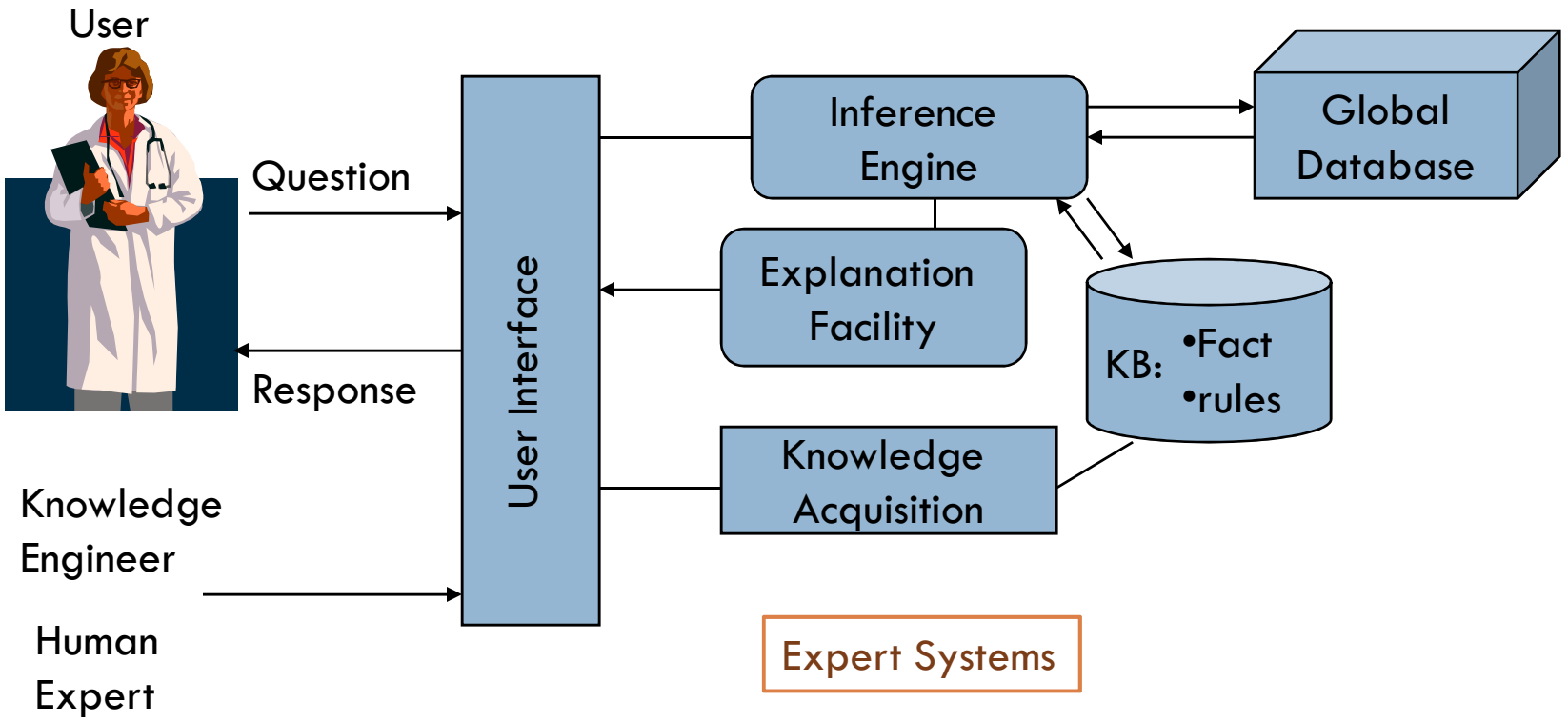
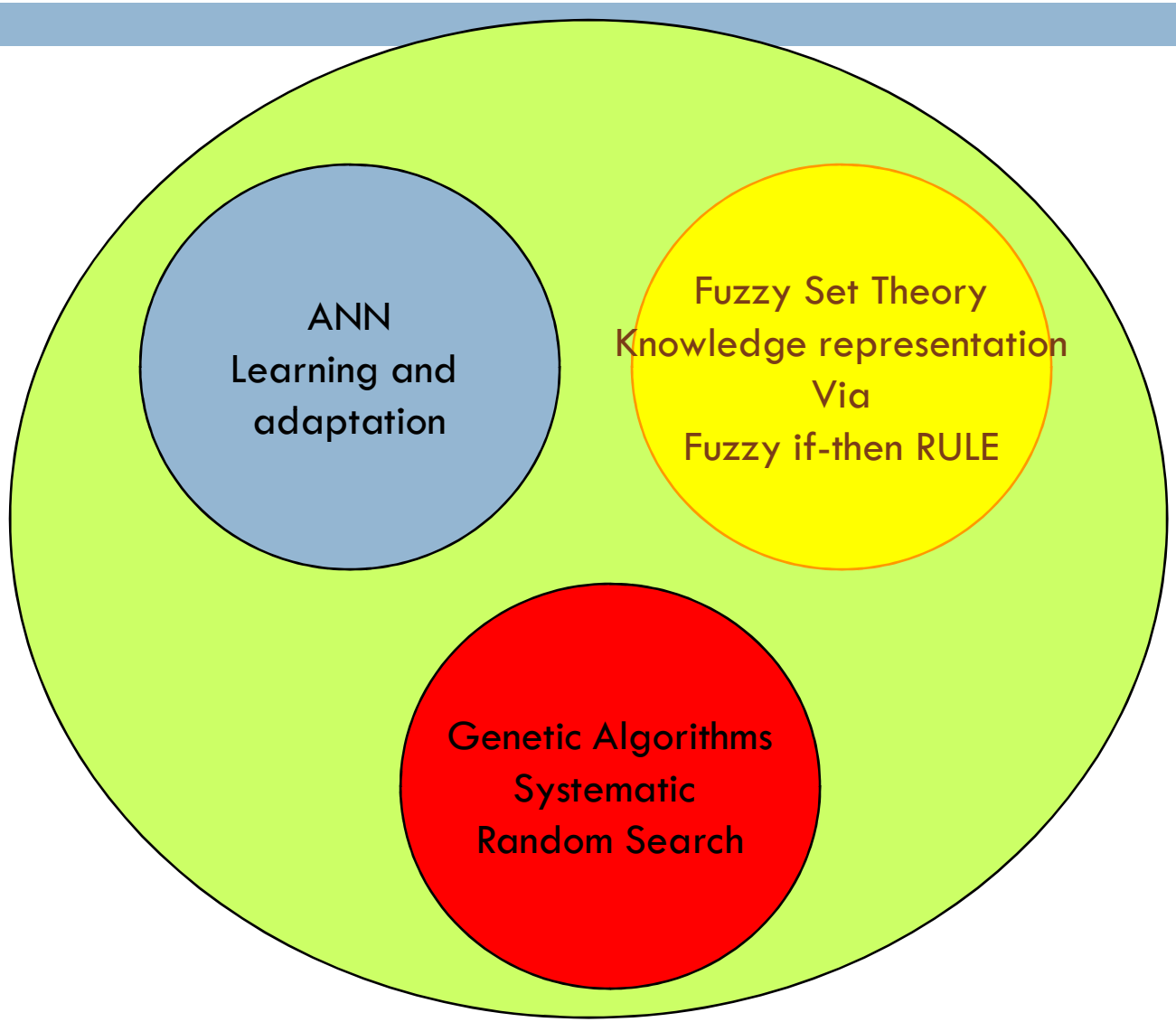
NEURAL NETWORKS

