

Application of AI

Chapter 6

6.1 Neural network:

Biological neural network

- ⇒ A Neural circuit is a population of neurons interconnected by ~~snap~~ synapses to carry out a specific function when activated.
- ⇒ Neural circuit interconnect to one other to form a large scale brain network.
- ⇒ Biological neural network have inspired the design of artificial neural network.
- ⇒ The human brain incorporates nearly 10 billion neurons & 60 trillion connection (synapses) between them.
- ⇒ By using multiple neuron simultaneously. The brain can perform its func much faster than the fastest computer in the existence today.

Artificial Neural Network (ANN) or Neural Network

- ⇒ A Neural Network is a network or circuit of Neurons composed of artificial neurons or nodes.
- ⇒ An ANN is an information processing paradigm that is inspired by the way biological neural system such as brain process information.

⇒ ANN learn by example just like human does.

⇒ An ANN is configured for a specific application such as pattern recognition or data classification through a learning process.

⇒ It usually involves large number of processor operating in parallel and arranged in tiers.

⇒ The first tier receive the raw I/p information similar optic nerve in human visual processing.

⇒ Each successive tier receive the O/p from the preceding tier in the same way neurons receives signal from the optic nerve.

⇒ The last tier produces the O/p of the system.

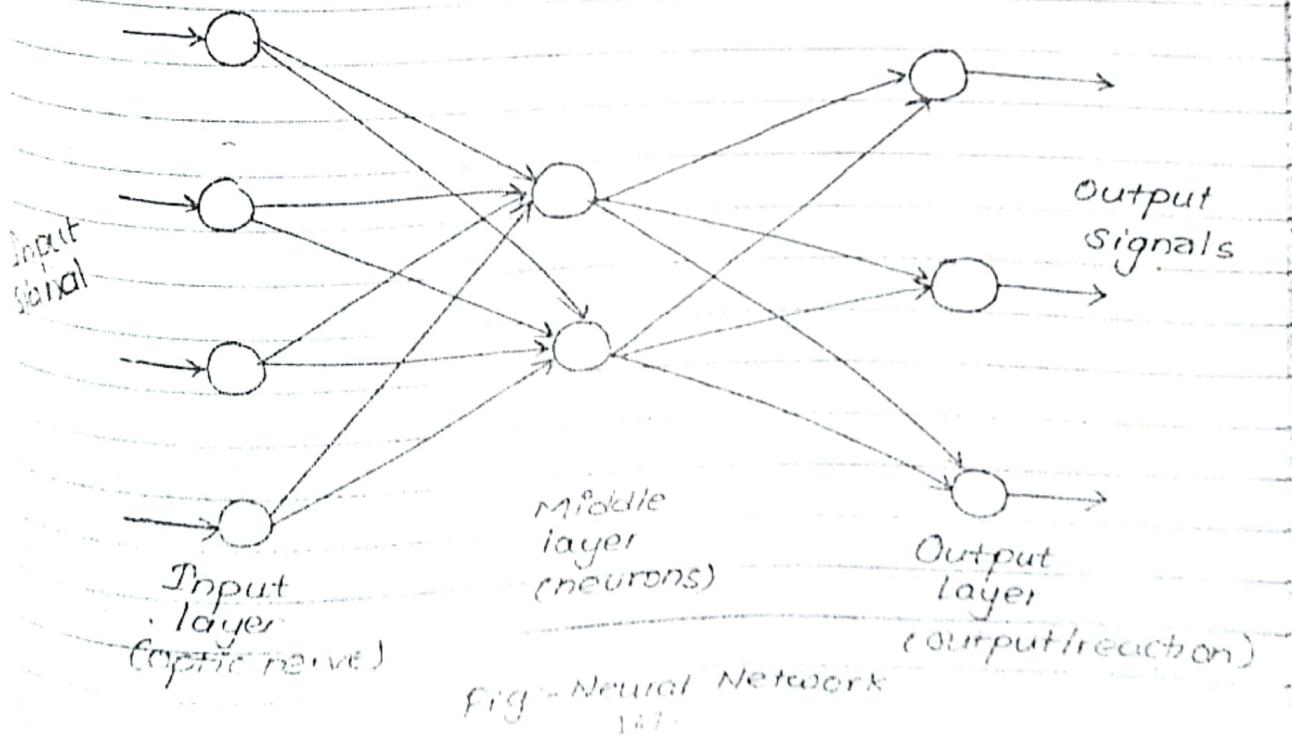


Fig - Neural Network
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Advantages of neural network / Application:

- ⇒ It can be used to extract pattern or detect patterns that are too complex to be noticed by either humans or other computer techniques.
- ⇒ It is used in expert system in which the neural network is trained and helps to analyse.
- ⇒ It is used in order to perform adaptive learning.
- ⇒ It has the ability of tolerance two.

Q. How do neural network differ from conventional computing?

- ⇒ ANN are not sequential or deterministic.
- ⇒ There are no complex central processes in ANN.
- ⇒ ANN respond to program instruction in parallel as per the pattern of input.

Units of Neural Network / Basic Terminologies

1) Nodes (units)

⇒ Nodes represent a cell of neural network

2) Leaf Links

⇒ Links are directed arrows that show propagation of information from one node to another node.

3) Activation:

⇒ Activation are input to or outputs from a unit

4) Weight:

⇒ Each link has weight associated with it which determine strength and sign of connection.

5) Activation function:

⇒ A function which is used to derive output activation from the input activation to a given node is called activation func.

6) Bias:

⇒ Bias is a feature of technique or of its result whereby the expected value of the result differ from the underlying quantitative parameter being estimated.

Bias weight

$a_0 = 1$

$a_1 = g(w_1)$

W₁

8

b₁

a₁

Input
function

Activation
function

Neuron as a simple Computing element

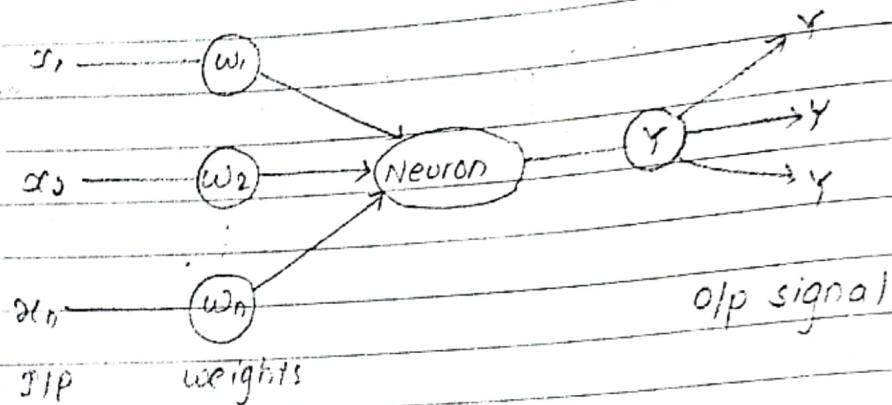


Fig:- Diagram of a neuron

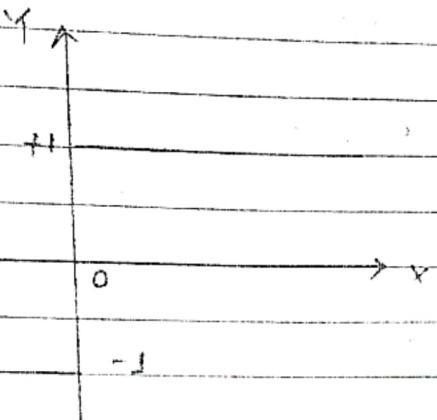
⇒ The neurons have 2 modes of operation, the training mode & the using mode. In the training mode the neuron can be trained to fire for particular input pattern.

⇒ In the using mode, when a taught input pattern is detected at the current input, its associated o/p becomes the current output.

⇒ The neurons compute the weighted sum of the input signal and compares the result with a threshold value (θ). If the need i/p is less than the threshold then the o/p is -1 else, if it is greater or equals to than the threshold then it is +1.

