Introduction to Artificial Neural Networks

• What is an Artificial Neural Network ?

- It is a computational system inspired by the

    Structure

    Processing Method

    Learning Ability

of a biological brain

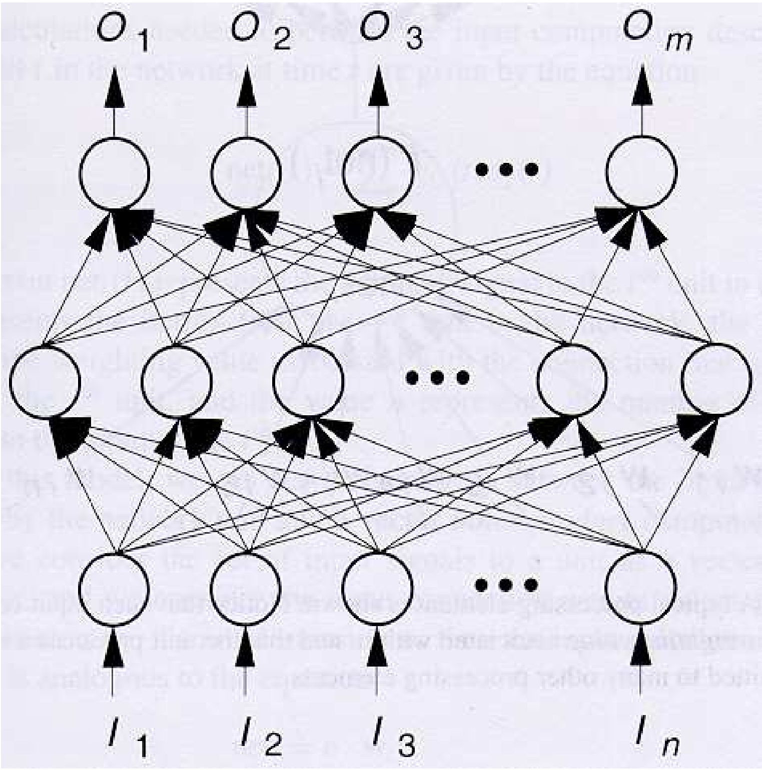
- Characteristics of Artificial Neural Networks

