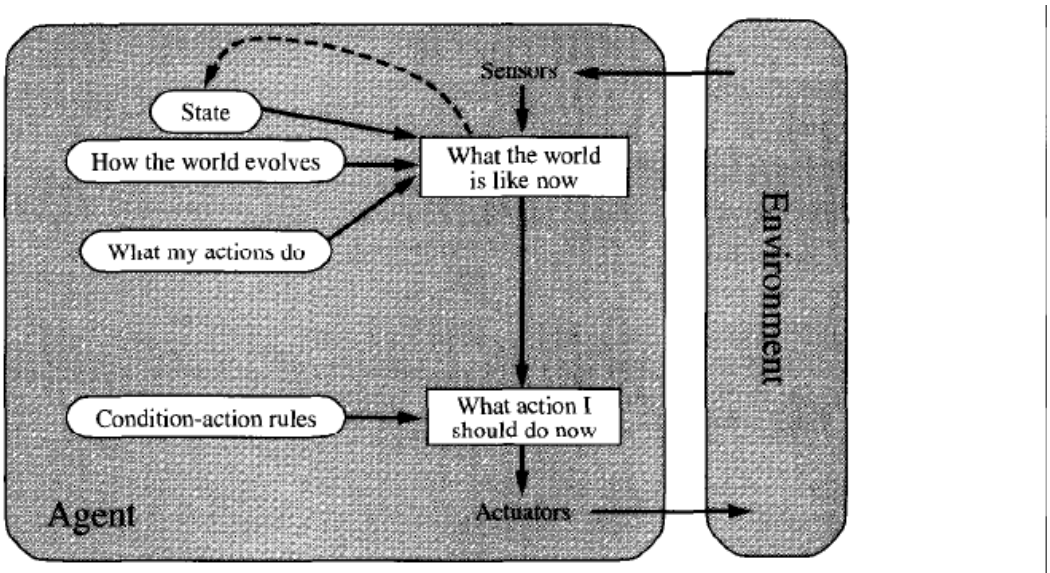


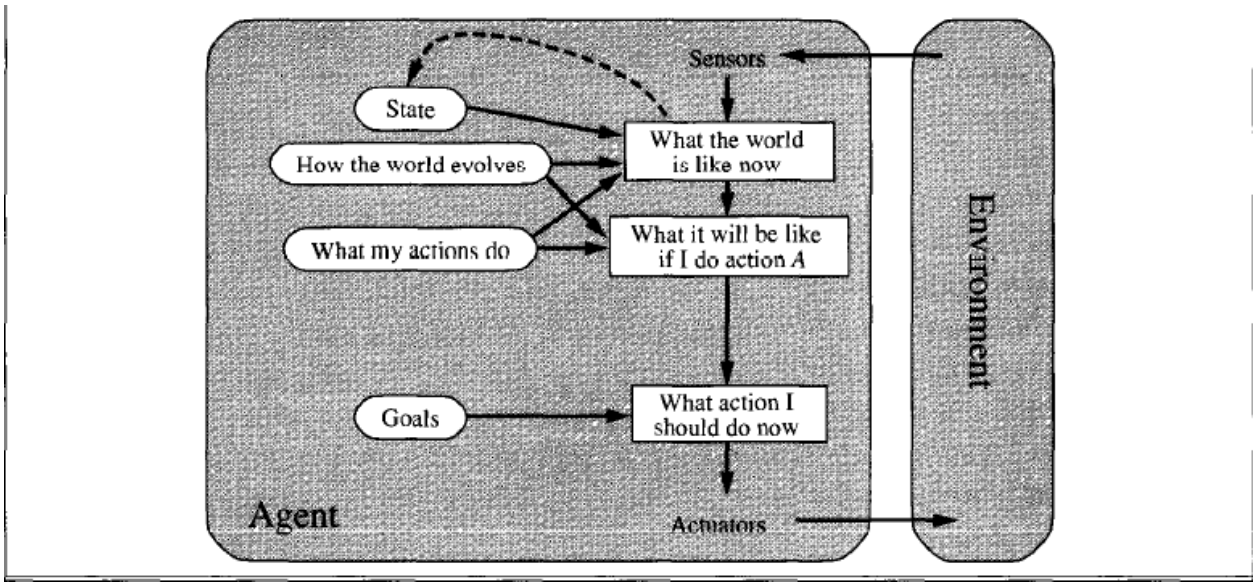
Figure 2.11 A model-based reflex agent.

```
function REFLEX-AGENT-WITH-STATE(percept) returns an action
  static: state, a description of the current world state
          rules, a set of condition–action rules
          action, the most recent action, initially none

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

c) ***Goal based agent:*** Along with the current state description, agent needs some sort of goal information.

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Result can sometimes be straight forward which is from single action. Else we will have to employ search and planning techniques for finding best results.

Advantage – flexible because the knowledge that supports its decisions is represented explicitly and can be modified.

d) Utility based agent: If goal is achieved, we are happy. Else unhappy.

Preferring one over the other is utility.

Utility function maps a state (or a sequence of states) onto real numbers. Complete specification of utility function allows rational decisions in two kinds of cases where goals are inadequate.

