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Neural network

A Brief Introduction

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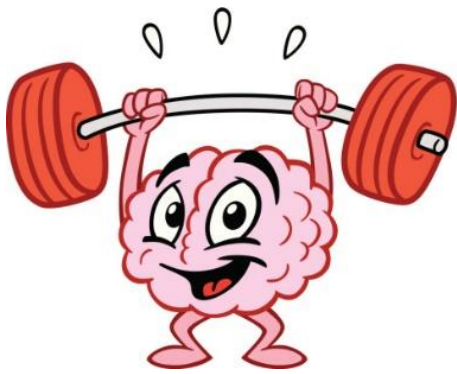
Introduction

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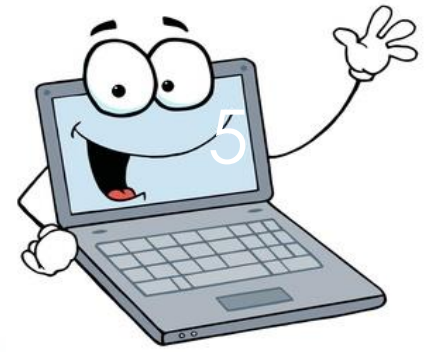
Data mining is essentially a task of learning from the data and hence any known technique which attempts to learn from data can ,in principle,be applied for data mining purpose.Some of the techniques which holds promise of being suitable for data mining purpose are Neural network, GA, Rough set theory,SVM and many more.

Neural network is a technique derived from Artificial Intelligence research that uses generalized regression & provided that an iterative method to carry out it.It has started way back in 1940 but gained popularity after 1980.Most neural network have some sort of training rule.It learns from example and prohibit some capability of generalization beyond the training data.

Neural network is one of the most useful technique in the world of data analytics.



Why neural network ?



- Brain is a live organ afterall and computer is an electronic device.
- 100 billions of neurons in the brain which are connected in complex manner.
- This connection of neurons forms a complete complex network called neural network.
- On the other hand computer is simply made up of transistors.

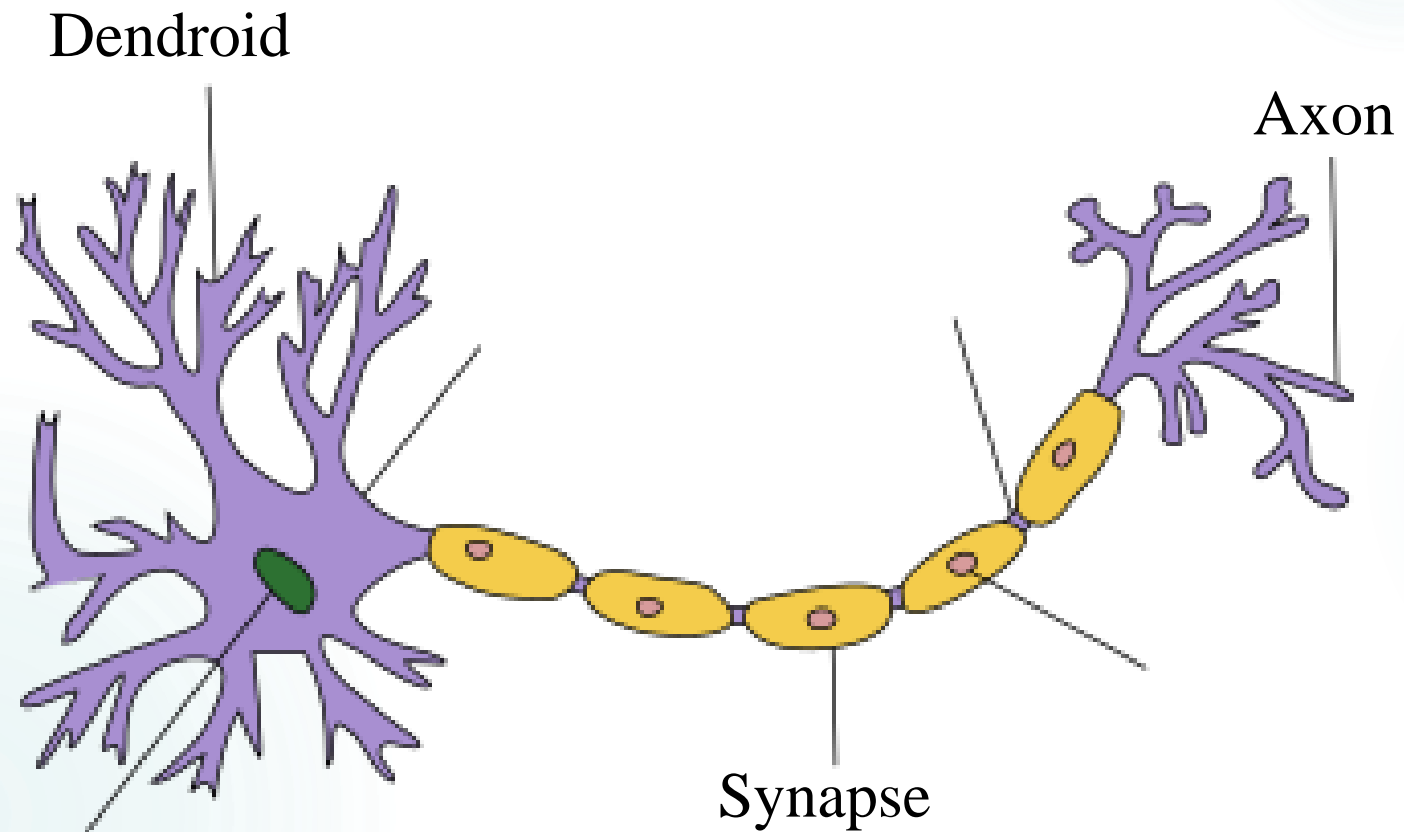
- Computer has a processor which is made up of thousands of transistors but which are in serial manner.
- Computer knows only 0 and 1
- Where brain knows beyond 0 and 1