AI and Soft Computing: A Different Perspective

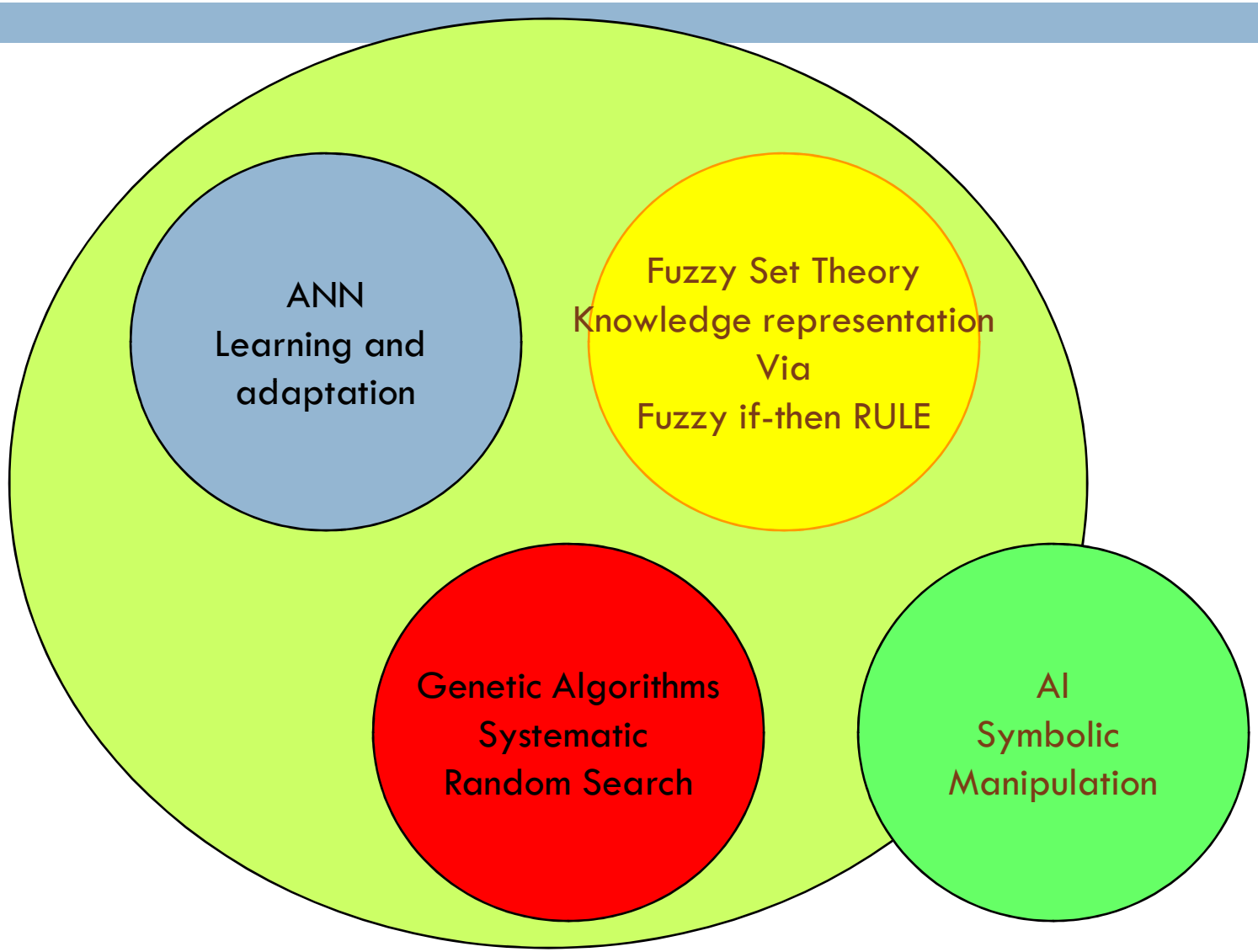
- AI: predicate logic and symbol manipulation techniques



