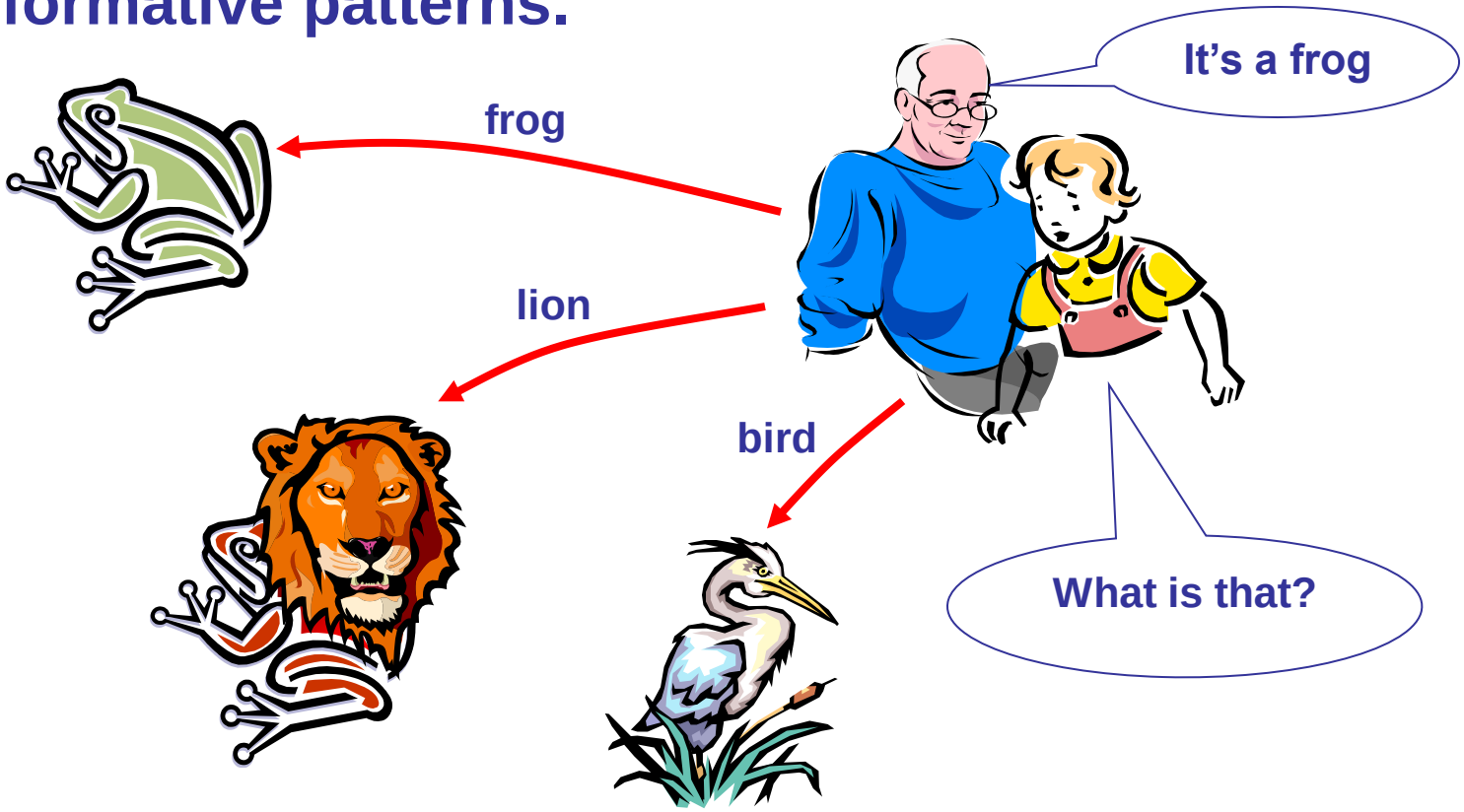
INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS (ANN)

Outline

- Definition, why and how are neural networks being used in solving problems
- Human biological neuron
- Artificial Neuron
- Applications of ANN
- Comparison of ANN vs conventional AI methods

The idea of ANNs..?

- **NNs learn relationship between cause and effect or organize large volumes of data into orderly and informative patterns.**



Neural networks to the rescue…

- **Neural network:** *information processing paradigm inspired by biological nervous systems, such as our brain*
- Structure: large number of highly interconnected processing elements (*neurons*) working together
- Like people, they learn *from experience* (by example)

