Class-5
Artificial Neural Network
Unit-1
Introduction-ADALINE

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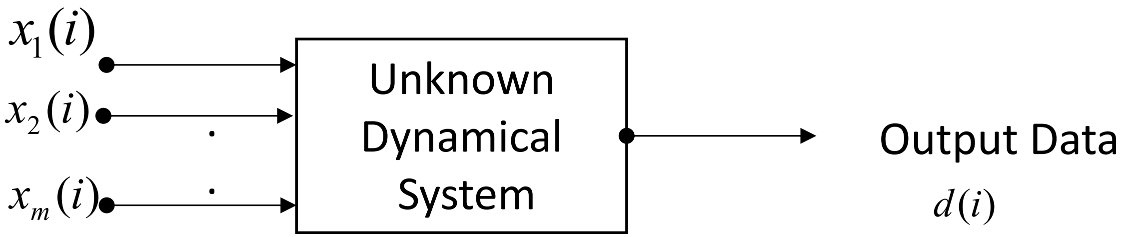
Outline

- Adaptive filtering problem
- Unconstrained Optimization Techniques
- Linear least square Solution

Linear Neuron:
Adaptive filtering problem

Unknown dynamical system:



The external behavior of the system is described by the data set

$$\Im : \{X(i), d(i); i = 1,2,\ldots., n, \ldots..\}$$

where,

$$X(i) = [x_1(i), x_2(i), x_3(i) \ldots\ldots, x_m(i)]^T$$

the 'm' pertaining to the input vetor x(i) is referred to as dimensionality of the input space.

Linear Neuron:
Adaptive filtering model

The stimulus X(i) can arise in one of two fundamentally different ways:

1. The m elements of X(i) originate at different points in space:Spatial

2. The m element of X(i) represent the set of present and (m-1) past values of some excitation that are uniformly spaced in time: Temporal

Linear Neuron:
Adaptive filtering model

Objective:

- Design a multiple input-single output model of the unknown dynamical system using a single neuron.

Linear Neuron:
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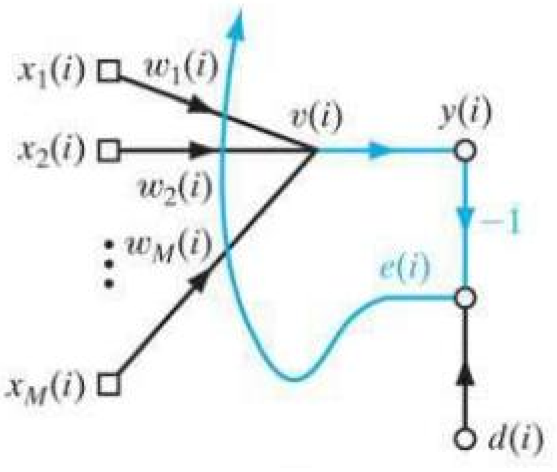
Signal Flow Graph of linear neuron model:



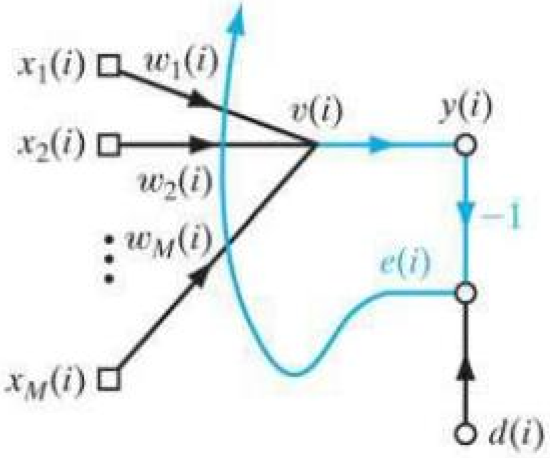
Linear Neuron:
Adaptive filtering model

- Develop an algorithm that adopt by neuronal model such that it controls necessary adjustment to the synaptic weights of the neuron.
- The neuronal model described is referred as adaptive filter.