Neuron and its functioning

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- Neuron is basically a fundamental unit of computing in our nervous system.
- It contains Dendrite which acts as an input.
- The cell body which acts as a processor to the neuron where integration and all things happens.
- After the summation some non-linear function of the output goes to the axon as an output.

- One neuron sends signals to other neuron
- Transfer of information from one neuron to the other neuron takes place through synapse.
- Strength of synapse is nothing but the synaptic strength.



Structure of neuron of the human brain

Neural network in Brain

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- Neural networks are different paradigm for computing which draws inspiration from neuroscience.
- Dendrite of one neuron is connected to the axon of other neuron and so on.
- When plenty of neurons binds together forms a neural network.
- The transmission process is complex chemical process which effectively increase or decrease the electrical potential within the cell body of receiving neuron.

- When this electrical potential reaches a threshold value (i.e.action potential) it enters its excitatory state and is said to be fire.
- Neural network is an adaptive technique ,it will change the strength of synapse.
- Next If you give same pattern again it form a memory ,short time memory.
- Time when you give same kind of input what happens ,it will quickly recognize.

Artificial neural network

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- It is an information processing machine and can be viewed as analogous to human nervous system. just like human nervous system, which is made up of interconnected neurons, a neural network is made up of interconnected information processing units.
- The information processing units do not work in linear manner. Infact, neural network draws its strength from parallel processing of information, which allows it to deal with non linearity.
- Neural network becomes handy to infer meaning and detect patterns from complex data sets.

What is an Artificial neuron

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- Artificial neuron (PE) are highly simplified models of biological neuron.
- Like in biological neuron an AN has many inputs and an output which can be connected to a no of other AN.
- Like in BN, AN most often consist of the summation node and transfer function.
- The evolution of neural network as computational model originates since 1943.