⇒ The neuron uses the following transfer function or activation function

$$x = \sum_{i=1}^n x_i w_i, \quad y = \begin{cases} +1 & \text{if } x \geq 0 \\ -1 & \text{if } x < 0 \end{cases}$$

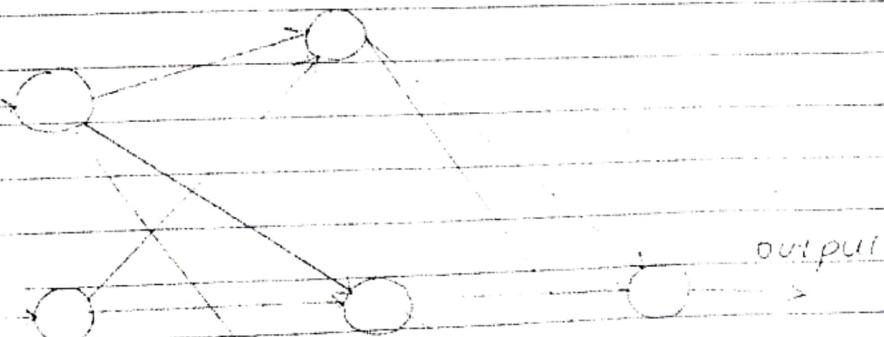


Sign function

Architecture of Artificial neural network

- i) Feed forward ANN
- ii) Feedback ANN

i) Feed forward ANN



Feed Forward ANN

- ⇒ allow signals to travel only one way; from I/p to O/p.
- ⇒ no feedback (loops)
- ⇒ used in pattern recognition.

(ii) Feedback ANN

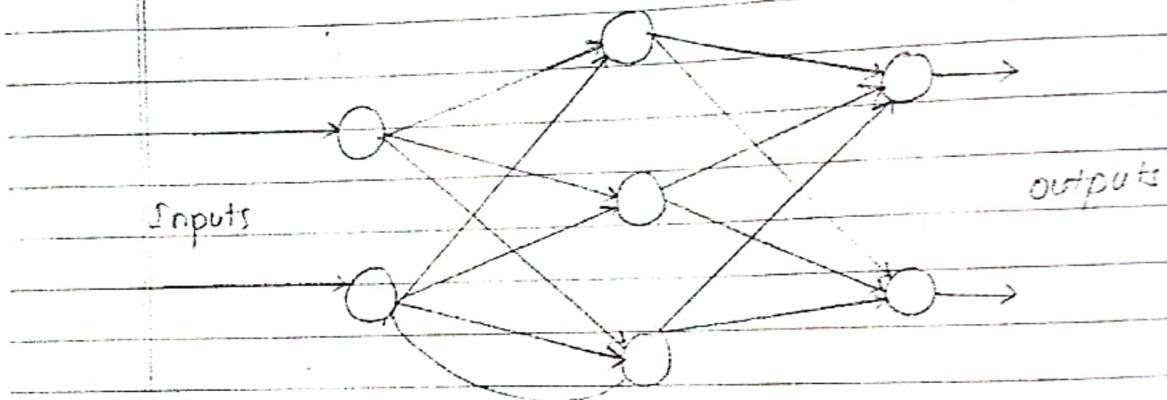


Fig :- Feedback ANN

- ⇒ have signals traveling in both 'directions'.
- ⇒ They are powerful & extremely complex
- ⇒ They are dynamic

Types of Neural network.