AI and Soft Computing



AI and Soft Computing



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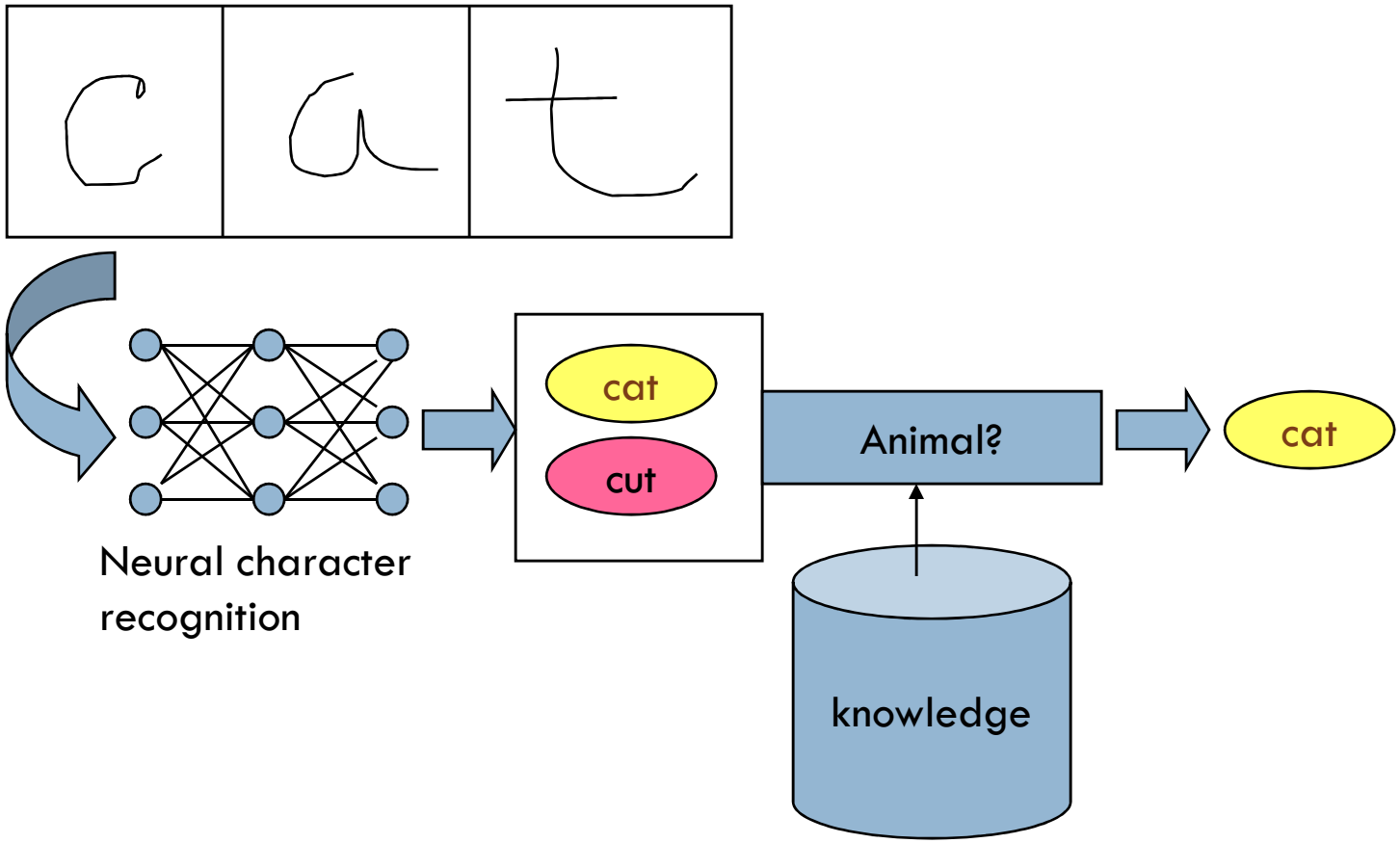