A simple perceptron

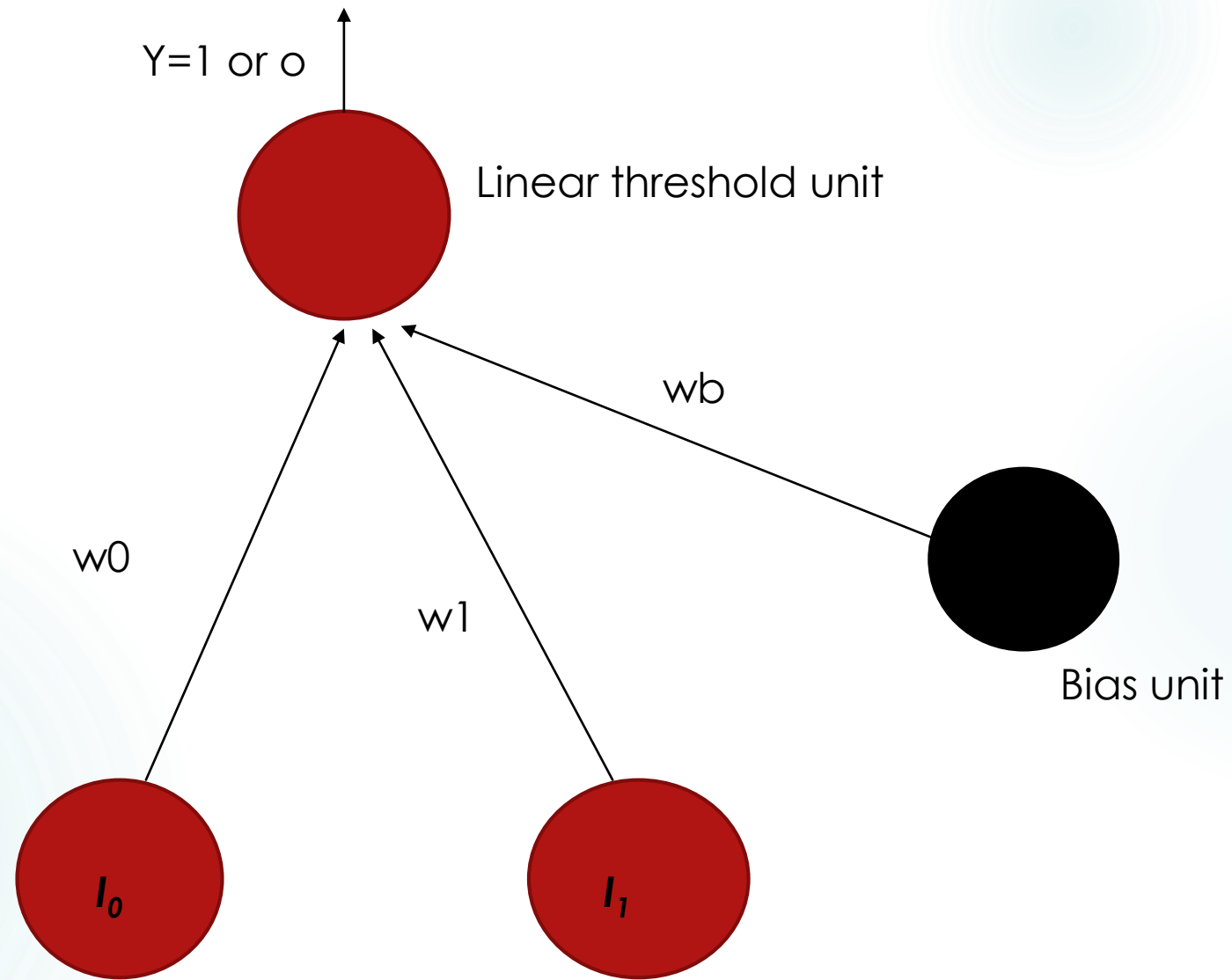
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- It is far from a true model of biological neuron.
- Biological neuron's output is continuous function rather than a step function.
- This represents only a linear separation .
- The network has 2 binary inputs I_0 and I_1 & binary output Y .
- w_0 and w_1 are the connection strengths of inputs 1 and 2 respectively,

Thus the total input received at processing unit is

$$w_0 \mathbf{I}_0 + w_1 \mathbf{I}_1 - w_b$$

- Where w_b =threshold (or bias)
- The output Y takes on the value 1 if $w_0 \mathbf{I}_0 + w_1 \mathbf{I}_1 - w_b > 0$ and otherwise it is 0.



A simple perceptron

Typical AN with activation function

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- The threshold function or the step function is replaced by the more general, continuous function called *activation function*.
- This is the structure of a node with an activation function .For this particular node , n weighted inputs (w_i) are combined via combination function that often consist of a simple summation.
- A transfer then calculates a corresponding value, the result yielding a single output value usually between 0 & 1. Together the combination function and the transfer function make up the activation function of the node.