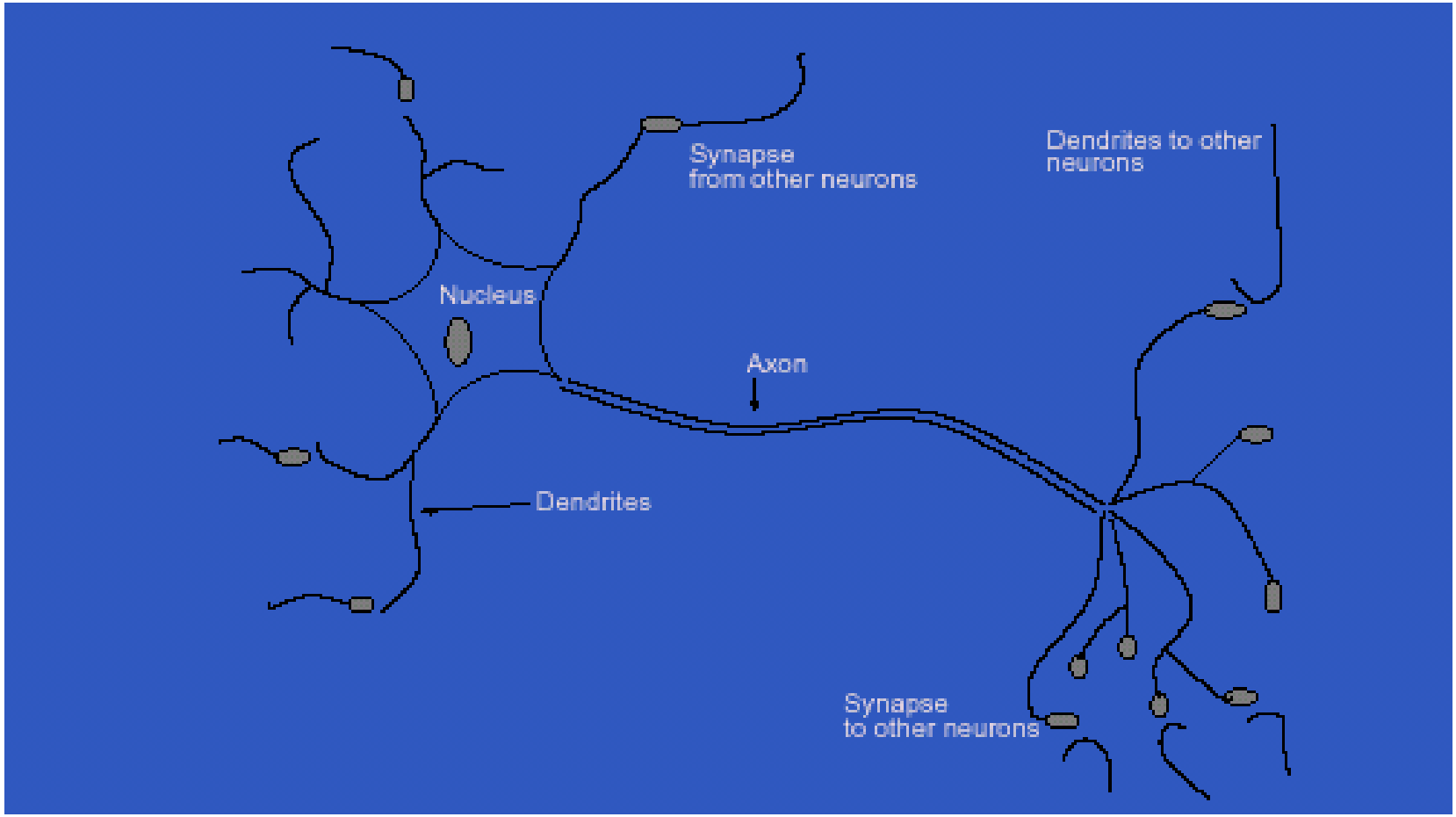
Definition of ANN

"Data processing system consisting of a large number of simple, highly interconnected processing elements (artificial neurons) in an architecture inspired by the structure of the cerebral cortex of the brain"

(Tsoukalas & Uhrig, 1997).

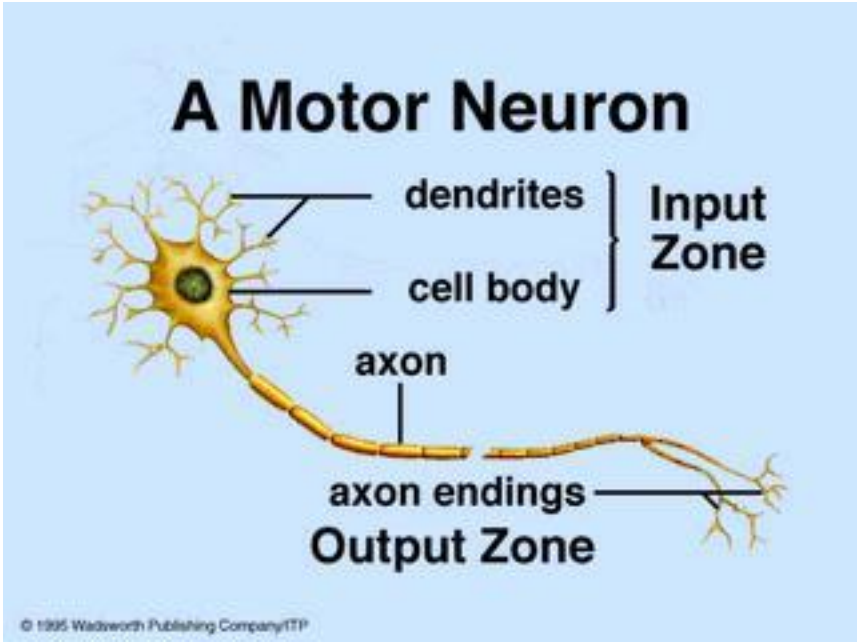
Inspiration from Neurobiology

Human Biological Neuron



Biological Neural Networks

- A biological neuron has three types of main components; dendrites, soma (or cell body) and axon.
- Dendrites receives signals from other neurons.