(i) Single layer feed forward network



iii) Multilayer feed forward n/w

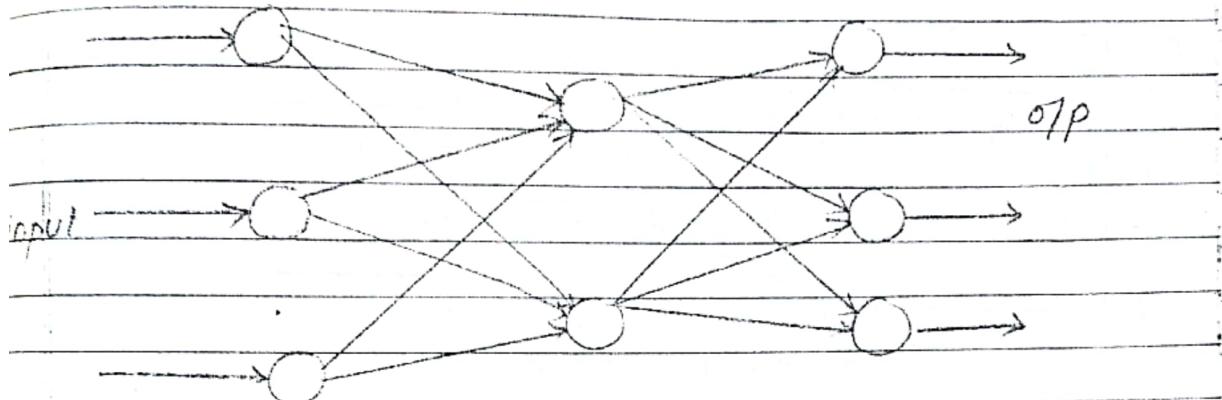


Fig - Multilayer feed forward network

iv) Recurrent feedback n/w

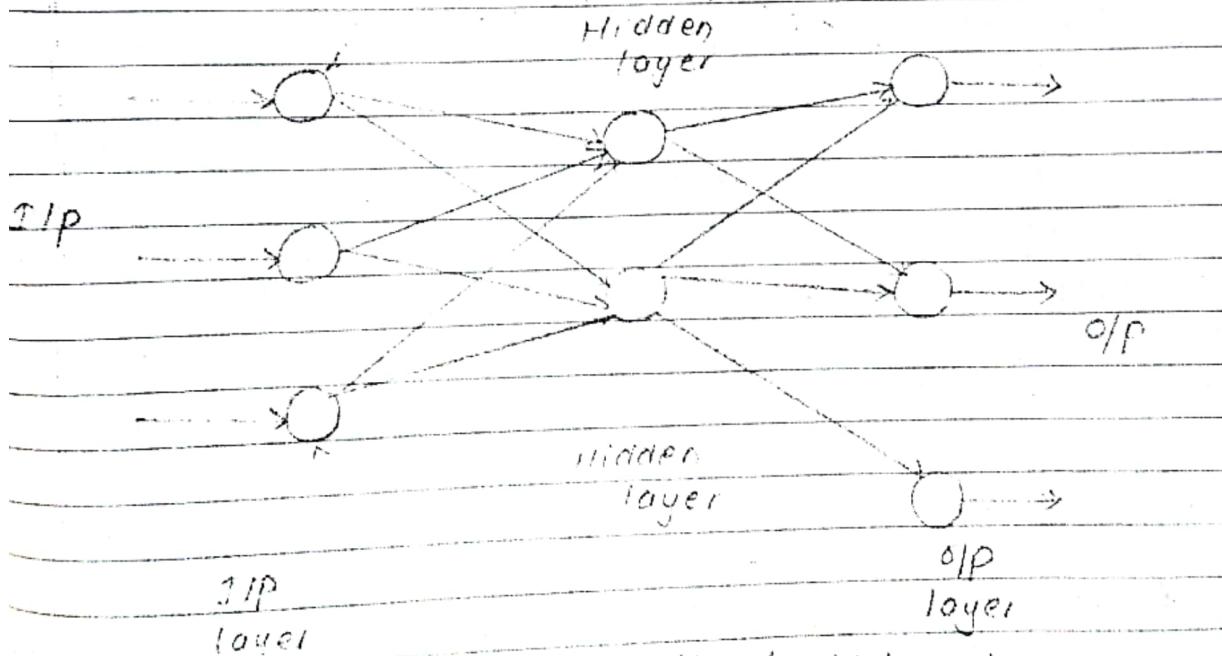


Fig - Recurrent feedback network

Q. Explain how neuron act as a simple computing element. what are the different types of neural network

6.1.2. Perceptron

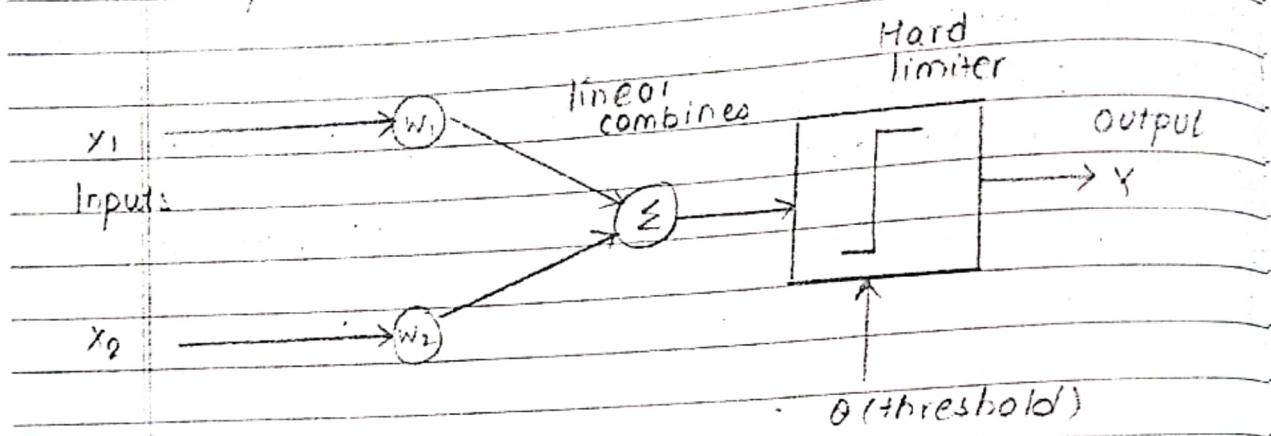


Fig:- Single layer two input perception

⇒ The perception is the simple form of neural network.

⇒ It consists of a single neuron with adjustable synaptic weights & a hard limiter.

⇒ The perceptron is an algorithm for supervised learning. The perceptron can learn any linearly separable functions, if given enough training.

⇒ The model consists of a linear combine followed by an activation function. It produces o/p equal to +1 if the input is positive & -1 if it is negative.

* Perceptron algorithm

i) Initialization:- Set the initial weight w_i & threshold to θ random number in the range $[-0.5, +0.5]$.

⇒ If the error $e(P)$ is positive we need to increase the perceptron o/p y_{CP} but if

it is negative we need to decrease the y_p .

ii) Activation:

- Activate the perceptron by applying input $x_i^o(p)$ & desired output $y_d(p)$.
- Calculate the actual output at iteration $P=1$.
as

$$Y(P) = \text{step} \left[\sum_{i=1}^n x_i^o(p) \cdot w_i(p) - \theta \right]$$

where,

n = no. of perception i/p &
Step is step activation func.

iii) Weight training

- Update the weight of the perceptron as

