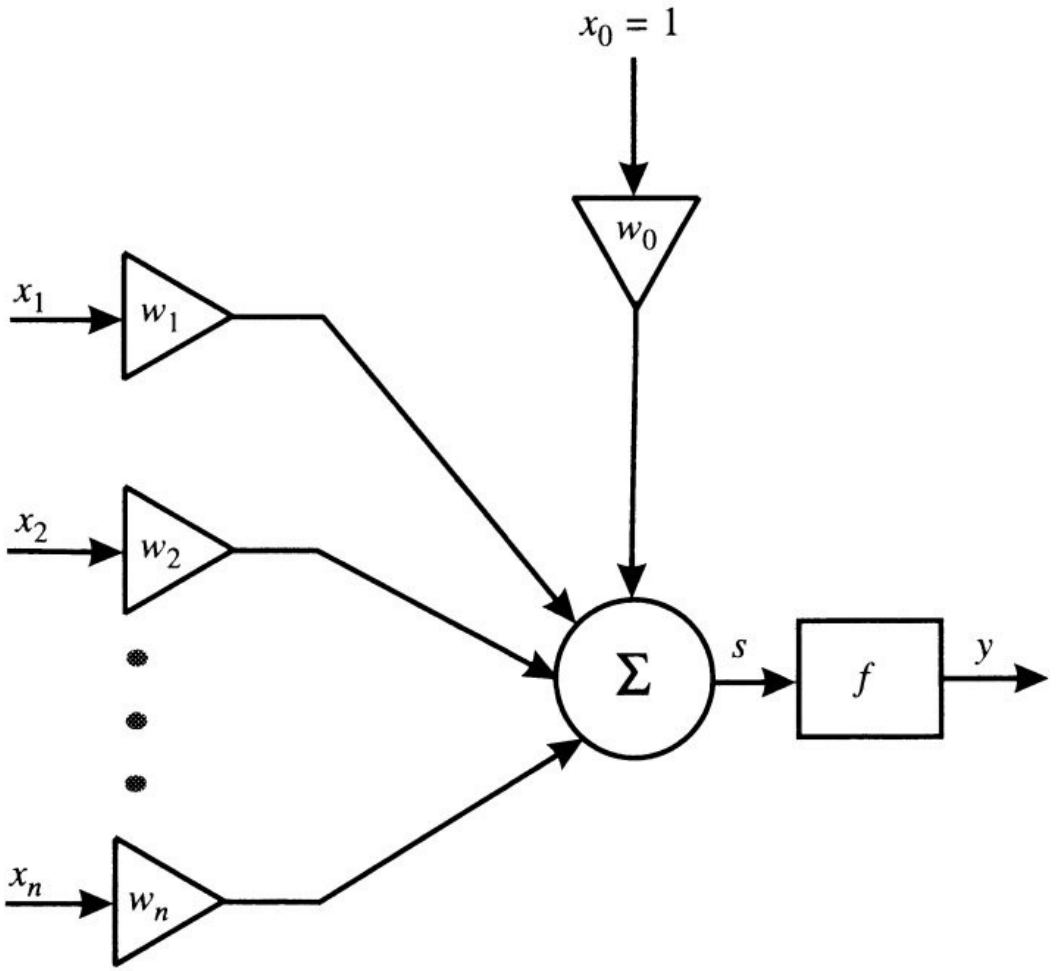
Artificial Intelligence

LECTURE 2

Neural Networks

- Neural networks are networks of nerve cells in the brains of humans and animals.
- The first big step toward neural networks in AI was made 1943 by McCulloch and Pitts in an article entitled “A logical calculus of the ideas immanent in nervous activity”.
- Artificial neural networks (ANNs) are composed of interconnecting artificial neurons (programming constructs that mimic the properties of biological neurons).