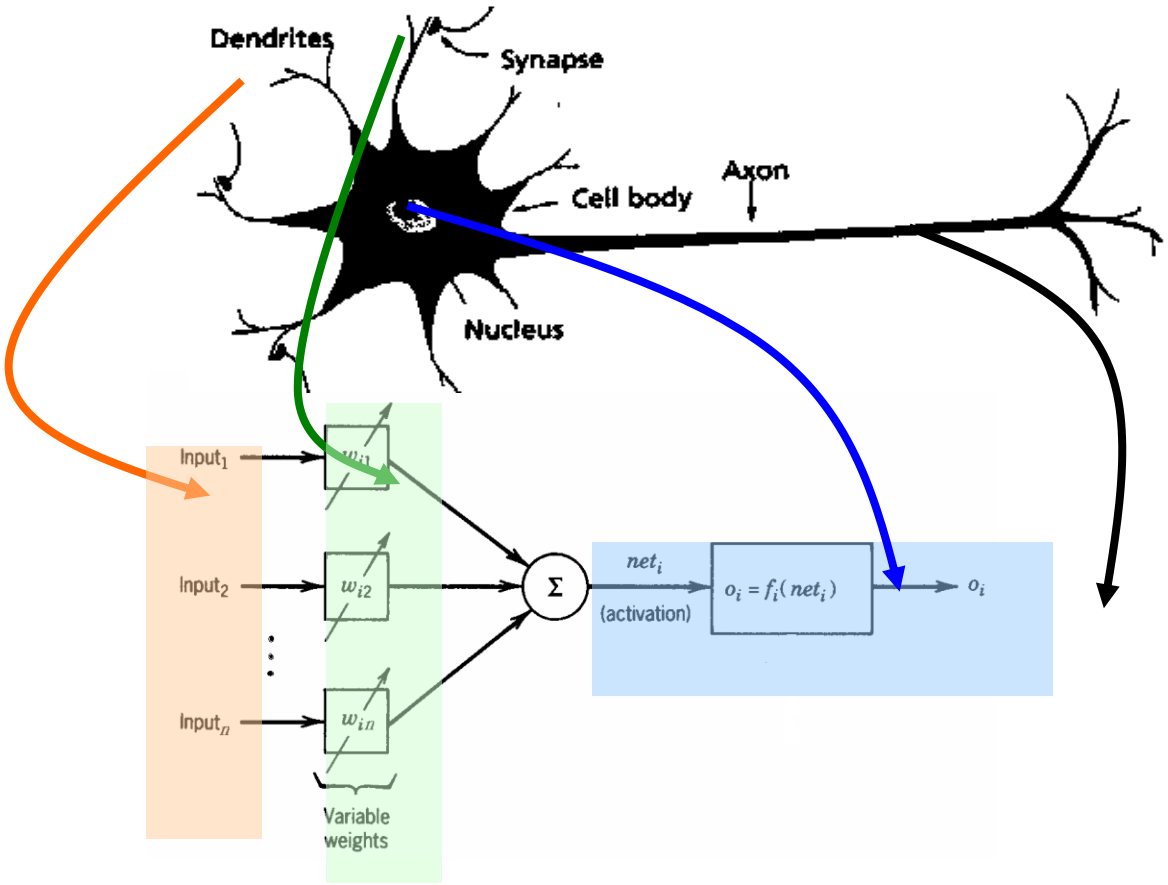


- The soma, sums the incoming signals. When sufficient input is received, the cell fires; that is it transmit a signal over its axon to other cells.

Artificial Neurons

- From experience: examples / training data
- Strength of connection between the neurons is stored as a weight-value for the specific connection.
- Learning the solution to a problem = changing the connection weights

A physical neuron



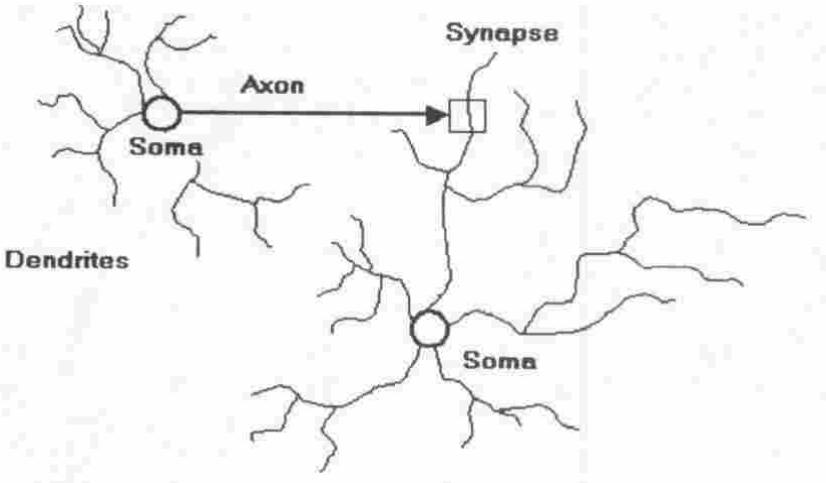
An artificial neuron

Artificial Neurons

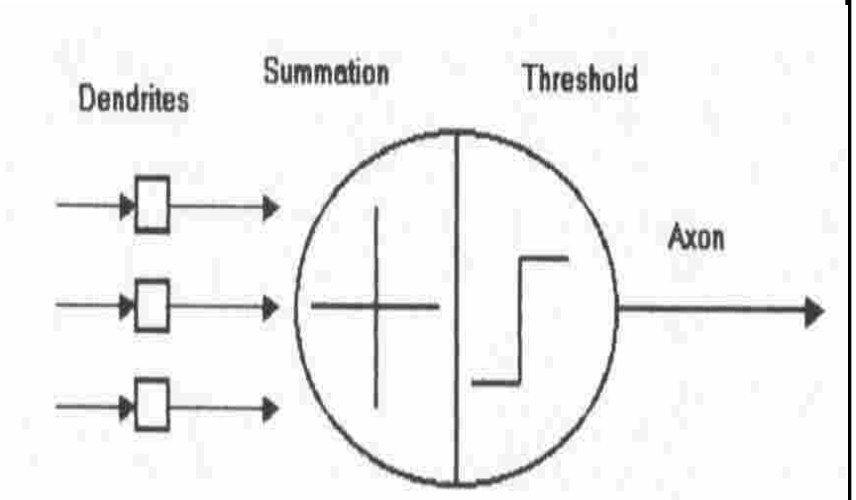
- **ANNs have been developed as generalizations of mathematical models of neural biology, based on the assumptions that:**

  1. **Information processing occurs at many simple elements called neurons.**
  2. **Signals are passed between neurons over connection links.**
  3. **Each connection link has an associated weight, which, in typical neural net, multiplies the signal transmitted.**
  4. **Each neuron applies an activation function to its net input to determine its output signal.**