Types of activation function

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The activation function is defined as the function which transforms the input to output. This function is simple as identity function or as complex as non-linear mapping function.

Some of examples are:

1. Threshold Function:-

for this type of activation function we have,

$$f = \begin{cases} 1 & \text{if } net \geq 0 \\ 0 & \text{if } net < 0 \end{cases}$$

used in classification

2. Sigmoid Activation Function:-

This is the most common form of activation function used in the consideration of ANN

It is defined as strictly increasing function that displays smoothness and asymptotic properties.

an example of sigmoid is the *logistic function*.
defined as,

$$f = \frac{1}{1 + e^{-\lambda(net)}}, \lambda > 0$$

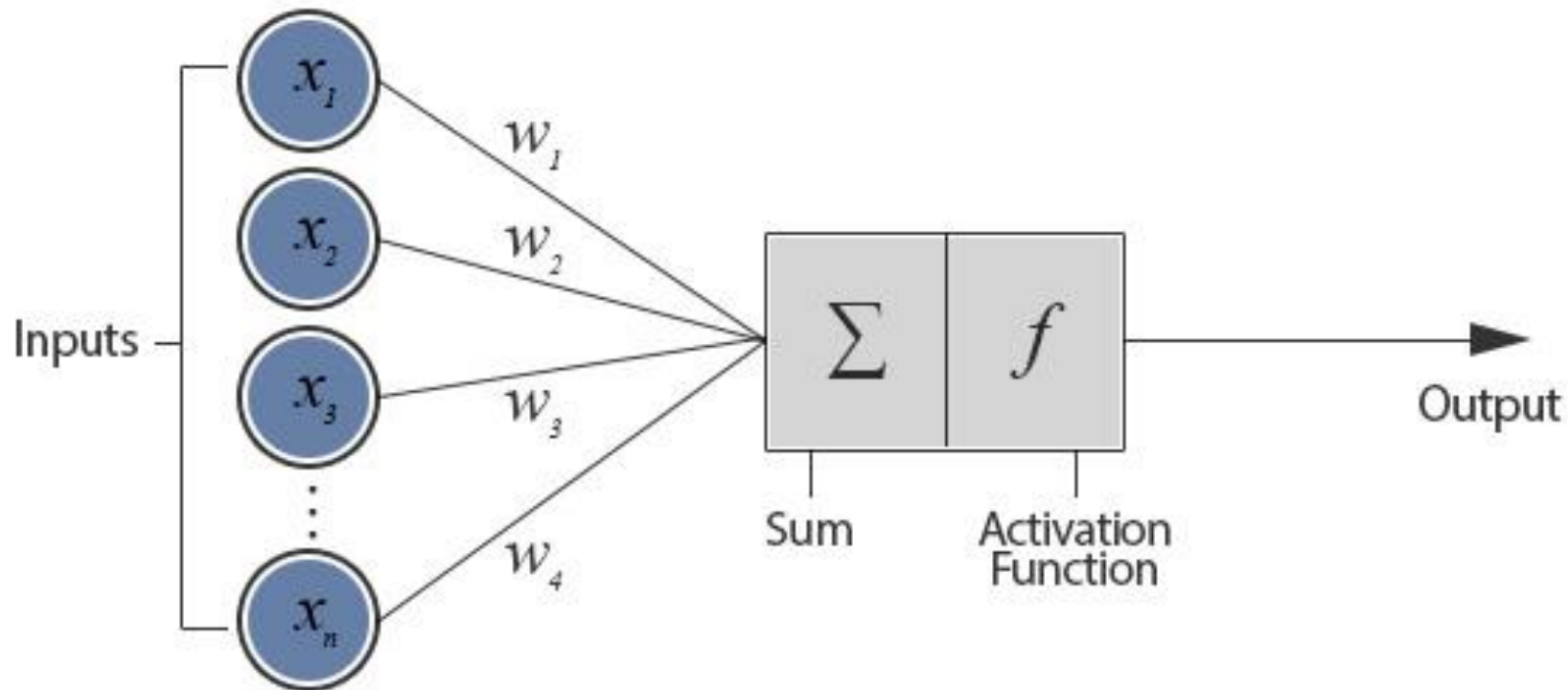
Some other activation functions are :

- ☐ Simple recurrent network
- ☐ Hopfield network
- ☐ Echo state network
- ☐ Stochastic neural network

Single layer neural network

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A network that is constructed with an input and output is turned as single layer neural network model.