Artificial Neuron Model



$$y = f\left(\sum_{i=0}^{n} w_i x_i\right)$$

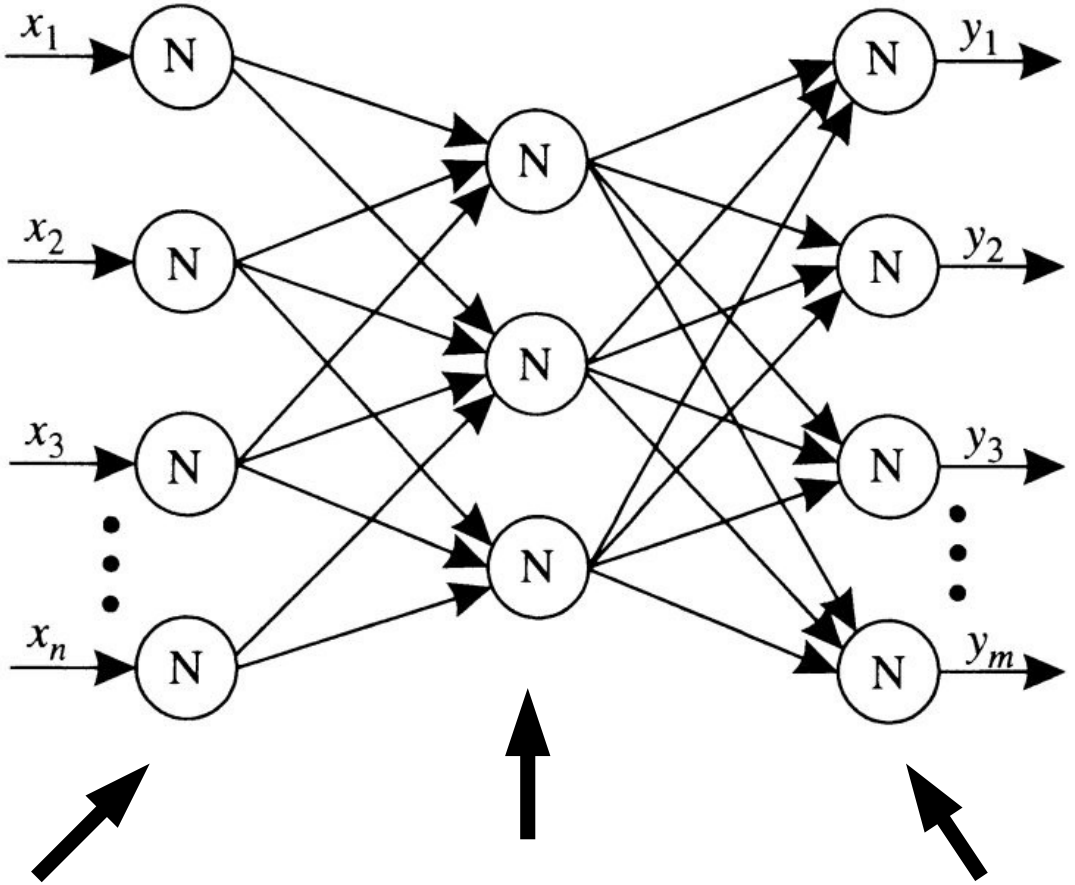
f - an output activation function

$x_1, x_2, \ldots, x_n$ – inputs

$w_0, w_1, \ldots, w_n$ – weights

y – output

Multi-layer Neural Network



INPUT LAYER

HIDDEN LAYER

OUTPUT LAYER

Learning Rules

Learning rules update connections (weights) between neurons.

Supervised Learning

A training set *(k* instances)*:*

$$(\mathbf{x}(t), d(\mathbf{x}(t))$$

$\mathbf{x}(t)=[x_1(t),x_2(t), ..., x_n(t)]$ – a vector of inputs
$d(\mathbf{x}(t))$ – correct output for a vector of inputs

$t=1,2, ..., k$

Learning Rules

1) Randomly initialize the weights between neurons. Set t=1.

2) Present the input vector:

$$\mathbf{x}(t)=[x_1(t),x_2(t), ..., x_n(t)]$$

3) Compute the output y.

4) Compare the output y with its correct value $d(\mathbf{x}(t))$ included in the training set.

5) Modify the weights according to:

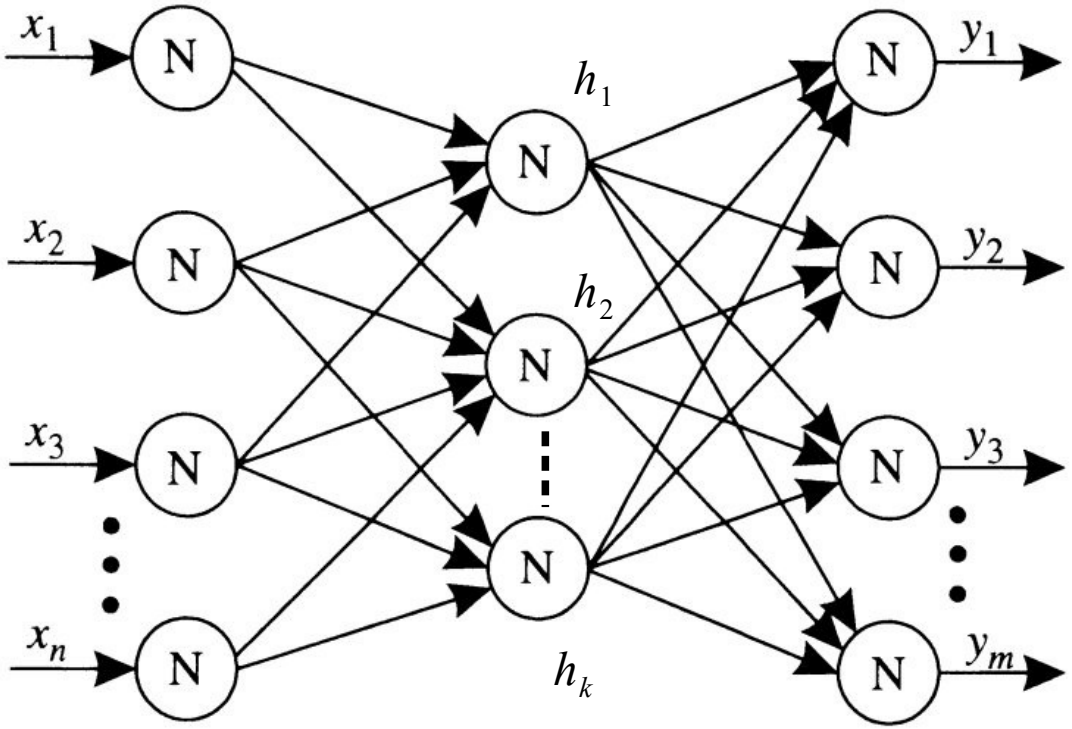
$$if \;\; y \neq d(\boldsymbol{x}(t)): \quad w_i(t+1)=w_i(t)+d(\boldsymbol{x}(t))\cdot x_i(t)$$
$$if \;\; y = d(\boldsymbol{x}(t)): \quad w_i(t+1)=w_i(t)$$

6) Increase t.

7) If t is not greater than k, return to 2.

Modifying Weights

- The backward propagation of errors (backpropagation)



Output neuron error:

$$e_i = y_i(1-y_i)(d_i-y_i)$$

New output neuron weights:

$$w'_{ji} = w_{ji} + e_i \cdot h_j$$

Hidden neuron error:

$$\varepsilon_j = h_j(1-h_j)\sum e_i w_{ji}$$

New hidden neuron weights:
as for output neuron