Artificial Neuron

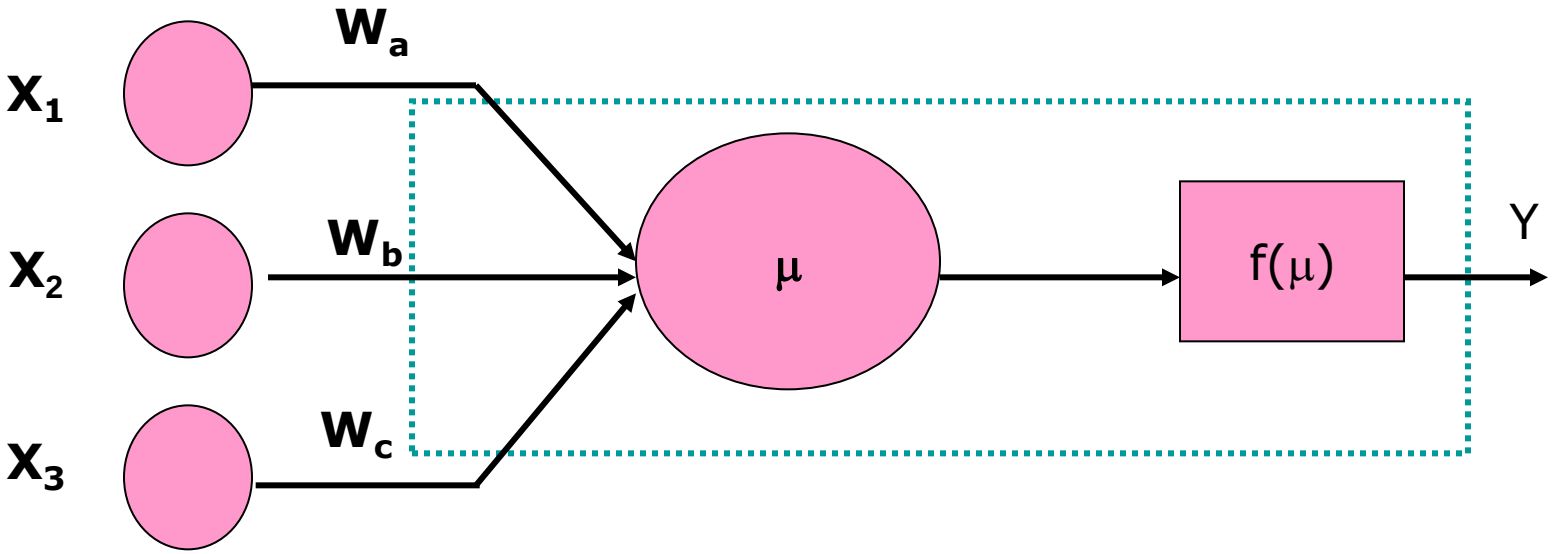


Four basic components of a human biological neuron



The components of a basic artificial neuron

Model Of A Neuron



Input units

Connection weights

Summing function

computation

(dendrite)

(synapse)

(soma)

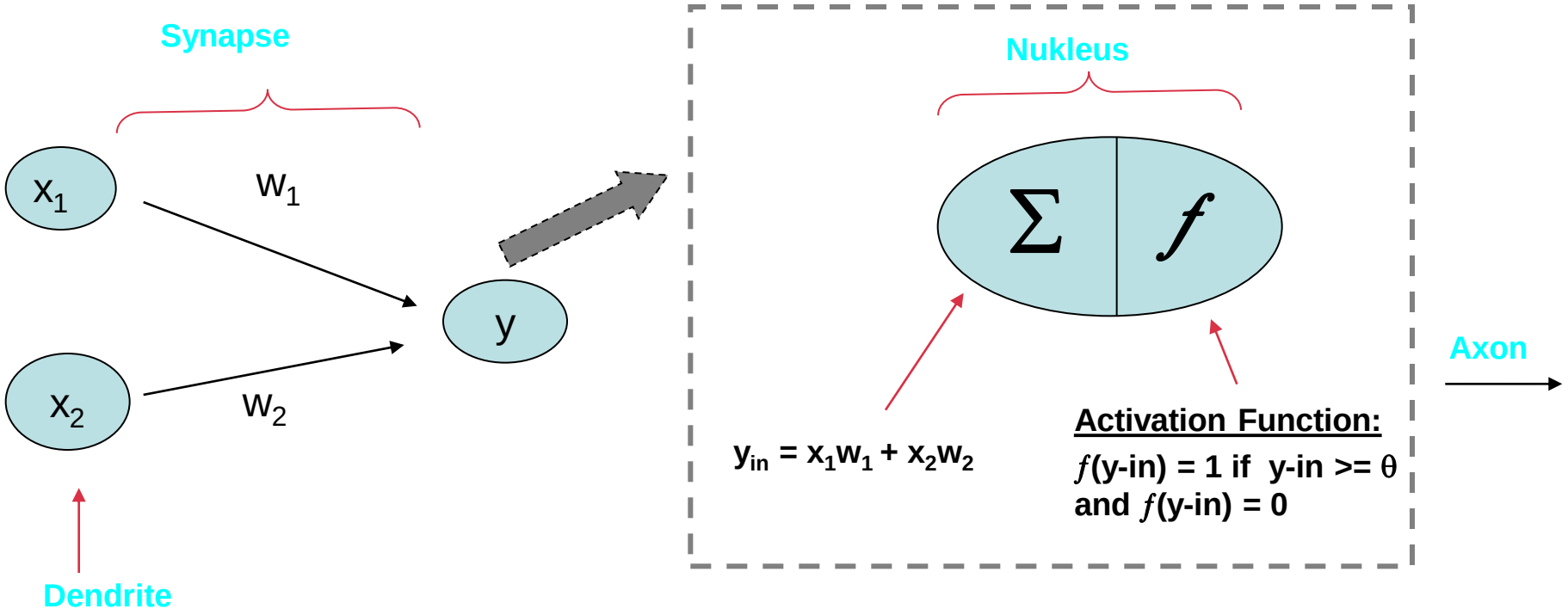
(axon)

- A neural net consists of a large number of simple processing elements called neurons, units, cells or nodes.
- Each neuron is connected to other neurons by means of directed communication links, each with associated weight.
- The weight represent information being used by the net to solve a problem.

- Each neuron has an internal state, called its activation or activity level, which is a function of the inputs it has received. Typically, a neuron sends its activation as a signal to several other neurons.

- It is important to note that a neuron can send only one signal at a time, although that signal is broadcast to several other neurons.

Artificial Neural Network



-A neuron receives input, determines the strength or the weight of the input, calculates the total weighted input, and compares the total weighted with a value (threshold)