Soft Computing

What is Soft Computing?

Soft computing is an emerging approach to computing which parallel the remarkable ability of the human mind to reason and learn in a environment of uncertainty and imprecision.

Some of it's principle components includes:

- Neural Network(NN)
- Fuzzy Logic(FL)
- Genetic Algorithm(GA)

These methodologies form the core of soft computing.

APPLICATION OF SOFT COMPUTING

- Consumer appliance like AC, Refrigerators, Heaters, Washing machine.
- Robotics like Emotional Pet robots.
- Food preparation appliances like Rice cookers and Microwave.
- Game playing like Poker, checker etc.

Artificial Neural Network

- Terms
  - connectionist
  - parallel distributed processing
  - neural computation
  - adaptive networks..
- History
  - 1943-McCulloch & Pitts are generally recognised as the designers of the first neural network
  - 1949-First learning rule (**Hebb (1949)**)
  - 1969-Minsky & Papert - perceptron limitation - Death of ANN
  - 1980's - Re-emergence of ANN - multi-layer networks

Brain and Machine

- **The Brain**
  - Pattern Recognition
  - Association
  - Complexity
  - Noise Tolerance
- **The Machine**
  - Calculation
  - Precision
  - Logic

What are Neural Networks?

- Models of the brain and nervous system
- Highly parallel
  - Process information much more like the brain than a serial computer
- Learning
- Very simple principles
- Very complex behaviours
- Applications
  - As powerful problem solvers
  - As biological models

Features of the Brain

- Ten billion (10^{10}) neurons
- On average, several thousand connections
- Hundreds of operations per second
- Die off frequently (never replaced)
- Compensates for problems by massive parallelism

Neural Networks

- A neuron is connected to other neurons through about *10,000 synapses*
- Once input exceeds a critical level, the neuron discharges a spike - an electrical pulse that travels from the body, down the axon, to the next neuron(s)
- The axon endings almost touch the dendrites or cell body of the next neuron.
- Transmission of an electrical signal from one neuron to the next is effected by neurotransmitters.

