Chapter Five

Artificial intelligence
Learning

Learning

What is Learning

Learning denotes changes in a system that enable

the system to do the same task more efficiently next time.

Learning is an important feature of “Intelligence”.

Definition

A computer program is said to learn from experience with respect to

some class of tasks **T** and performance measure **P**, if its performance at

tasks in **T**, as measured by **P**, improves with experience **E**. (Mitchell 1997)

This means :

Given : A task **T**

A performance measure **P**

Some experience **E** with the task

Goal: Generalize the experience in a way that allows to improve your performance on the task.

Why do you require Machine Learning ?

- Understand and improve efficiency of human learning.
- Discover new things or structure that is unknown to humans.
- Fill in skeletal or incomplete specifications about a domain.

Learning Agents

An **agent** is an entity that is capable of **perceiving** and do **action**.

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

- Learning is essential for unknown environments,

i.e., when designer lacks omniscience

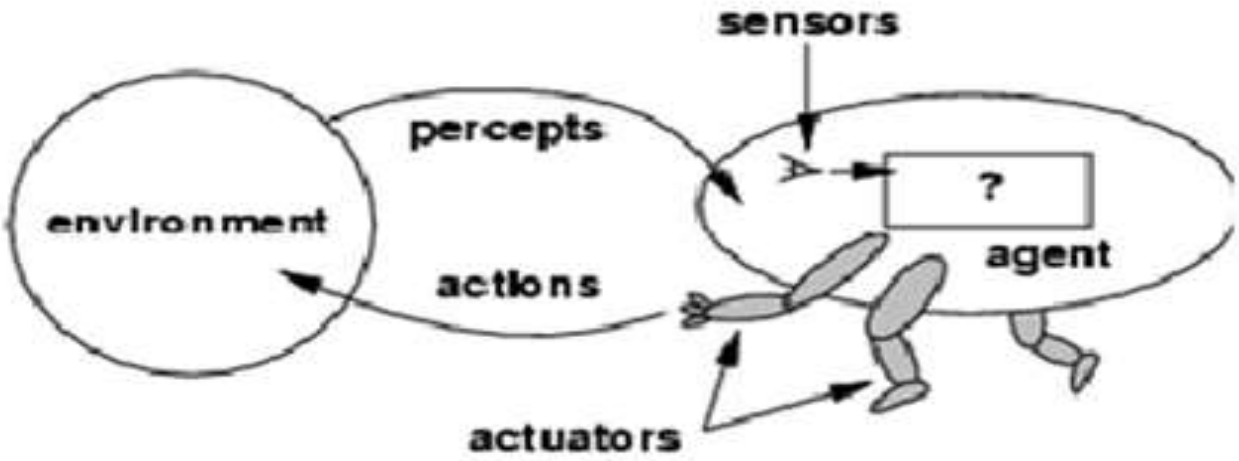
- Learning is useful as a system construction method,

i.e., expose the agent to reality rather than trying to write it down

Learning modifies the agent's decision mechanisms to improve performance

Learning agent = performance element + learning element

Learning performance = prediction accuracy measured on test set



Environment / Agent	Sensors	Actuators
Human agent	Eyes, ears, etc	Leg, hands, mouth
Robotic agent	Cameras, IR range finders	motors
Software agent	Key stroke, File contents	Displays to screen, write files

In computer science an **agent is a software agent** that assists users and acts in performing computer-related tasks**.**

Intelligent Agent (Learning Agent)

Agent is an entity that is capable of perceiving and do action.

In computer science an agent is a software agent.

In artificial intelligence, the term used for agent is an intelligent agent.

Learning is an important feature of “Intelligence”.

Percept**:** agent's perceptual inputs

Percept sequence**:** history of everything the agent has perceived

Agent function**:** describes agent’s behavior

Agent program**:** Implements agent's function

Learning Agent consist of four main components :