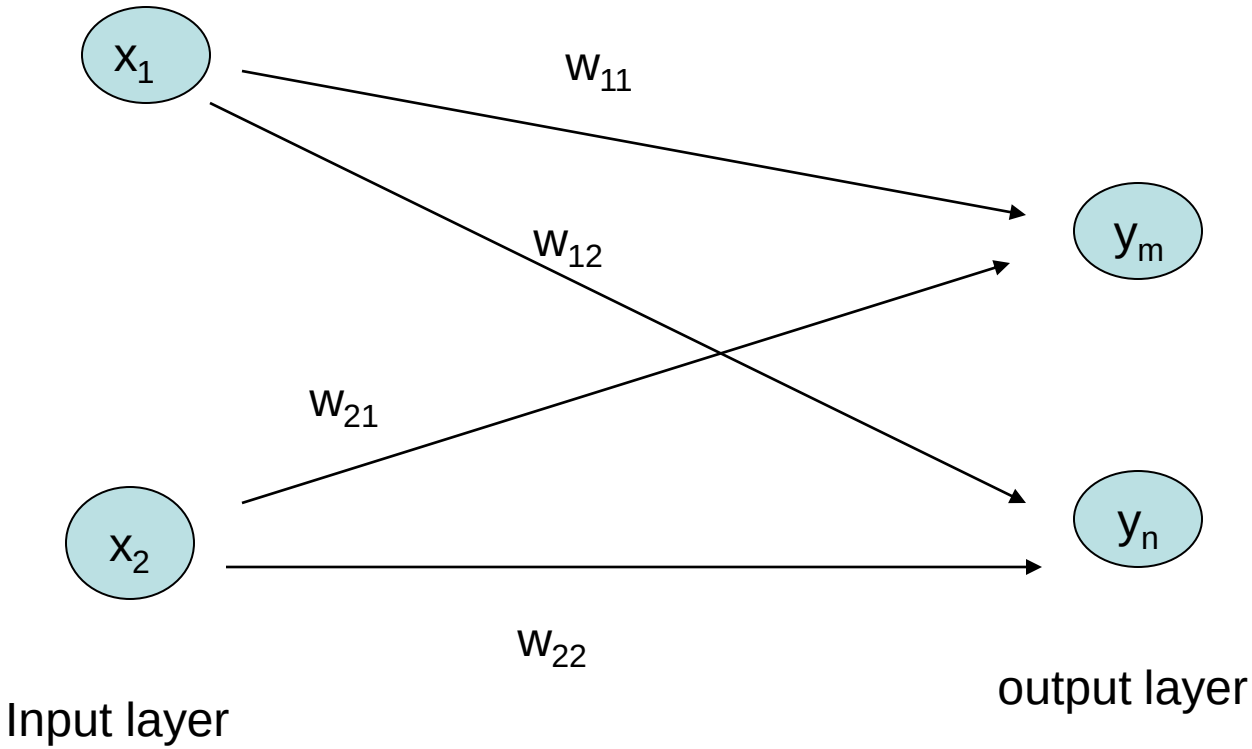
-The value is in the range of 0 and 1

- If the total weighted input greater than or equal the threshold value, the neuron will produce the output, and if the total weighted input less than the threshold value, no output will be produced

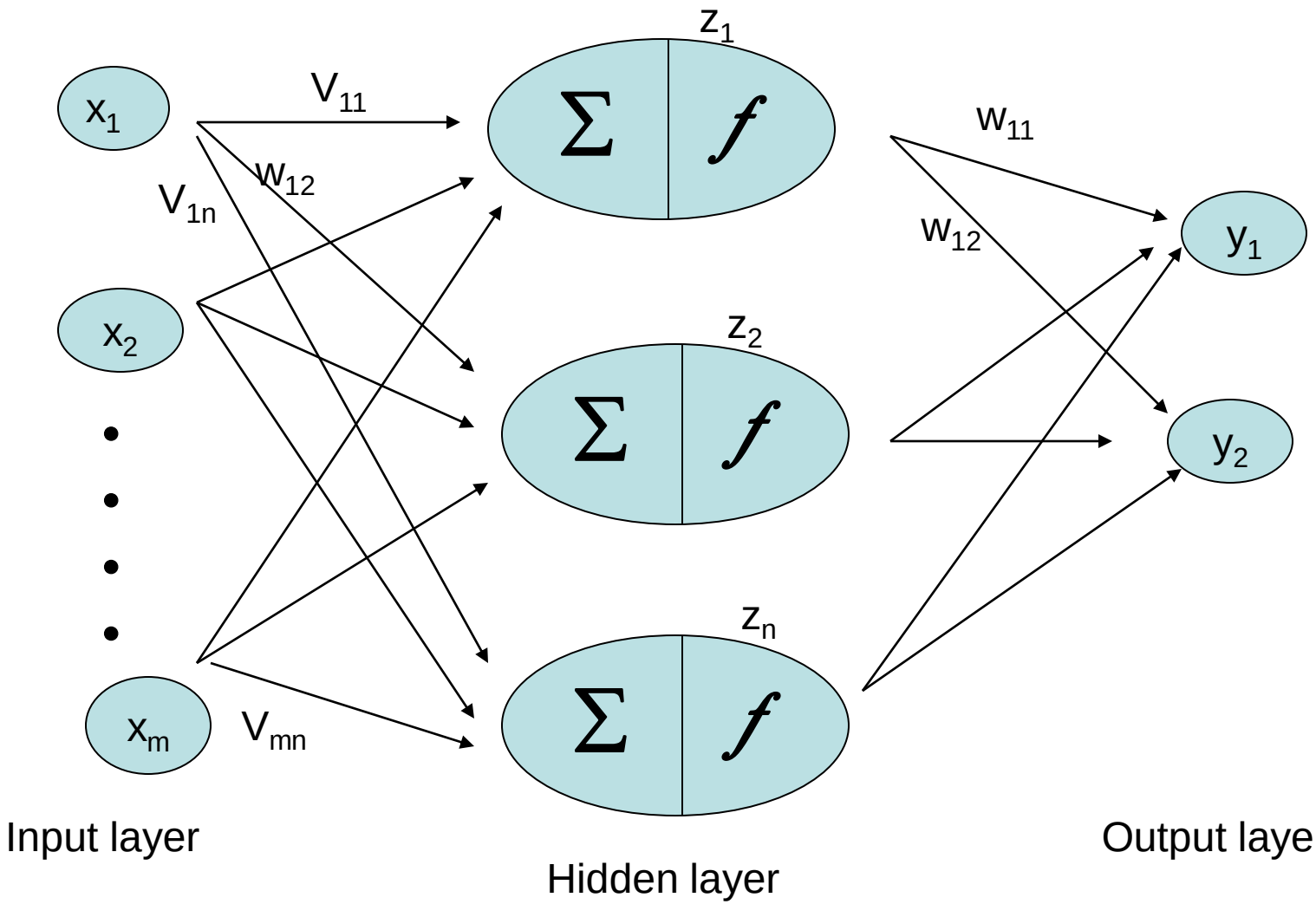
Characterization

- Architecture
  - a pattern of connections between neurons
    - Single Layer Feedforward
    - Multilayer Feedforward
    - Recurrent
- Strategy / Learning Algorithm
  - a method of determining the connection weights
    - Supervised
    - Unsupervised
    - Reinforcement
- Activation Function
  - Function to compute output signal from input signal