$$w_i^o(p+1) = w_i^o(p) + \Delta w_i^o(p)$$

where,

$\Delta w_i^o(p)$ = weight correction at iteration P .

- The weight correction is computed by delta rule.

$$\Delta w_i^o(p) = \alpha x_i^o(p) \cdot e(p)$$

α = learning rate

iv) Iteration

- Increase iteration P by one, go back to step 2 & repeat the process until convergence.

Adaline Network

- It is a variation of perceptron network.
- Inputs are +1 or -1, output are +1 or -1.
- It uses a bias input. It is trained by using delta rule.
- The activation function during training is the identify function & that after the training the activation is the threshold function.

Adaline Algorithm

Step 0: Initialize the weight to small random values & select a learning rate.

Step 1: For each input vector s which target output t set the input to s .

Step 2: Compute the neural networks.

Step 3: Use the delta rule to update bias & weight as

$$b(\text{new}) = b(\text{old}) + \alpha(t - y_{\text{in}})$$

$$w_i(\text{new}) = w_i(\text{old}) + \alpha(t - y_{\text{in}})x_i$$

Step 4: Stop if the largest weight change across all the training sample is less than a specified tolerance otherwise cycle through the training set again.

X

Backpropagation:

- ⇒ It is a supervised learning and is an implementation of delta rule.
- ⇒ It requires a teacher that knows or can calculate the desire output for an any given input.
- ⇒ It is mostly useful for feed forward network back propagation requires that the activation function used by the artificial neurons are differential.