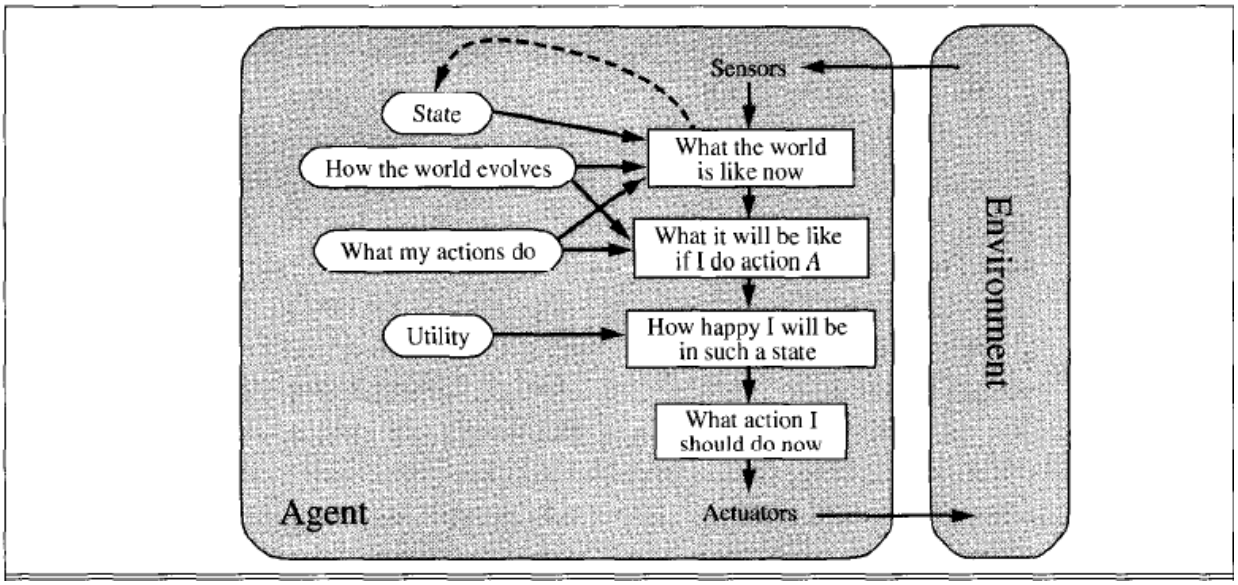
i. When there are conflicting goals only some of which can be achieved, utility function specifies appropriate trade off.
ii. When there are several goals that agent can aim for and none of them can be achieved with certainty, utility provides a way in which likelihood of success can be weighed up against the performance of goals.

Learning agent –

Build learning machines and then teach them.

Allows agent to operate in initially unknown environments.

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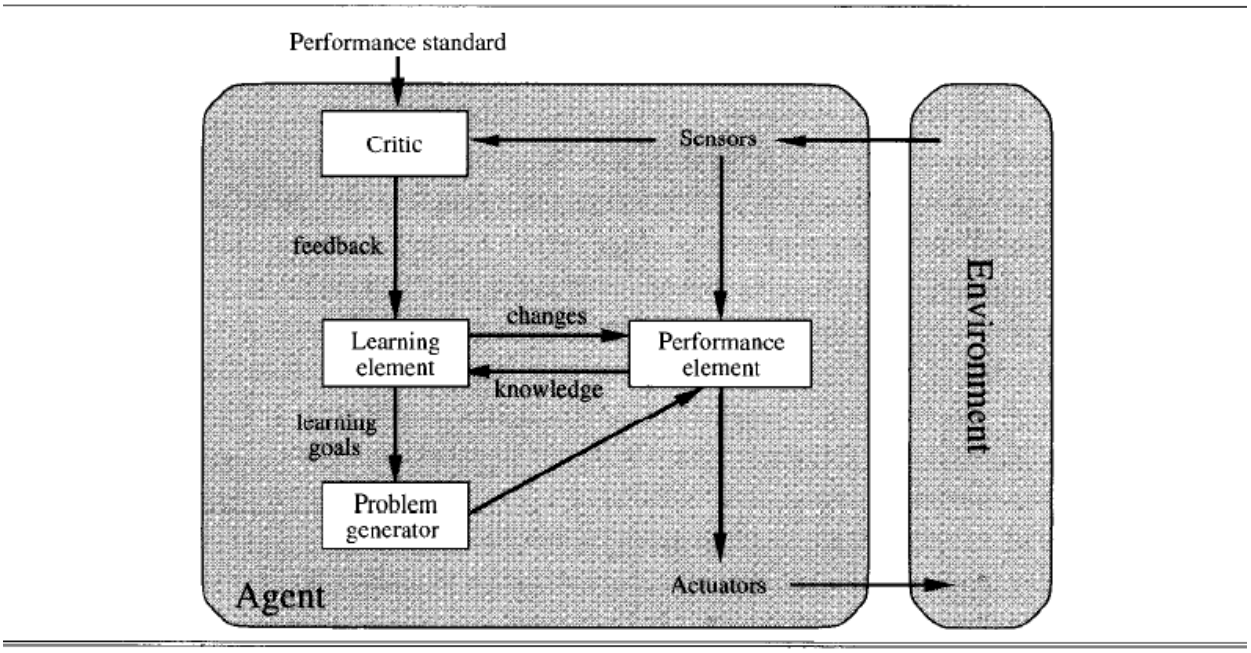


Learning element – make improvements, uses feedback from using fixed performance standard.

Performance element – select actions

Problem generator – suggests actions that will lead to new and informative experiences.

A general model of learning agent –



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