- Figure shows two layer ,layer with input and output signals or nodes are called input layer and output layer.
- Let x_1, x_2, \dots, x_k be set of input signals or nodes and y is an output signal.
- The output signals are linearly combined with respect to synaptic weights.
- The input signals are passed through an activation function f to yield output y .

- Thus a mathematical model representation of single layer neural network model is,

$$\begin{aligned} y &= f(w_0 + \underline{x}' \underline{w}) & \text{where, } x_0 &= 1 \\ &= f(\underline{x}, \underline{w}) \end{aligned}$$

where, $\underline{x} = (1, x_1, \dots, x_k)$

$$\underline{w} = (w_0, w_1, \dots, w_k)$$

- Therefore a statistical model is given by,

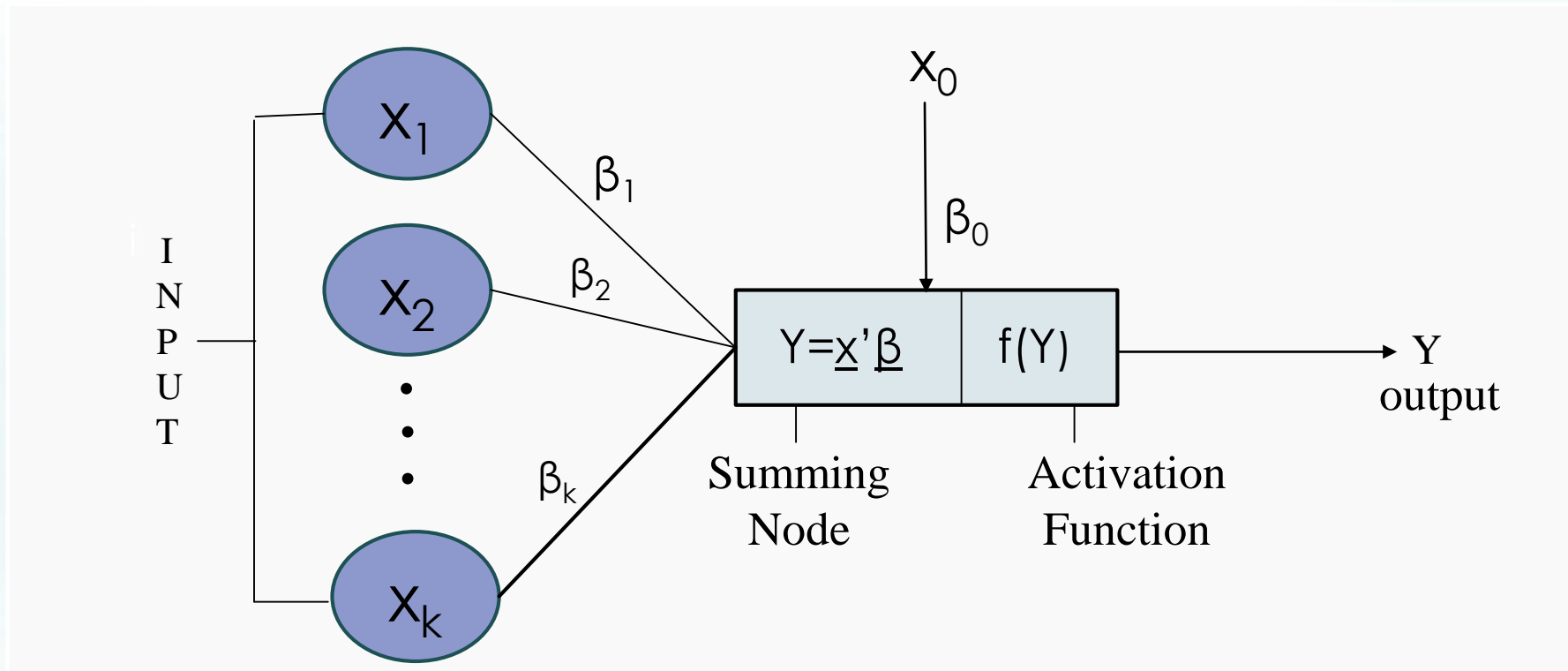
$$y = f(\underline{x}, \underline{w}) + \varepsilon$$

Single layer neural network and regression

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- A multilayer linear regression model that relates a response variable y with the regressor (x_1, x_2, \dots, x_k) is given by,

$y = \underline{x} \underline{\beta} + \varepsilon$ with usual notation.