    A large number of very simple processing neuron-like processing elements

    A large number of weighted connections between the elements

    Distributed representation of knowledge over the connections

    Knowledge is acquired by network through a learning process



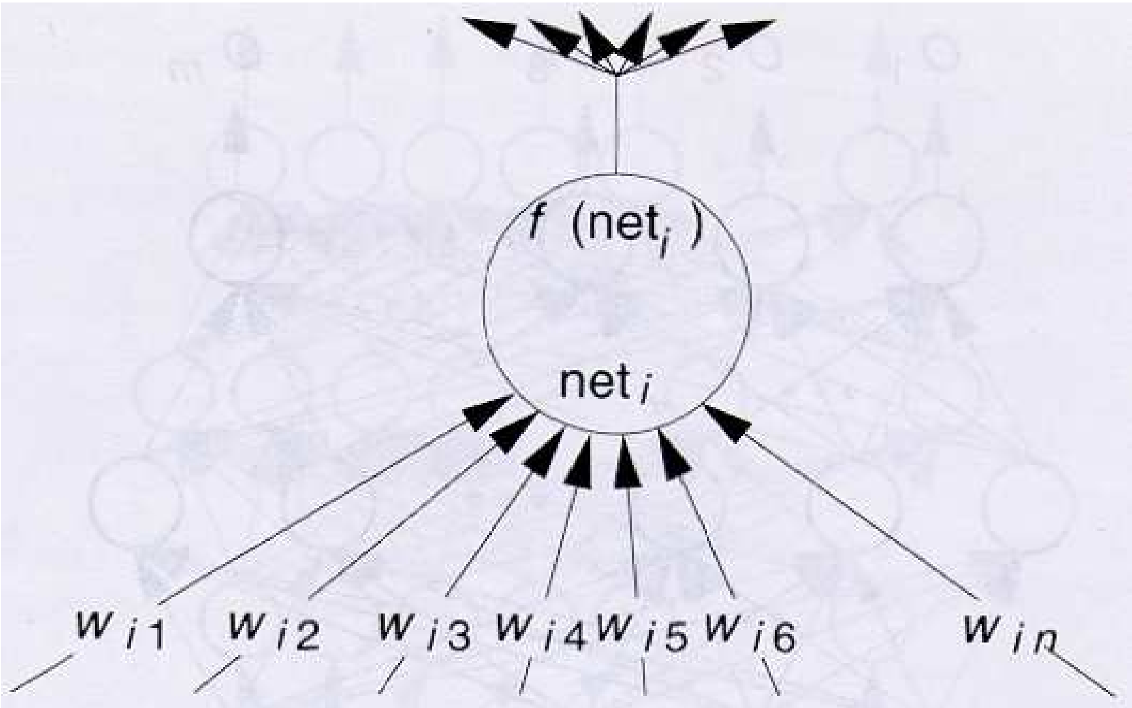
- **Why Artificial Neural Networks ?**

  - Massive Parallelism
  - Distributed representation
  - Learning ability
  - Generalization ablity
  - Fault tolerance