Backpropagation Algorithm

1) Initialization:

- ⇒ Set all the weights & threshold levels of the network to random no. uniformly distributed inside a small range.

$$[-0.4/T_i, 0.4/T_i]$$

where,

' T_i ' = total no. of i/p of neuron

' i ' in the network

2) Activation:

- ⇒ Activate the back propagation neural network by applying inputs $x_i^*(P)$ & desired output $y_i^*(P)$

→ Calculate the actual o/p of the neuron in the hidden layer.

$$y_j^i(p) = \text{Sigmoid} \left[\sum_n \sum_{i=0}^{i=0} x_i^i(p) \cdot w_{ij}^i(p) - \theta_j^i \right]$$

Calculate the actual output of the neurons in the output layer

$$y_k(p) = \text{Sigmoid} \left[\sum_n \sum_{i=0}^{i=0} x_i^i(p) \cdot w_{ij}^i(p) - \theta_k \right]$$

where,

n = no. of inputs of neuron ' k ' in the output layer.

3) Weight training

$$\delta_k = y_k(p) [1 - y_k(p)] e_k(p) \text{ where}$$

$$e_k(p) = y_{d,k}(p) - y_k(p)$$

⇒ Calculate the weight corrections

$$\Delta w_{jk} = \alpha \cdot y_j(p) \cdot \varepsilon_k(p)$$

⇒ Update the weight at the output neurons

$$w_{jk}(p+1) = w_{jk}(p) + \Delta w_{jk}(p)$$

⇒ Calculate the error gradient for the neurons in the hidden layer:

$$\varepsilon_j(p) = y_j(p) [1 - y_j(p)] \cdot \left[\sum_{k=1}^l \delta_{kj}(p) \cdot w_{jk}(p) \right]$$