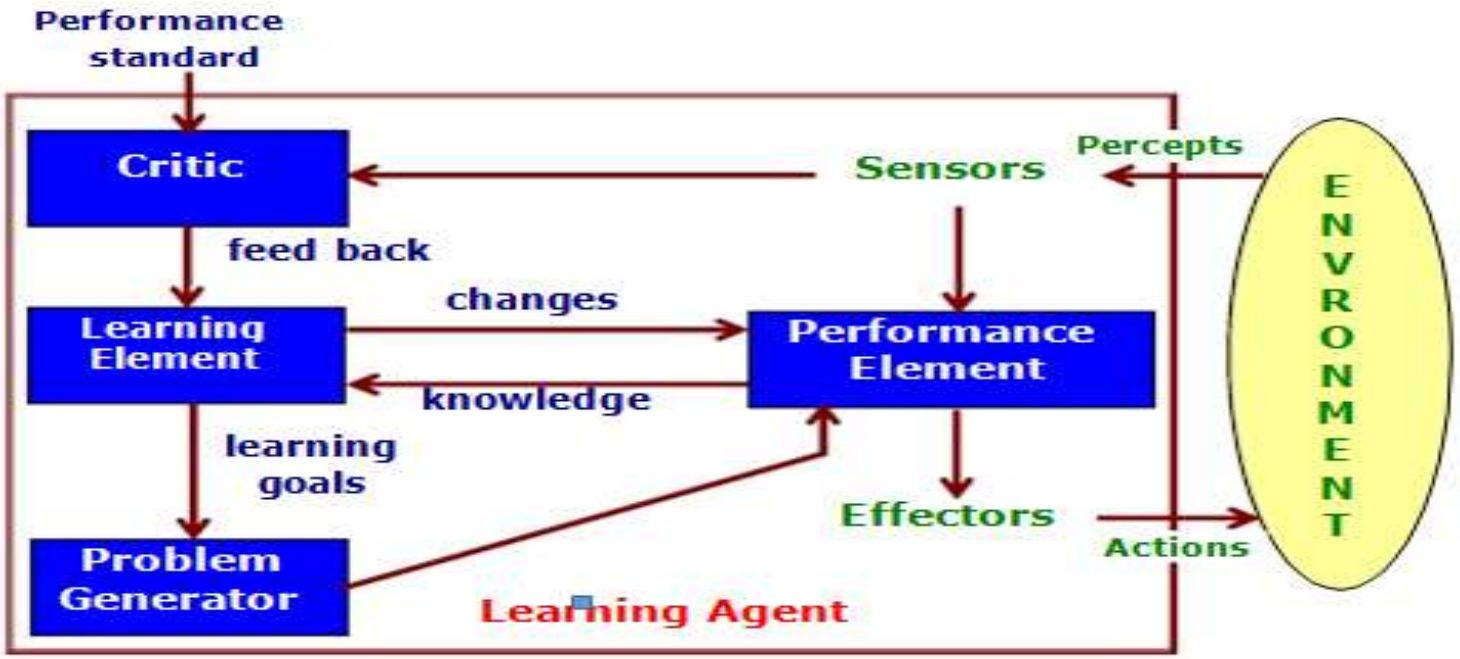
◊ Learning element,

◊ Performance element,

◊ Critic, and

◊ Problem generator.

Components of a Learning System



Components of a Learning System

***Learning Element**

- responsible for making improvements
- uses knowledge about the agent and feedback on its actions to improve performance

***Performance Element**

The Performance Element is the agent itself that acts in the world.

- selects external actions
- collects percepts, decides on actions
- incorporated most aspects of our previous agent design

***Critic**

- informs the learning element about the performance of the action
- must use a fixed standard of performance
  - should be from the outside
  - an internal standard could be modified to improve performance
    - sometimes used by humans to justify or disguise low performance

***Problem Generator**

- suggests actions that might lead to new experiences
- may lead to some sub-optimal decisions in the short run
  - in the long run, hopefully better actions may be discovered
- otherwise no exploration would occur

Example : Automated Taxi on city roads

■ Performance Element: Consists of knowledge and procedures for driving actions.

e.g., turning, accelerating, braking are performance element on roads.

■ Learning Element: Formulates goals.

e.g., learn rules for braking, accelerating, learn geography of the city.

■ Critic: Observes world and passes information to learning element.

e.g. , quick right turn across three lanes of traffic, observe reaction of other drivers.

■ Problem Generator: Try south city road.

Different kinds of learning:

Supervised learning: we get correct answers for each training instance

Supervised learning involves learning a function from examples

of its inputs and outputs

Unsupervised learning: we don't know anything. . .