- A single layer feed forward network with an activation function such as

$$f(x, \beta) = x \beta \text{ (identity)}$$

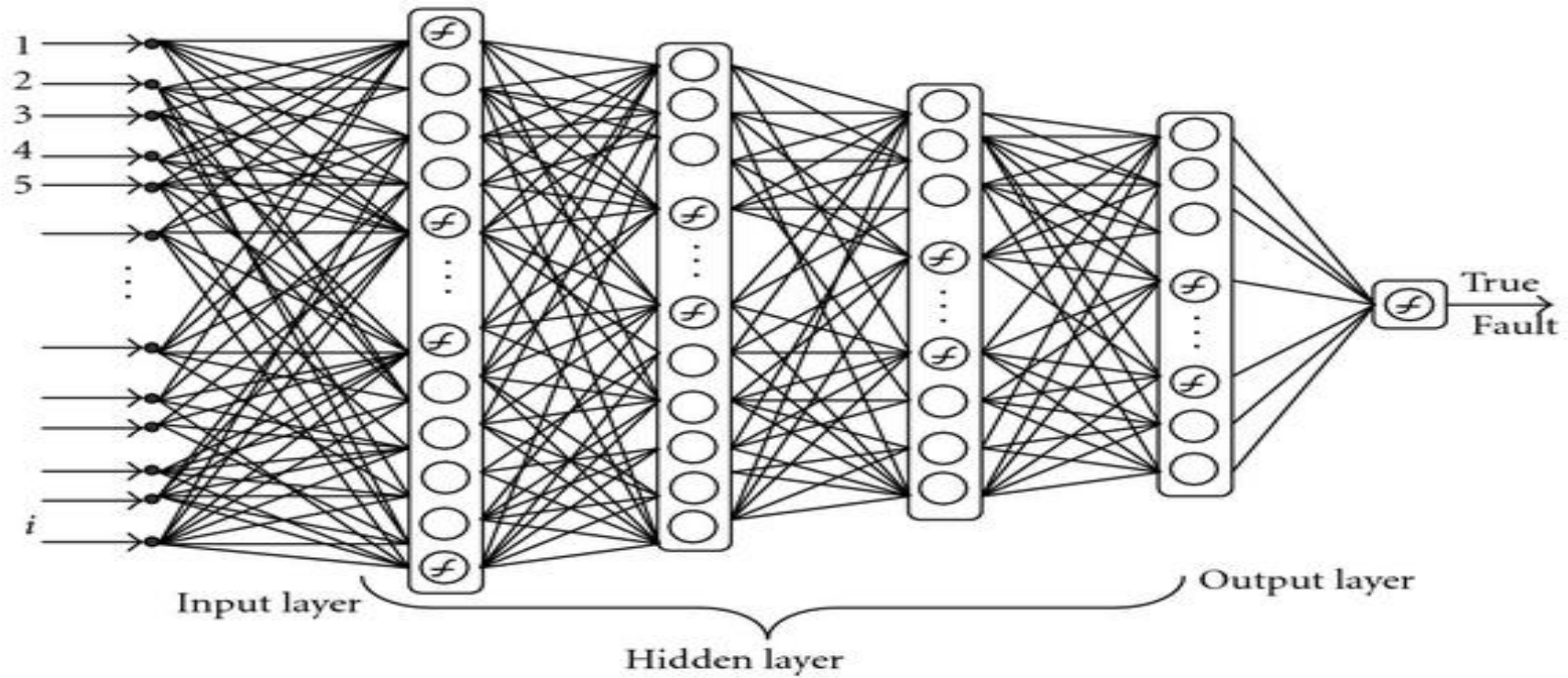
- The regressor corresponds to input layers of ANN and the response corresponds to output signal of ANN. The regression coefficient corresponds to synaptic weights in the model.
- More specifically the connecting weights are regression slopes and bias is the intercept.

