Learning processes:

To perform any neural processing task, N.N learning of an input-output mapping from a set of examples is needed.

- For the system to improve performance over time and therefore learn, it is recommended to use approximating techniques. Approximation theory focuses on approximating a continuous, multivariable function ***h(x)*** by another function ***H(w,x)***.
- The learning task is to find ***w*** that provides the best possible approximation of ***h(x)*** based on the set of training examples[**x**]. an important choice that needs to be made is which approximation function ***H(w, x)*** to use. Once ***H(w, x)*** has been chosen, the network learning algorithm is applied for finding optimal parameter ***w***. a more precise formulation of the learning problem can stated as calculation involving ***w**** such that:
- ***D[H(w*, x), h(x)] ≤ D[H(w, x), h(x)],***

Where ***D[ ]*** or the distance function is a measure of approximation.

In general, we may categorize the learning processes through which N.Ns function as follows:

1- Learning with a teacher
2- Learning without a teacher, it may sub-categorized into:
   2.1 Reinforcement learning
   2.2 Unsupervised learning

1- Learning with a teacher:

Learning with a teacher is also referred to as supervised learning. A block diagram of such leaning is illustrated in figure (15)

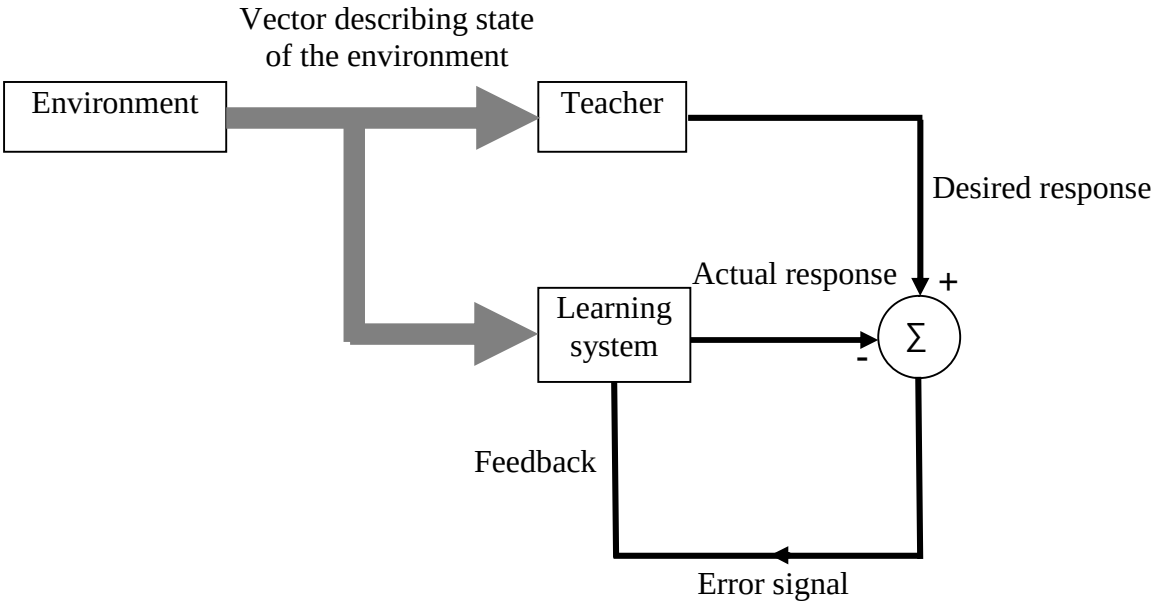

Figure (15) Block diagram of learning with a teacher

- In this type of learning it is assumed that at each instant of time when the input is applied, the desired response ***d*** of the system is provided.
- The distance between the actual and desired response serve as an error measure and is used to correct network parameters externally.
- Since we have assume adjustable weights, the teacher may implement a scheme to adapt the network's weight matrix **W.**
- The error between the desired and actual response can be used to modify weights so that the error decreases.