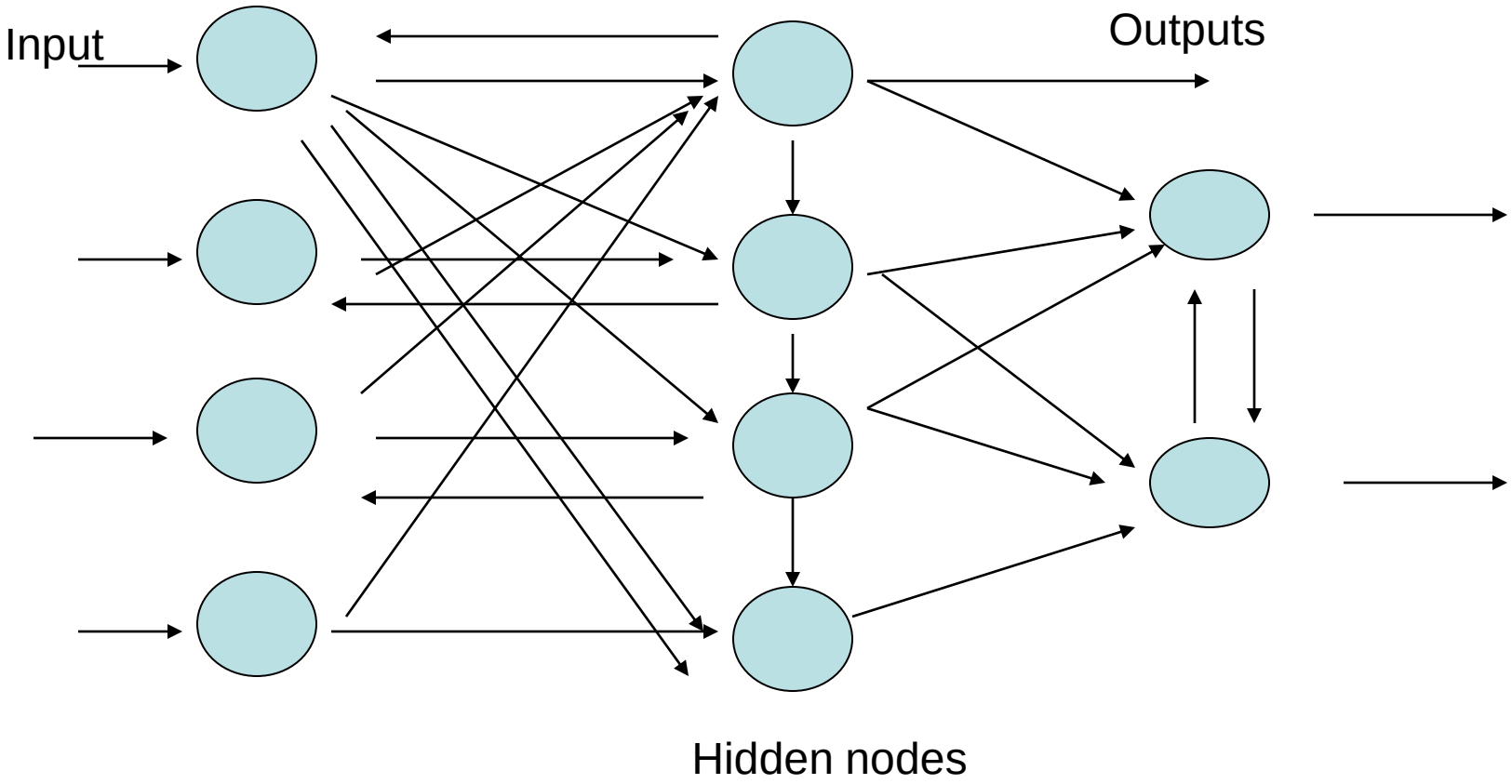
Single Layer Feedforward NN



Multilayer Neural Network



Recurrent NN



Strategy / Learning Algorithm

Supervised Learning

- Learning is performed by presenting pattern with target
- During learning, produced output is compared with the desired output
  - The difference between both output is used to modify learning weights according to the learning algorithm
- Recognizing hand-written digits, pattern recognition and etc.
- Neural Network models: perceptron, feed-forward, radial basis function, support vector machine.

Unsupervised Learning

- Targets are not provided
- Appropriate for clustering task
  - Find similar groups of documents in the web, content addressable memory, clustering.
- Neural Network models: Kohonen, self organizing maps, Hopfield networks.

Reinforcement Learning

- Target is provided, but the desired output is absent.
- The net is only provided with guidance to determine the produced output is correct or vise versa.
- Weights are modified in the units that have errors