Linear Neuron:
Adaptive filtering problem

- Adaptive filter operation consists of two continuous processes:
  1. Filtering process
  2. Adaptive Process
- Combination of this 2 processes working together constitutes a *feedback loop* acting around the neuron.
- Since the neuron is linear, the output y(i) is exactly the same as the induced local field v(i);

$$y(i) = v(i) = \sum_{k=1}^{m} w_k(i) x_k(i)$$



Linear Neuron:
Adaptive filtering problem

$$y(i) = v(i) = \sum_{k=1}^{m} w_k(i) x_k(i)$$

where

$w_1(i), w_2(i), ..., w_m(i)$ are the m synaptic weight of the neuron

In matrix form we may express y(i) as an inner product of the vector x(i) and w(i) as follows:

$$y(i) = X^T(i) W(i) = W^T(i) X(i)$$

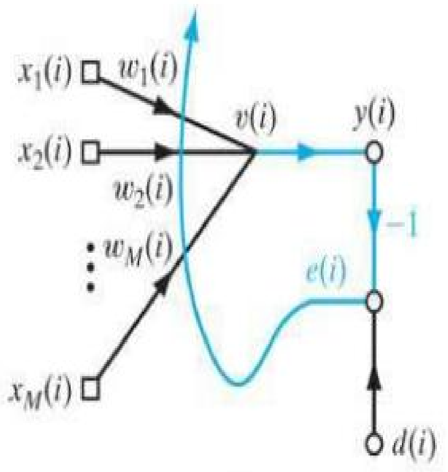
where $W(i) = [w_1(i), w_2(i), ..., w_m(i)]^T$

Linear Neuron:
Adaptive filtering problem

- The neuron's output is compared with the corresponding output d(i) received from the unknown system at time i.

$$e(i) = d(i) - y(i)$$

- This error signal is used to control the adjustment of the neuron's synaptic weight.
- The manner in which error signal is to be used is determine by the cost function and used to derive the adaptive filtering algorithm of interest.



Adaptive filtering problem:
Unconstrained Optimization Techniques

- Adaptive filtering problem is close to optimization problem.
- Optimization techniques:it is a mathematical technique for finding a maximum or minimum value of a function of several variables subject to a set of constraints.
- if it is not subjected to a set of constraints then, the technique is referred as Unconstrained optimization.

Adaptive filtering problem:
Unconstrained Optimization Techniques

- Consider a cost function that is continuously differentiable function of some unknown weight vector W.
- The cost function is a measure of how to choose the weight vector W of an adaptive filtering algorithm so that it behaves in an optimum mannner.
- Find the optimum solution W* that satisfies the condition

$$\xi(W^*) \leq \xi(W)$$

This is referred as an Unconstrained Optimization Techniques

- Unconstrained Optimization Techniques:

Minimize the cost function w.r.t the weight vector W, and the necessary condition for optimality is

$$\nabla \xi(W^*) = 0$$

where the gradient operator:

$$\nabla = \left[\frac{\partial}{\partial w_1}, \frac{\partial}{\partial w_2}, \ldots\ldots, \frac{\partial}{\partial w_m} \right]^T$$

$$\nabla \xi(W) = \left[\frac{\partial \xi}{\partial w_1}, \frac{\partial \xi}{\partial w_2}, \ldots\ldots, \frac{\partial \xi}{\partial w_m} \right]^T$$

- **Unconstrained Optimization Techniques:**

It is well suited to local iterative method and the statement as follows:

Starting with an initial guess denoted by W(0), generate a sequence of weight W(1),W(2),..., such that the cost function is reduced at each iteration of the algorithm as shown by

$$\xi(W^*(n+1)) \leq \xi(W(n))$$

Adaptive filtering problem: Unconstrained Optimization Techniques

- Linear Least Square filter
- Wiener filter
- Gauss-Netwon Method
- Steepest Descent Method
- Newton's Method
- LMS Method

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THANK YOU

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