Unsupervised learning involves learning patterns in the input when no specific output values are supplied

Reinforcement learning: we get occasional rewards

In reinforcement learning the agent must learn from reinforcement (reward, less exact feedback than in supervised learning)

Paradigms of Machine Learning

■ **Rote Learning:** Learning by memorization; One-to-one mapping from

Inputs to stored representation; Association-based storage and retrieval.

■ **Induction:** Learning from examples; A form of supervised learning, uses specific examples to reach general conclusions; Concepts are learned from sets of labeled instances.

■ **Clustering:** Discovering similar group; Unsupervised, Inductive learning in which natural classes are found for data instances, as well as ways of classifying them.

■ **Analogy:** Determine correspondence between two different representations that come from Inductive learning in which a system transfers knowledge from one database into another database of a different domain.

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■ **Discovery**: Learning without the help from a teacher; Learning is both inductive and deductive. It is deductive if it proves theorems and discovers concepts about those theorems. It is Inductive when it raises conjectures (guess). It is unsupervised, specific goal not given.

■ **Genetic Algorithms:** Inspired by natural evolution; In the natural world, the organisms that are poorly suited for an environment die off, while those well-suited for it prosper. Genetic algorithms search the Space of individuals for good candidates. The "goodness" of an individual is measured by some fitness function. Search takes place in parallel, with many individuals in each generation.

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Reinforcement: Learning from feedback (+ve or -ve reward) given at end of a sequence of steps. Unlike supervised learning, the Reinforcement learning takes place in an environment where the Agent cannot directly compare the results of its action to a desired result. Instead, it is given some reward or punishment that relates to its actions. It may win or lose a game, or be told it has made a good move or a poor one. The job of reinforcement learning is to find a successful function using these rewards.

Rote Learning

Rote learning technique avoids understanding the inner complexities but focuses on memorizing the material so that it can be recalled by the learner exactly the way it was read or heard.

- **Learning by Memorization** which avoids understanding the inner complexities the subject that is being learned; Rote learning instead focuses on memorizing the material so that it can be recalled by the learner exactly the way it was read or heard.
- **Learning something by Repeating** over and over and over again; saying the same thing and trying to remember how to say it; it does not help us to understand; it helps us to remember, like we learn a poem, or a song, or something like that by rote learning.

Learning from Example : Induction

A process of learning by example. The system tries to induce a general rule from a set of observed instances. The learning methods extract rules and patterns out of massive data sets.
The learning processes belong to supervised learning, does classification and constructs class definitions, called induction or concept learning.
The techniques used for constructing class definitions (or concept leaning) are :

- Winston's Learning program
- Version Spaces
- Decision Trees

Inductive Learning

- tries to find a function h (the hypothesis) that approximates a set of samples defining a function f
  - the samples are usually provided as input-output pairs (x, f(x))
- supervised learning method
- relies on inductive inference, or induction
  - conclusions are drawn from specific instances to more general statements

Machine Learning

Definition: A computer program is said to *learn* from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E.

Why is Machine Learning Important?

- Some tasks cannot be defined well, except by examples (e.g., recognizing people).
- Relationships and correlations can be hidden within large amounts of data. Machine Learning/Data Mining may be able to find these relationships.
- Human designers often produce machines that do not work as well as desired in the environments in which they are used

Why is Machine Learning Important (Cont'd)?

- The amount of knowledge available about certain tasks might be too large for explicit encoding by humans (e.g., medical diagnostic).
- Environments change over time.
- New knowledge about tasks is constantly being discovered by humans. It may be difficult to continuously re-design systems "by hand".

Areas of Influence for Machine Learning

- **Statistics:** How best to use samples drawn from unknown probability distributions to help decide from which distribution some new sample is drawn?
- **Brain Models:** Non-linear elements with weighted inputs (Artificial Neural Networks) have been suggested as simple models of biological neurons.
- **Adaptive Control Theory:** How to deal with controlling a process having unknown parameters that must be estimated during operation?

Areas of Influence for Machine Learning (Cont'd)

- **Psychology:** How to model human performance on various learning tasks?
- **Artificial Intelligence:** How to write algorithms to acquire the knowledge humans are able to acquire, at least, as well as humans?
- **Evolutionary Models:** How to model certain aspects of biological evolution to improve the performance of computer programs?

Designing a Learning System: An Example

1. Problem Description
2. Choosing the Training Experience
3. Choosing the Target Function
4. Choosing a Representation for the Target Function
5. Choosing a Function Approximation Algorithm
6. Final Design