Activation Functions

- Identity

  $f(x) = x$

- Binary step

  $f(x) = 1$ if $x >= \theta$

  $f(x) = 0$ otherwise

- Binary sigmoid

  $f(x) = 1 / (1 + e^{-\sigma x})$

- Bipolar sigmoid

  $f(x) = -1 + 2 / (1 + e^{-\sigma x})$

- Hyperbolic tangent

  $f(x) = (e^{x} - e^{-x}) / (e^{x} + e^{-x})$

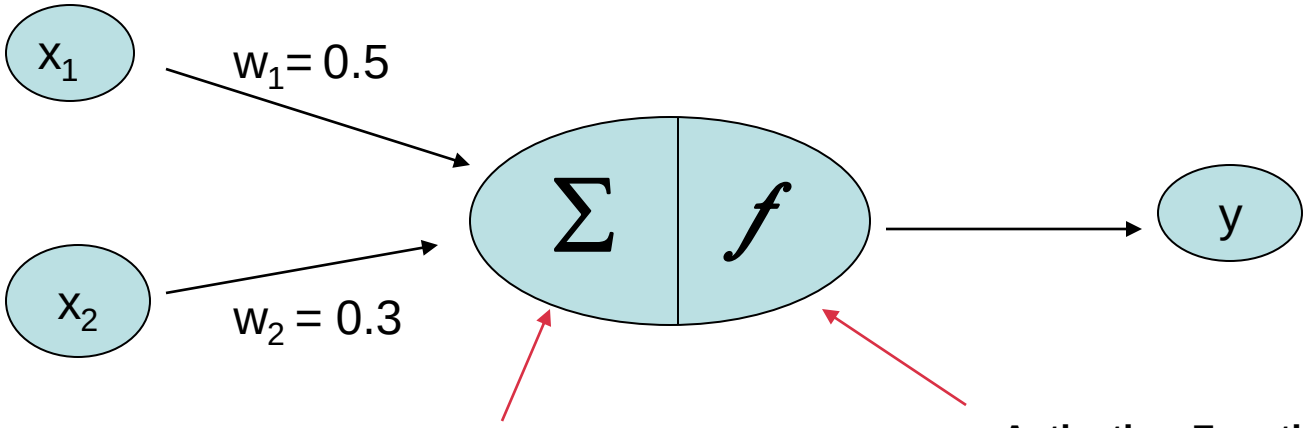
Exercise

- 2 input AND

1	1	1
1	0	0
0	1	0
0	0	0

- 2 input OR

1	1	1
1	0	1
0	1	1
0	0	0



$y_{in} = x_1w_1 + x_2w_2$

Activation Function:
Binary Step Function
θ = 0.5,

f(y-in) = 1 if y-in >= θ
dan f(y-in) = 0

Where can neural network systems help…

- when we can't formulate an algorithmic solution.
- when we ***can*** get lots of examples of the behavior we require.

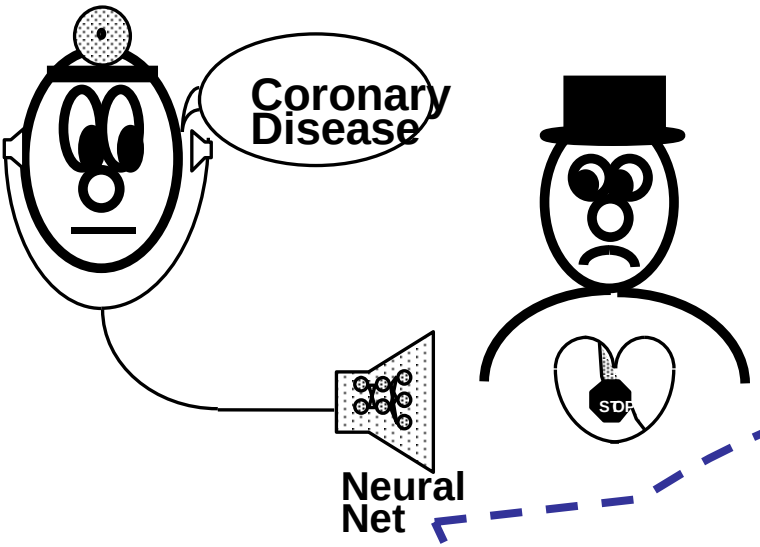
  'learning from experience'
- when we need to pick out the structure from existing data.

Who is interested?...

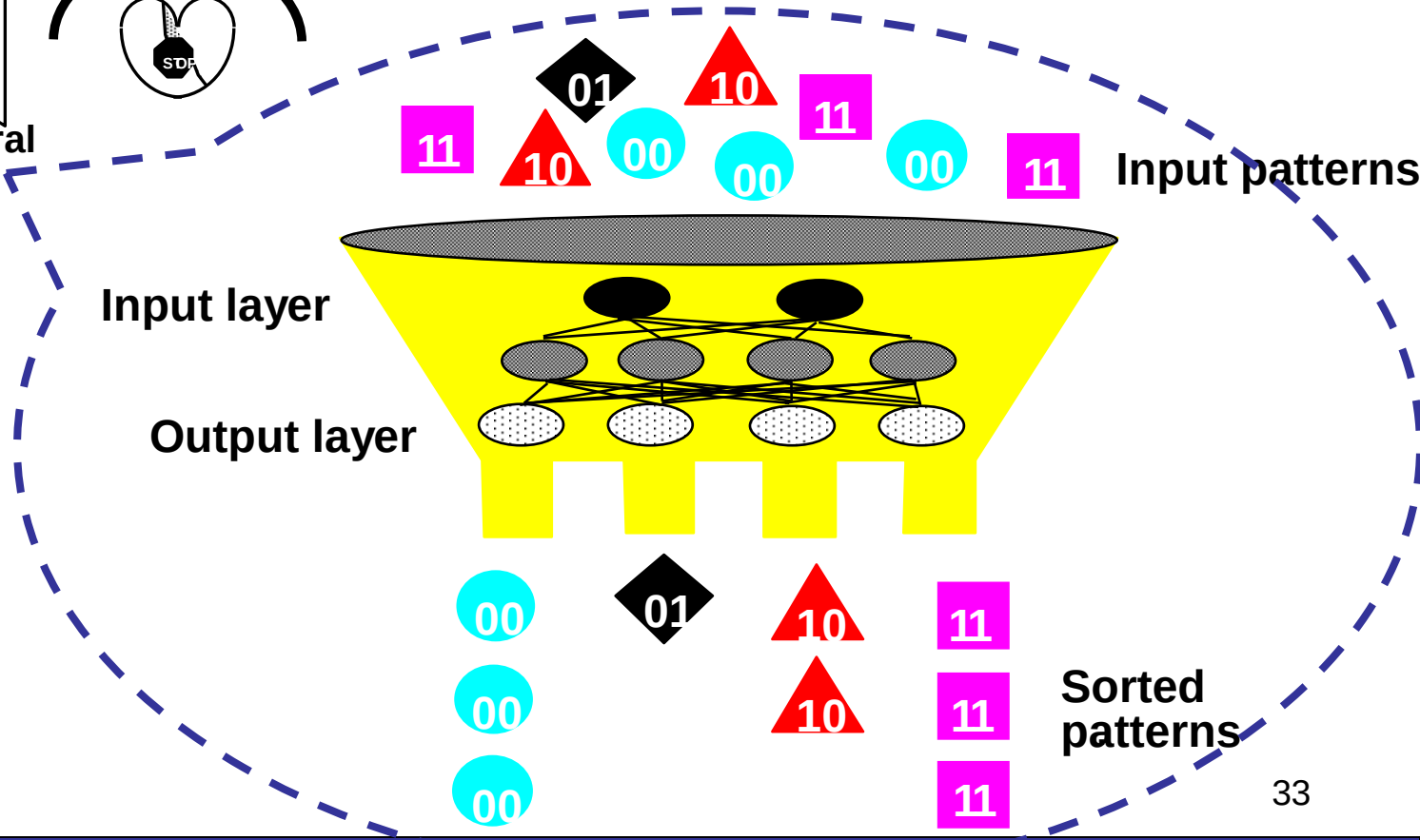
- Electrical Engineers – signal processing, control theory
- Computer Engineers – robotics
- Computer Scientists – artificial intelligence, pattern recognition
- Mathematicians – modelling tool when explicit relationships are unknown