Multilayer perceptron

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- MLP is development from the simple perceptron in which extra hidden layers (layers additional to input layer and output layers, not connected externally) are added. More than one hidden layer can be used.
- Generally, the connections are allowed from the input layer to the first (and possibly only) hidden layer: from the first hidden layer to the second, and so on, until the last hidden layer to the output layer.
- The presences of these layers allows an ANN to approximate a variety of non linear functions.

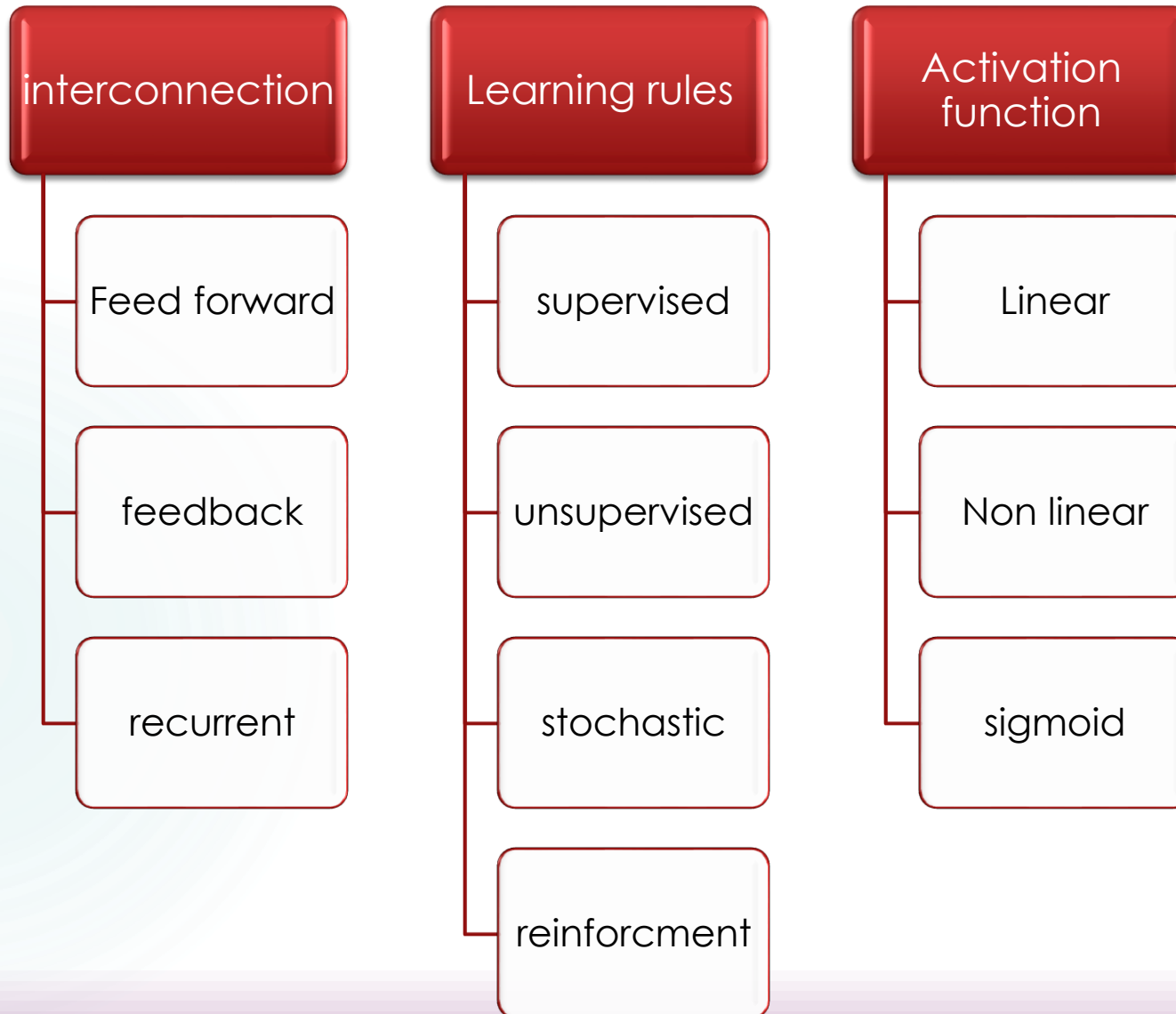
- The actual construction of a network, as well as the determination of the no of hidden layers and the determination of no of units, is something like trial and error process , determined by the nature of the problem.
- The transfer function is generally a sigmoid function.