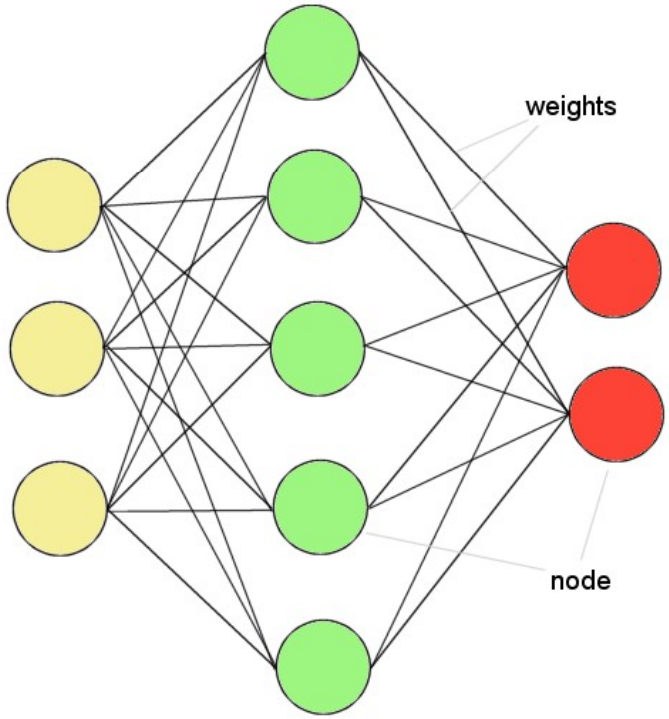
Neural Networks

- Neurotransmitters are chemicals which are released from the first neuron and which bind to the Second.
- This link is called a synapse. The strength of the signal that reaches the next neuron depends on factors such as the amount of neurotransmitter available.

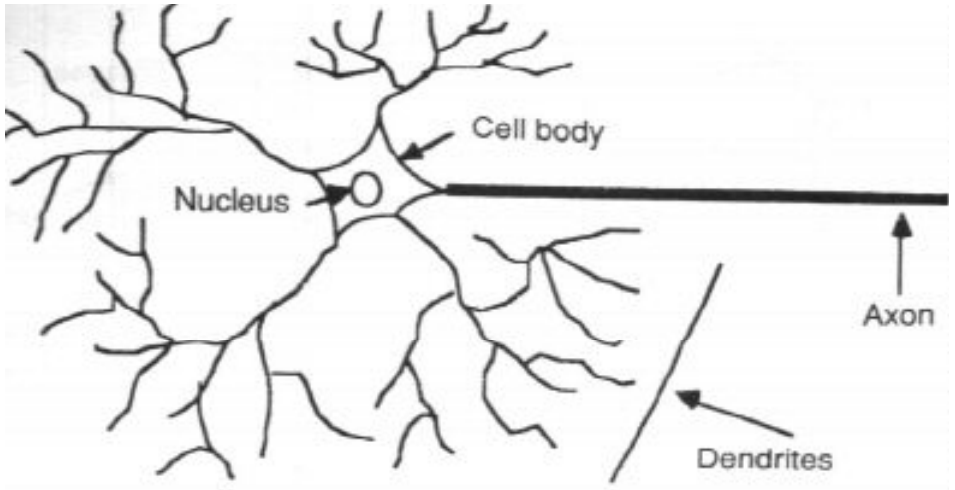
ANNs – The basics

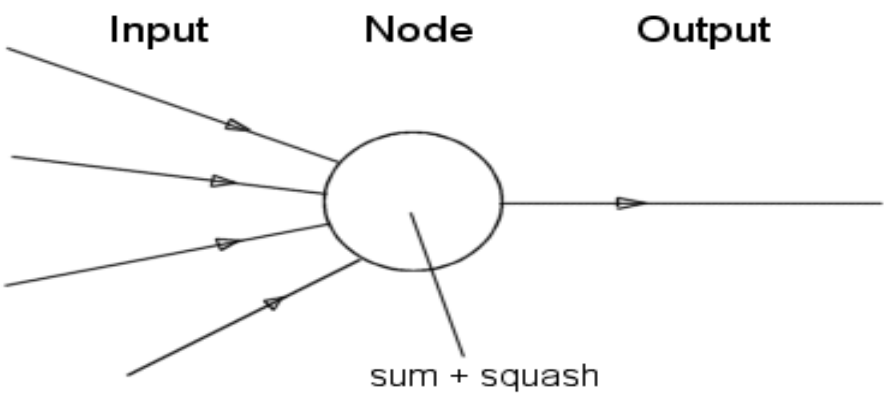
- ANNs incorporate the two fundamental components of biological neural nets:

1. Neurons (nodes)
2. Synapses (weights)

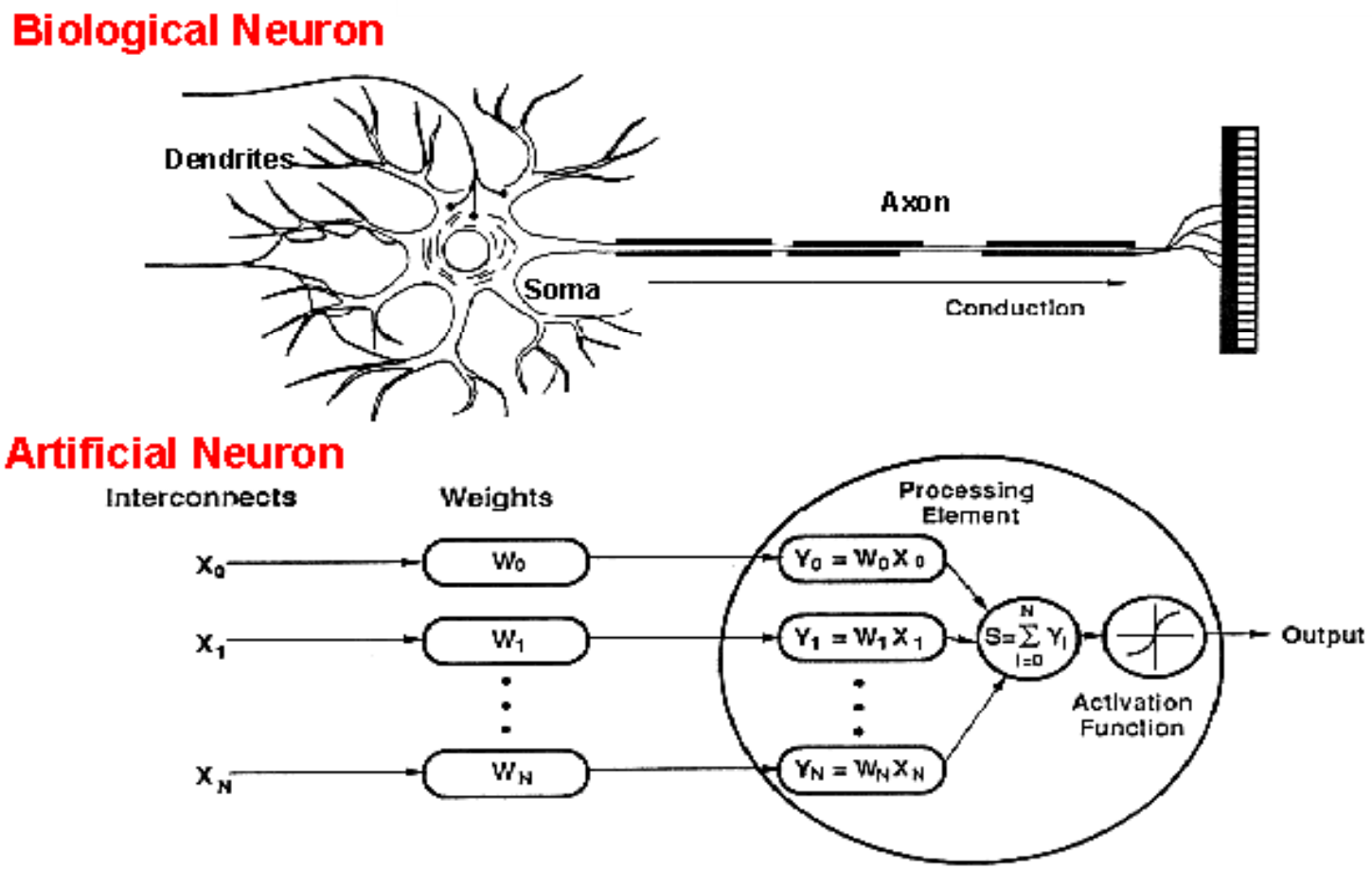


Neuron vs. Node





How do ANNs work?