Problem Domains

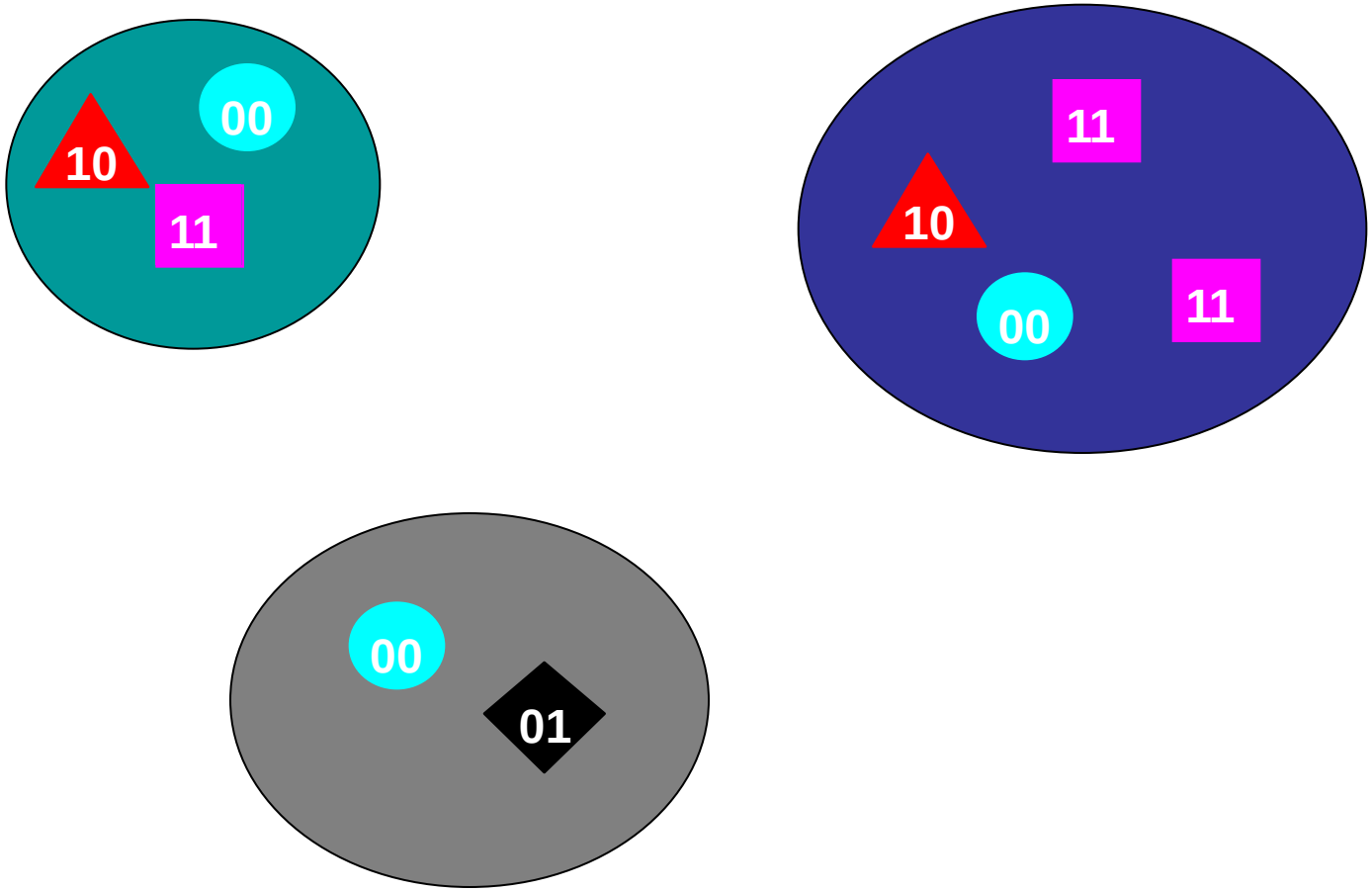
- Storing and recalling patterns
- Classifying patterns
- Mapping inputs onto outputs
- Grouping similar patterns
- Finding solutions to constrained optimization problems



Classification

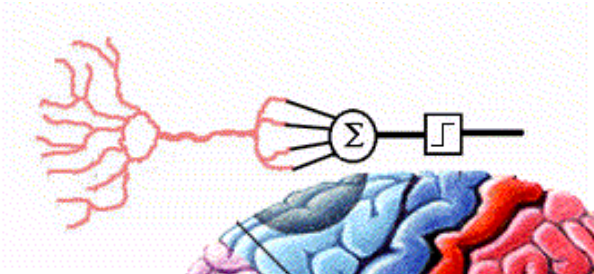


Clustering



ANN Applications

Medical Applications



Chemistry

Information
Searching & retrieval

Education

Business & Management

Applications of ANNs

- Signal processing
- Pattern recognition, e.g. handwritten characters or face identification.
- Diagnosis or mapping symptoms to a medical case.
- Speech recognition
- Human Emotion Detection
- Educational Loan Forecasting

Comparison of ANN with conventional AI methods

CHARACTERISTICS	TRADITIONAL COMPUTING (including Expert Systems)	ARTIFICIAL NEURAL NETWORKS
Processing style	Sequential	Parallel
Functions	Logically (left brained) via Rules Concepts Calculations	Gestault (right brained) via Images Pictures Controls
Learning Method	by rules (didactically)	by example (Socratically)
Applications	Accounting, word processing, math, inventory, digital communications	Sensor processing, speech recognition, pattern recognition, text recognition