2- Learning without a teacher

2.1 Reinforcement learning (RL)

- In supervised learning we have assumed that there is a target output value for each input value. However, in many situations, there is less detailed information available. In extreme situations, there is only a single bit of information after a long sequence of inputs telling whether the output is right or wrong. Reinforcement learning is one method developed to deal with such situations.

- In RL the feedback signal is only evaluative, not instructive.

Reinforcement learning is often called ***learning with a critic*** as opposed to ***learning with a teacher***.

In RL, the learning of an input-output is performed through continued interaction with the environment in order to minimize a scalar index of performance.

Figure (16) represents the block diagram of one form of a reinforcement learning system.

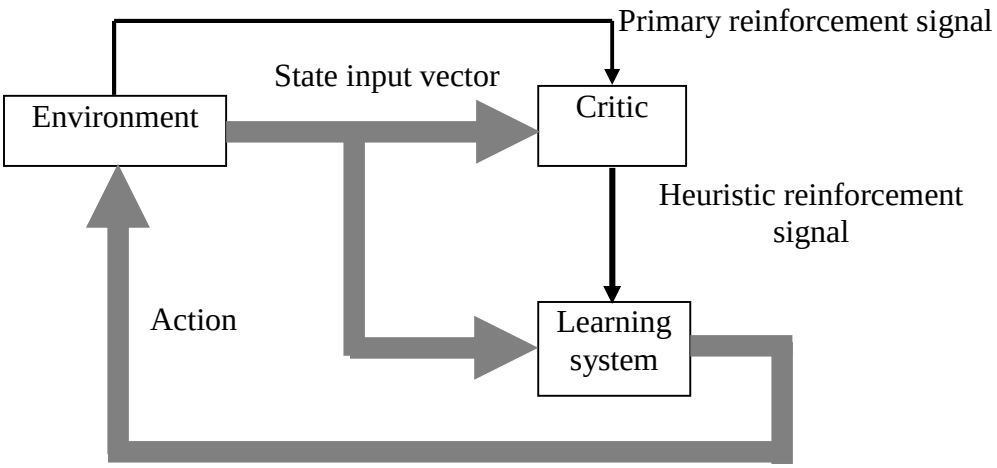

Figure (16) Block diagram of reinforcement learning.

The learning system and the environment are both inside the feedback loop

- The system is designed to learn under delayed reinforcement. The "action" taken over a sequence of steps instead of simply the immediate one.
- It may turn out that certain actions taken earlier in that sequence of time steps are in fact the best determinants of overall system behavior.
- The function of the learning system is to discover these actions and feed them back to the environment.
- As an example, A network designed to play chess would receive a reinforcement signal (win or lose) after a long sequence of moves.

2.2 Unsupervised learning

In unsupervised learning, or self-organized learning, there is no external teacher or critic to oversee the learning process, as indicated in figure (17).

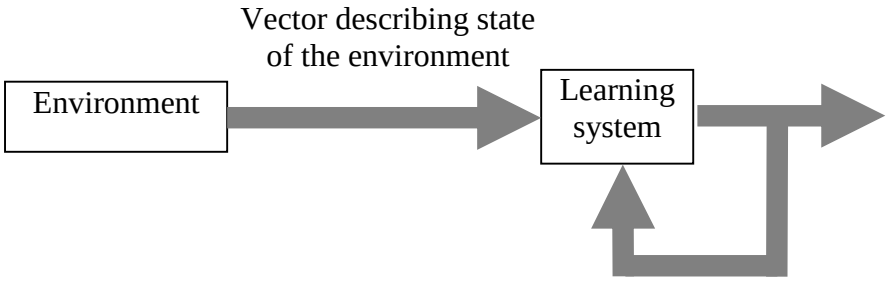

Figure (17) Block diagram of unsupervised learning.

Rather, provision is made for “task independent measure” of the quality representation that the network is required to learn, and the free parameters of the network are optimized with respect to that measure.

For a specific task-independent measure, once the network has become tuned to the statistical regularities of the input data, the network develops the ability to form internal representations for encoding features of the input and thereby to create new class automatically.