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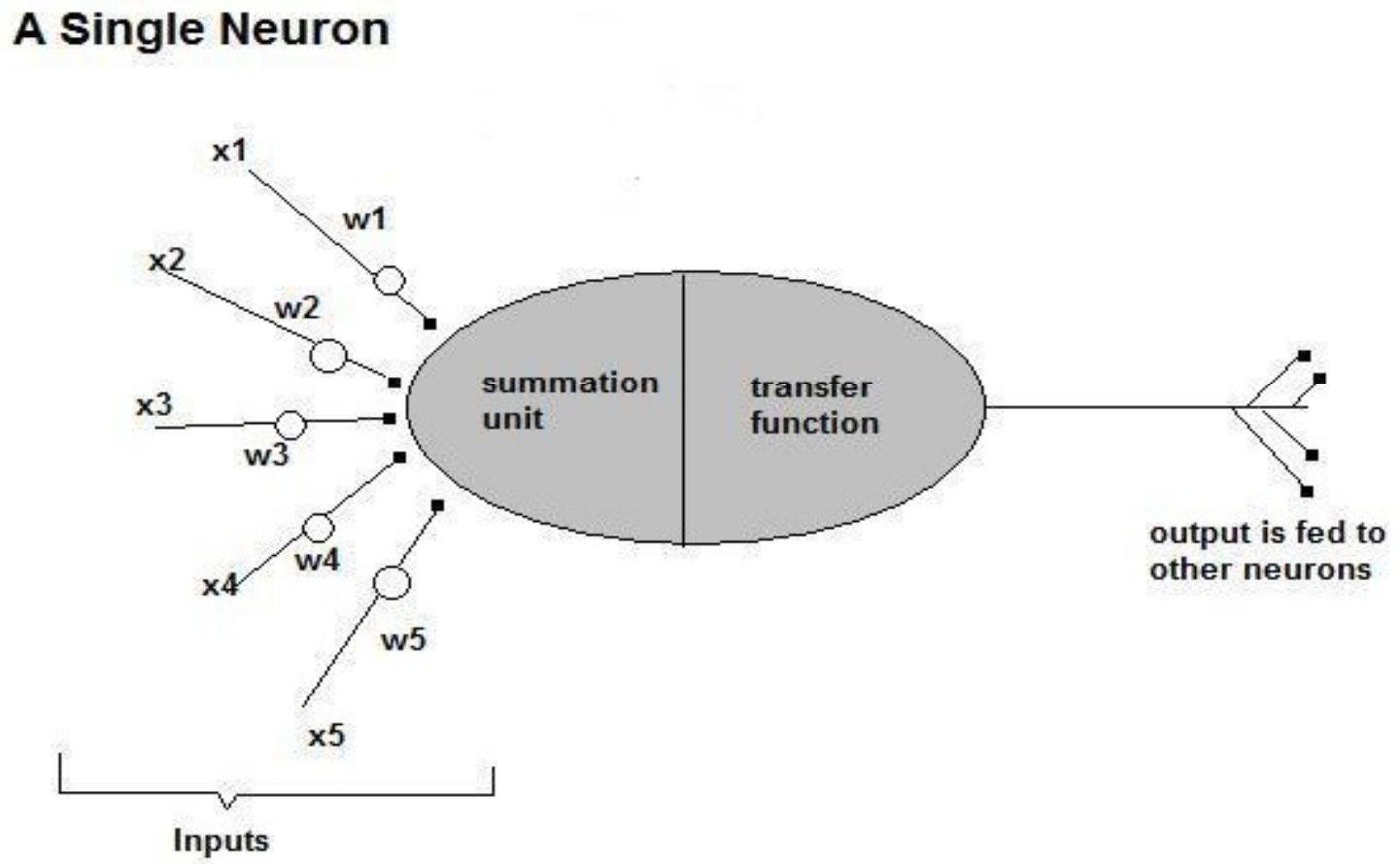
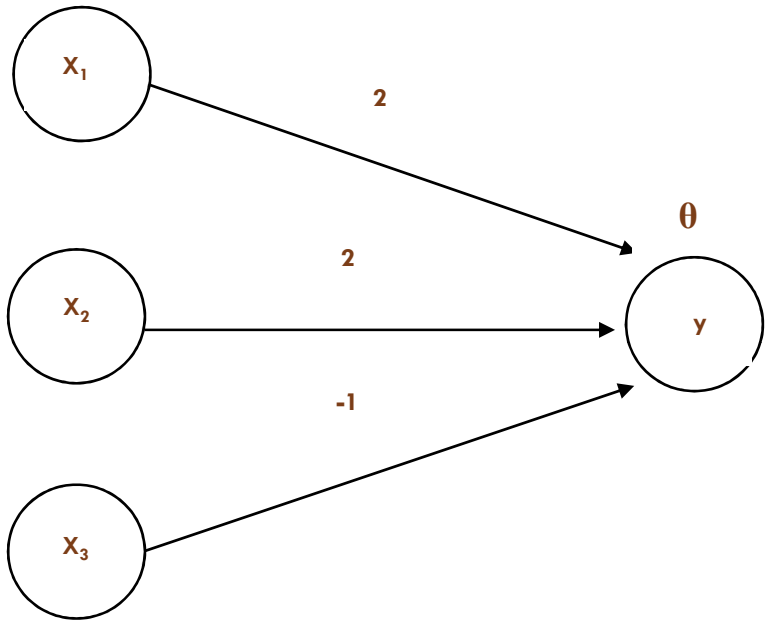