- **Elements of Artificial Neural Networks**

  - Processing Units
  - Topology
  - Learning Algorithm

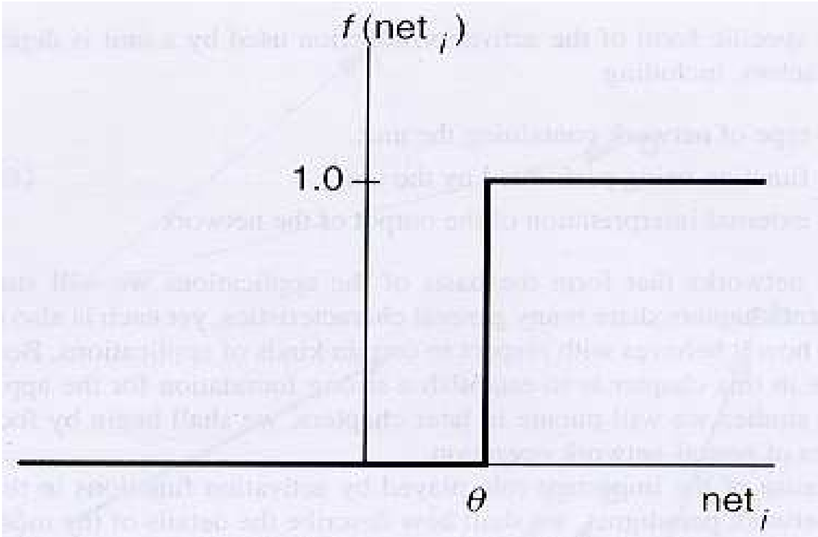
- **Processing Units**



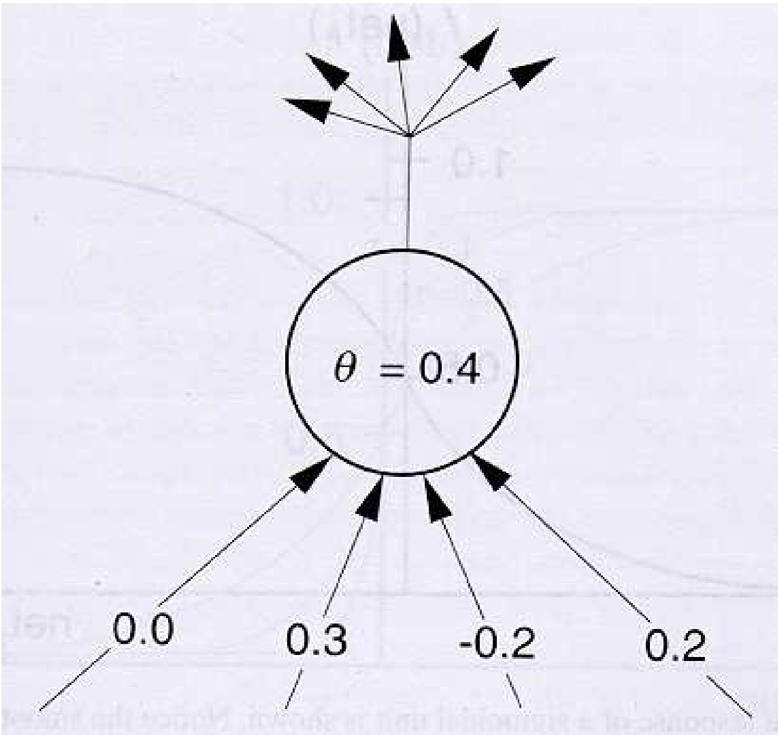
Node input: $net_i = \sum_j w_{ij} I_i$

Node Output: $O_i = f(net_i)$

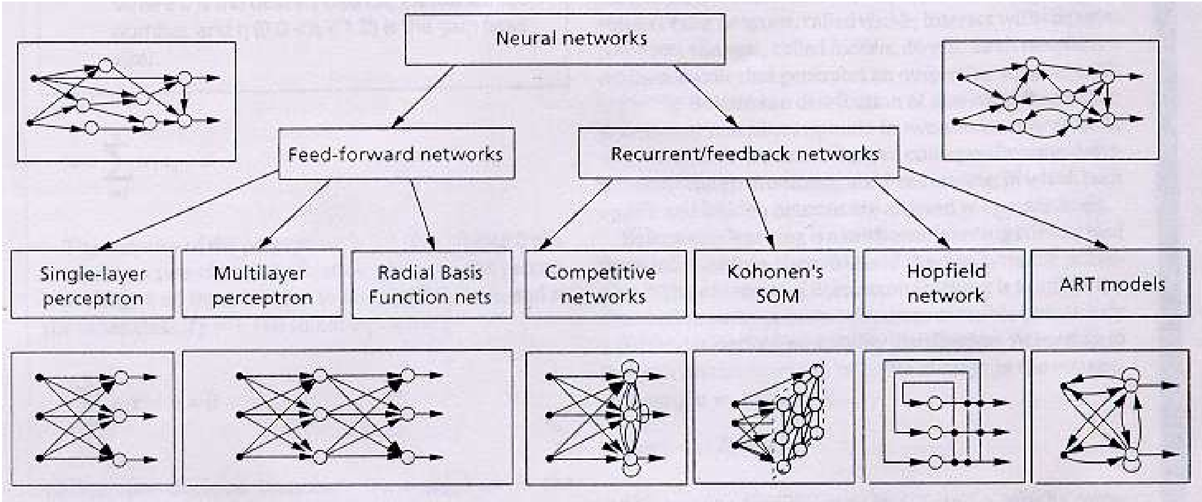
- **Activation Function**



- An example



- **Topology**



- **Learning**

- Learn the connection weights from a set of training examples

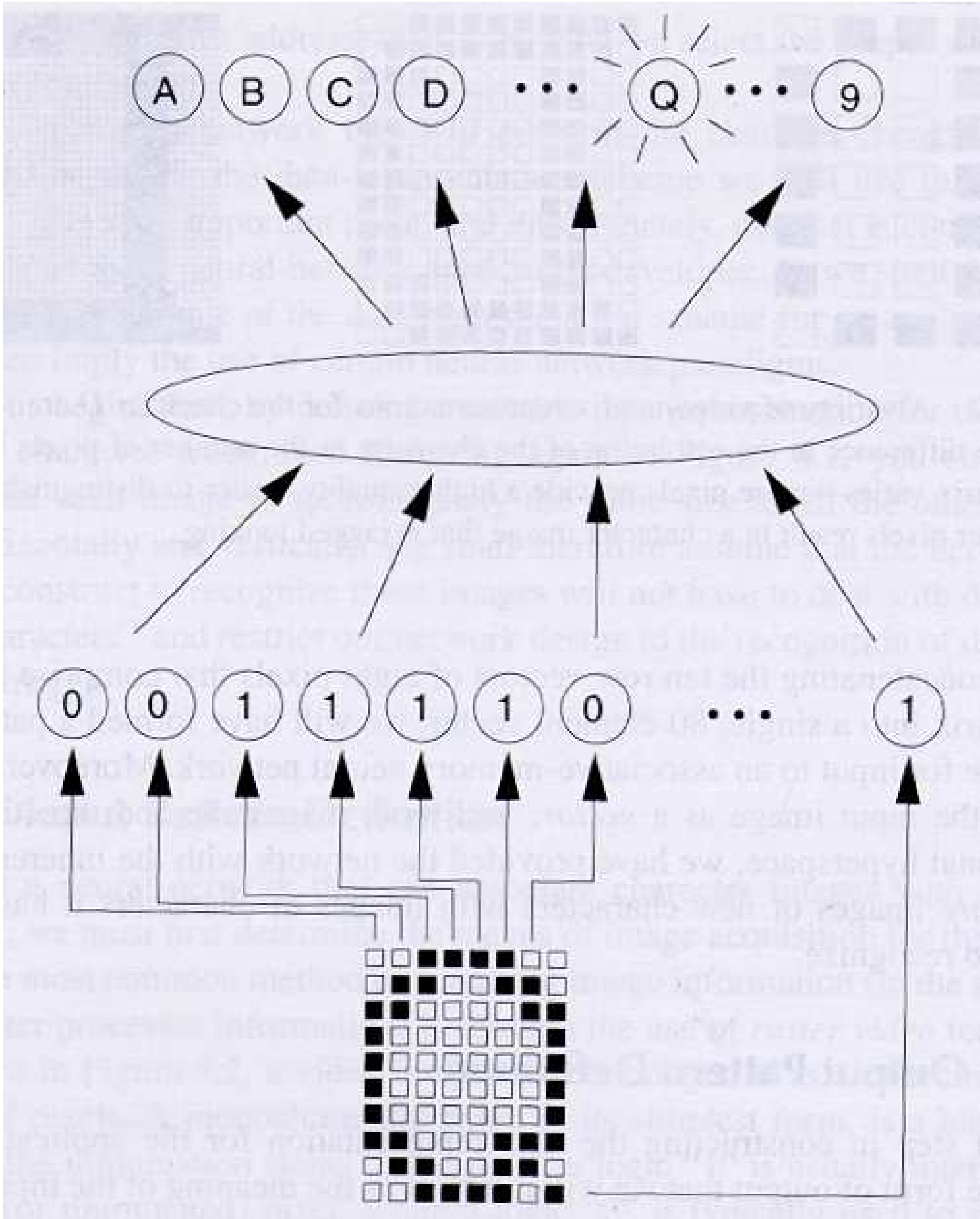
- Different network architectures required different learning algorithms

Supervised Learning

The network is provided with a correct answer (output) for every input pattern

Weights are determined to allow the network to produce answers as close as possible to the known correct answers

The *back-propagation* algorithm belongs into this category


A
B
C
D
Q
9
0
0
1
1
1
1
0
1

Unsupervised Learning

Does not require a correct answer associated with each input pattern in the training set

Explores the underlying structure in the data, or correlations between patterns in the data, and organizes patterns into categories from these correlations