Multilayer perceptron

Components of ANN

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Advantages

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- It is a data oriented process which learns the model or pattern from the data.
- A neural network can perform task that a linear program cannot.
- When the element of a NN fails, it can continue without any problem by their parallel nature.
- A neural network learns and does not need to be reprogrammed.
- It can be implemented in any application.

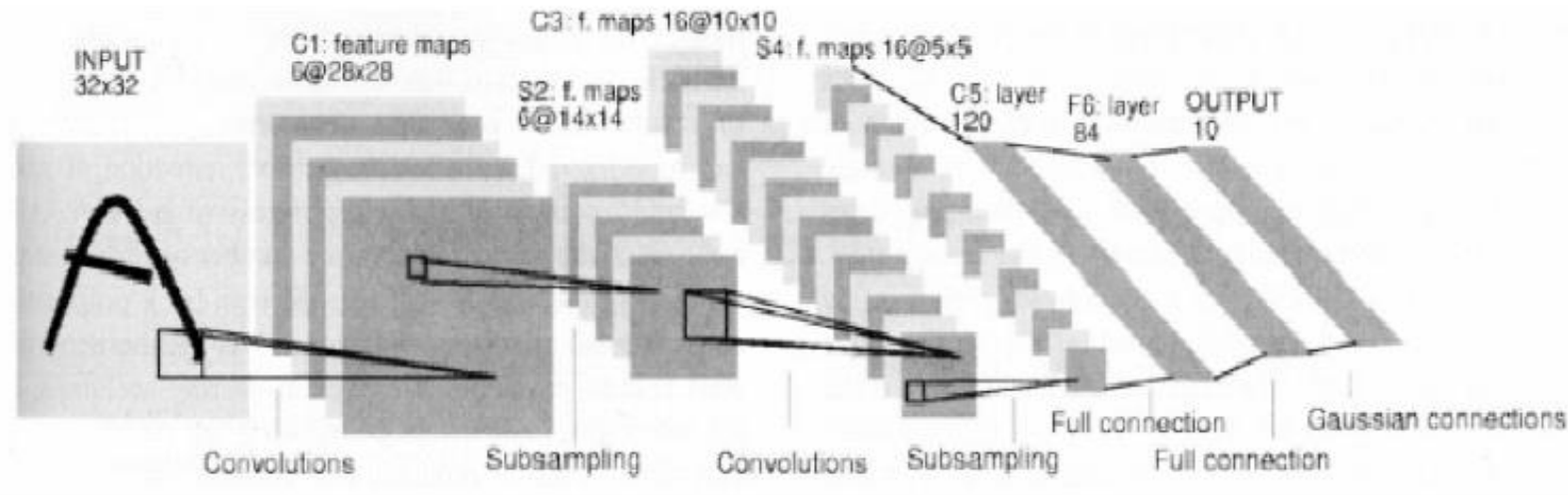
- It is more appropriate technique than multiple linear regression model or any other non linear regression, if underlined regression function is non linear.
- It can be used to model time series data.

Disadvantages

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- Many parameters (learning rate, etc.)
- Need to design the architecture of the network (how many units? How many layers? What transfer function at each unit? Etc.)
- Requires a substantial amount of engineering in designing the network
- Training can be very slow

Real Example



- Takes as input image of handwritten digit
- Each pixel is an input unit
- Complex network with many layers
- Output is digit class

Fields where neural network works

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☐ Classification:

- In marketing
- Defence
- In agriculture and fishing
- Medicine

☐ Recognition and Identification:

- In general computation and telecommunication ,Finance

☐ Assessment

- In engineering
- In security

☐ Forecasting and Prediction

- Finance
- Agriculture
- Marketing
- Meteorology

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