The First Neural Neural Networks

- The activation of a neuron is binary. That is, the neuron either fires (activation of one) or does not fire (activation of zero).
- For the network shown here the activation function for unit
- Y is $f(y\_in) = 1$, if $y\_in >= \theta$

  else 0 where y_in is the total input signal received

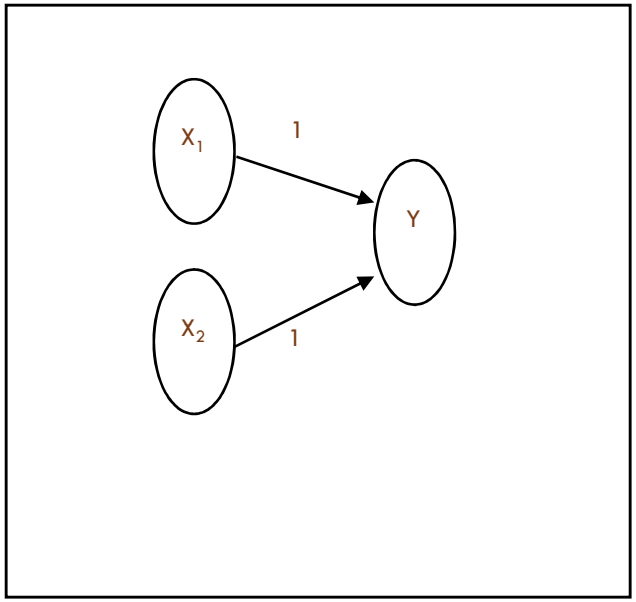
  θ is the threshold for Y



The First Neural Neural Networks

- Neurons is a McCulloch-Pitts network are connected by directed, weighted paths
- If the weight on a path is positive the path is excitatory, otherwise it is inhibitory
- Each neuron has a fixed threshold. If the net input into the neuron is greater than the threshold, the neuron fires
- The threshold is set such that any non-zero inhibitory input will prevent the neuron from firing

The First Neural Neural Networks



AND		
X1	X2	Y
1	1	1
1	0	0
0	1	0
0	0	0

Threshold(*Y*) = 2

Activation Functions

- Decides whether a neuron should be activated or not by calculating weighted sum and further adding bias with it.
- The purpose of the activation function is to **introduce non-linearity** into the output of a neuron.

Types OF ACTIVATION FUNCTION

1). Linear Function :-

Equation : Linear function has the equation similar to as of a straight line i.e. y = ax

Range : -inf to +inf

Uses : Linear activation function is used at just one place i.e. output layer.

Types OF ACTIVATION FUNCTION

2). Sigmoid Function :-

$A = 1/(1 + e^{-x})$

Nature : Non-linear

Small changes in x would also bring about large changes in the value of Y.

Value Range : 0 to 1

Uses : Usually used in output layer of a binary classification, where result is either 0 or 1, as value for sigmoid function lies between 0 and 1 only so, result can be predicted easily to be ***1*** if value is greater than **0.5** and ***0*** otherwise.

Types OF ACTIVATION FUNCTION

3. Tanh Function: Tangent Hyperbolic function.

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

OR $\tanh(x) = 2 * \text{sigmoid}(2x) - 1$

Value Range :- -1 to +1

Nature :- non-linear

Uses :- Usually used in hidden layers of a neural network as it's values lies between **-1 to 1** hence the mean for the hidden layer comes out be 0 or very close to it, hence helps in *centering the data* by bringing mean close to 0. This makes learning for the next layer much easier.

Types OF ACTIVATION FUNCTION

4) RELU :- *Rectified linear unit*

Implemented in *hidden layers* of Neural network.

A(x) = max(0,x).

It gives an output x, if x is positive and 0 otherwise.

Value Range :- [0, inf)

Nature :- non-linear, which means we can easily backpropagate the errors and have multiple layers of neurons being activated by the ReLU function.

Uses :- ReLu is less computationally expensive than tanh and sigmoid because it involves simpler mathematical operations. At a time only a few neurons are activated making the network sparse making it efficient and easy for computation.

Types OF ACTIVATION FUNCTION

Softmax Function :- The softmax function is also a type of sigmoid function but is handy when we are trying to handle classification problems.

Nature :- non-linear

Uses :- Usually used when trying to handle multiple classes. The softmax function would squeeze the outputs for each class between 0 and 1 and would also divide by the sum of the outputs.

Output:- The softmax function is ideally used in the output layer of the classifier where we are actually trying to attain the probabilities to define the class of each input.

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