The *Kohonen algorithm* belongs into this category

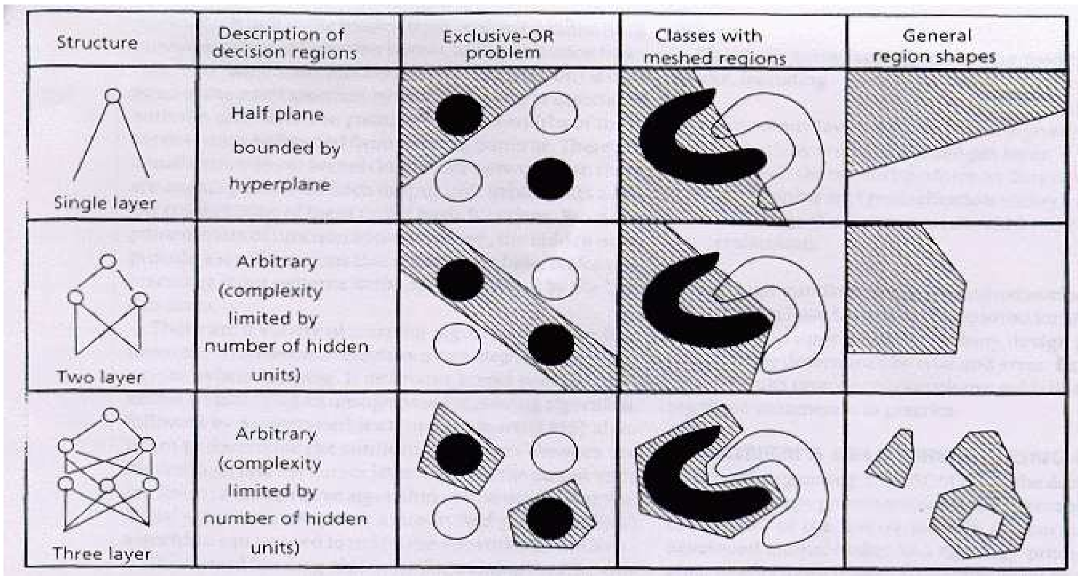
Hybrid Learning

Comnines supervised and unsupervised learning

Part of the weights are determined through supervised learning and the others are obtained through aunsupervised learning

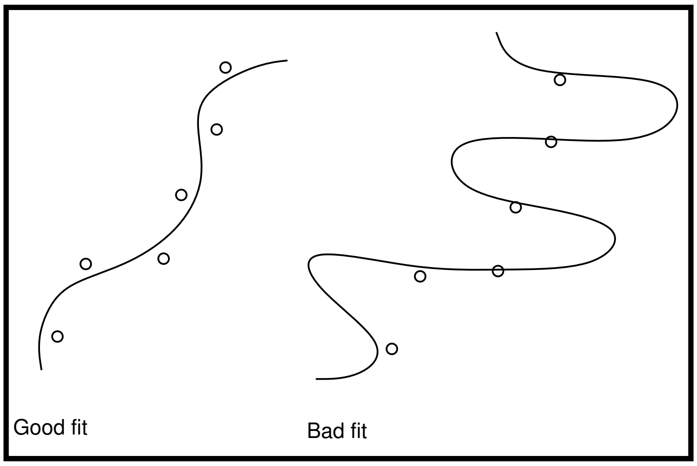
- **Computational Properties**

A single hidden layer feed-forward network with arbitrary sigmoid hidden layer activation functions can approximate arbitrarily well an arbitrary mapping from one finite dimensional space to another



• Practical Issues

- Generalization vs Memorization



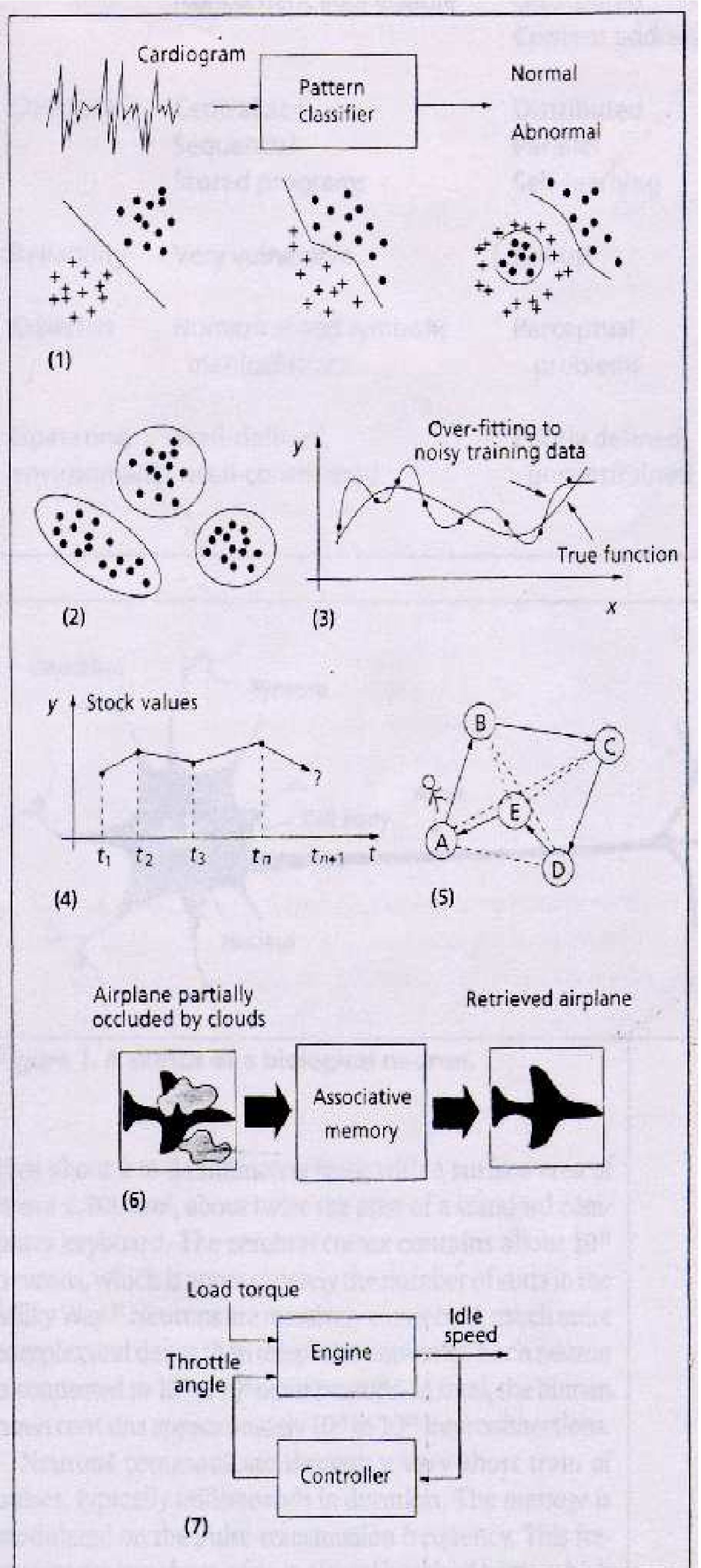
How to choose the network size (free parameters)

How many training examples

When to stop training

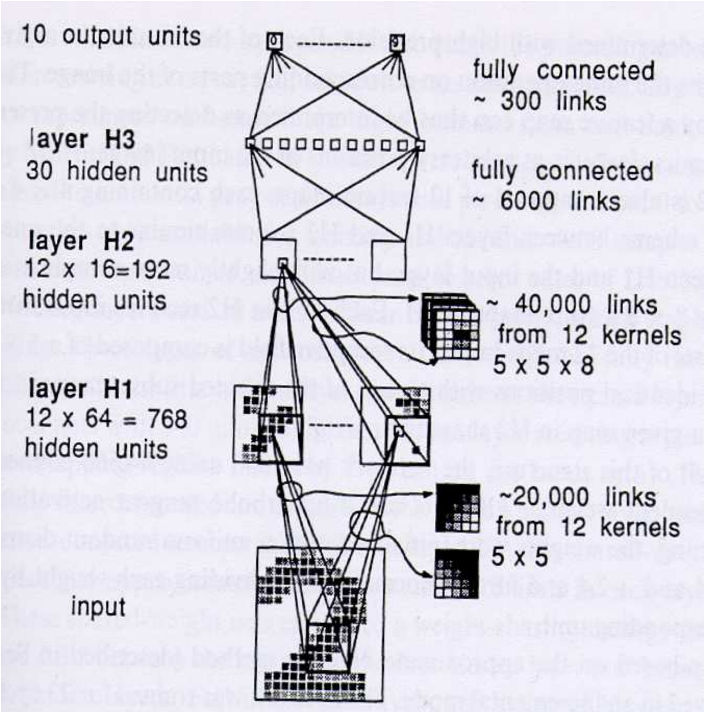
• Applications

- Pattern Classification
- Clustering/Categorization
- Function approximation
- Prediction/Forecasting
- Optimization
- Content-addressable Memory
- Control


Cardiogram
Pattern classifier
Normal
Abnormal
(1)
Over-fitting to noisy training data
True function
y
x
(2)
(3)
y
Stock values
t_1 t_2 t_3 t_n t_{n+1} t
?
(4)
B
C
E
A
D
(5)
Airplane partially occluded by clouds
Associative memory
Retrieved airplane
(6)
Load torque
Engine
Idle speed
Throttle angle
Controller
(7)

- **Two Successful Applications**

- Zipcode Recognition



- Text to voice translation (NeTtalk)