⇒ Calculate the weight correction

$$\Delta w_{ij} = \alpha \cdot x_i(p) \varepsilon_j(p)$$

⇒ Update the weight of the hidden neuron

$$w_{ij}(p+1) = w_{ij}(p) + \Delta w_{ij}(p)$$

6.1.5 Hopfield network

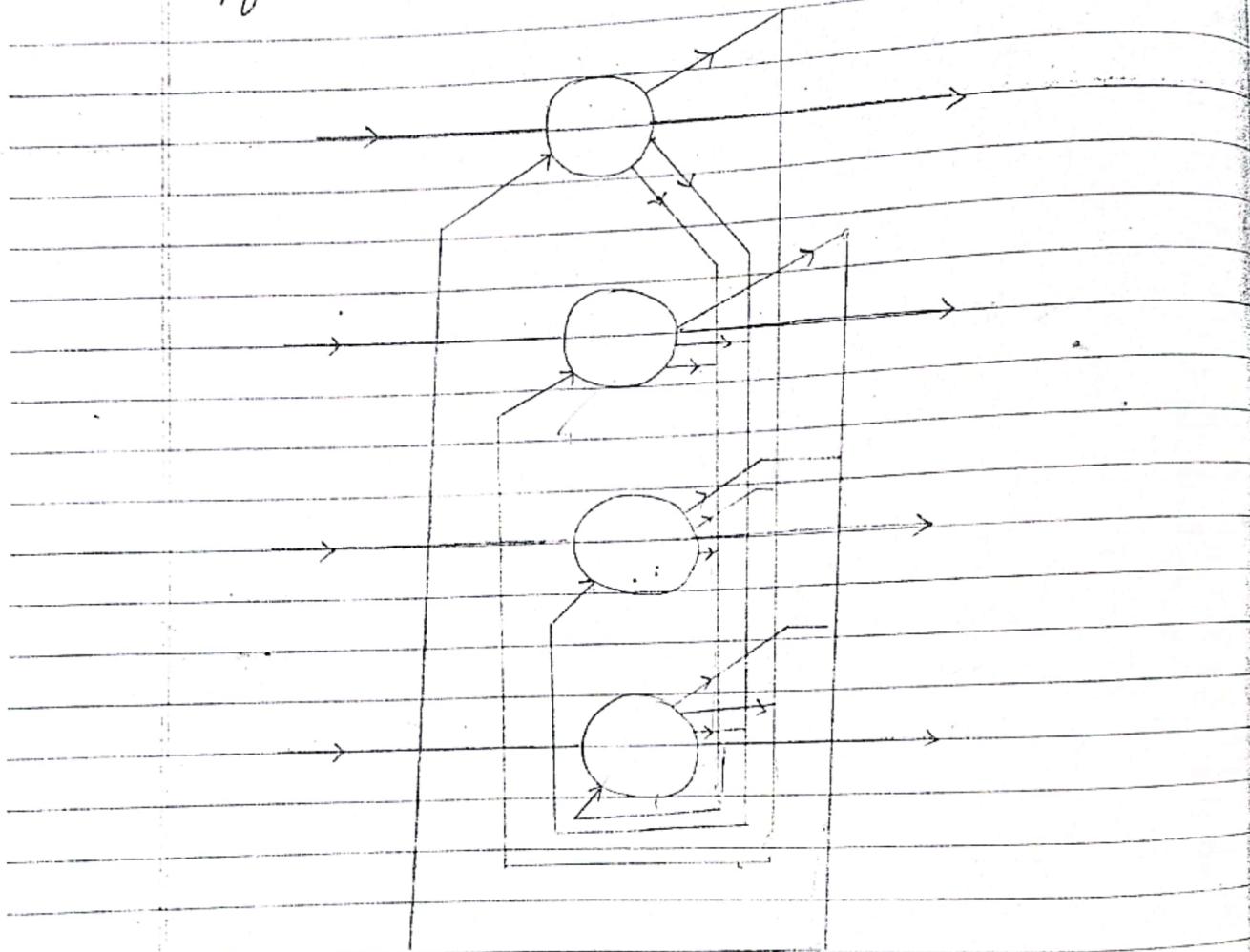


Fig:- Hopfield Network

→ It is a form of recurrent artificial neural net made popular by John Hopfield in 1982

→ The units in Hopfield network are binary threshold unit i.e. the units only take on two different values for their states & the value is determined by whether or not the units' inputs exceeds their threshold.

→ Hopfield network normally have units that

take on values of 1 or -1.

Upgrading Updating 1 unit in Hopfield n/w is performed using the following rules

$$s_i^t \leftarrow \begin{cases} +1 & \text{if } \sum_j w_{ij} s_j^{t-1} \geq \theta_i \\ -1 & \text{otherwise} \end{cases}$$

where,

s_j^t = state of unit j

w_{ij} = strength of the connect weight from unit j to unit i .

θ_i = the threshold of unit i .

Q. What is the Perceptron. Explain the back propagation algorithm.

Q. Write short notes on

a) Hopfield network

b) Kohonen Network (self)

• Kohonen Network



Fig: Kohonen Network

- It is one of the basic type of self organizing neural network.
 - Kohonen N/w is computational method for the visualization & analysis of high dimensional method especially experimentally acquired information.
 - It is composed of grid of o/p units and N i/p unit.
 - The i/p pattern is fed to each o/p unit.
 - The i/p lines to each o/p unit are provided with weights which are small random number.
- => It consists mainly of 3 stages
- 1) Construction
 - 2) Learning
 - 3) Identification.
- It is mainly used in pattern matching or pattern recognition.

6.2 Expert System.

- It is an AI program that has expert level knowledge about a particular domain
- Domains refers to area within which the task is being performed.
- In other words, we can define expert system as an intelligent program that uses knowledge and inference procedure to solve problems/cases that are difficult enough to require significant human expertise for their soln.

Q. Diff. betw Human expert & expert system. ✓

Actor	Human expert	Expert System.
Time	Limited or working days or time only	Anytime, apart from maintenance
Geography	Suitable places as per the need	Anywhere
Flexibility	Cannot be replaced due to its knowledge.	Can be replaced.
Consistency	Changes from time to time.	Consistent
Risk	It is high	It may be low or intermediate.

Q. What is an expert system? Why is it needed?

✓ # Characteristics of expert system

1) High performance

→ They should perform at the level of human expert

2) Response time

→ They should be able to perform or respond in a reasonable amount of time.

→ Time is crucial for expert system.

3) Reliable

→ They must be reliable and should not trash

4) Understandable

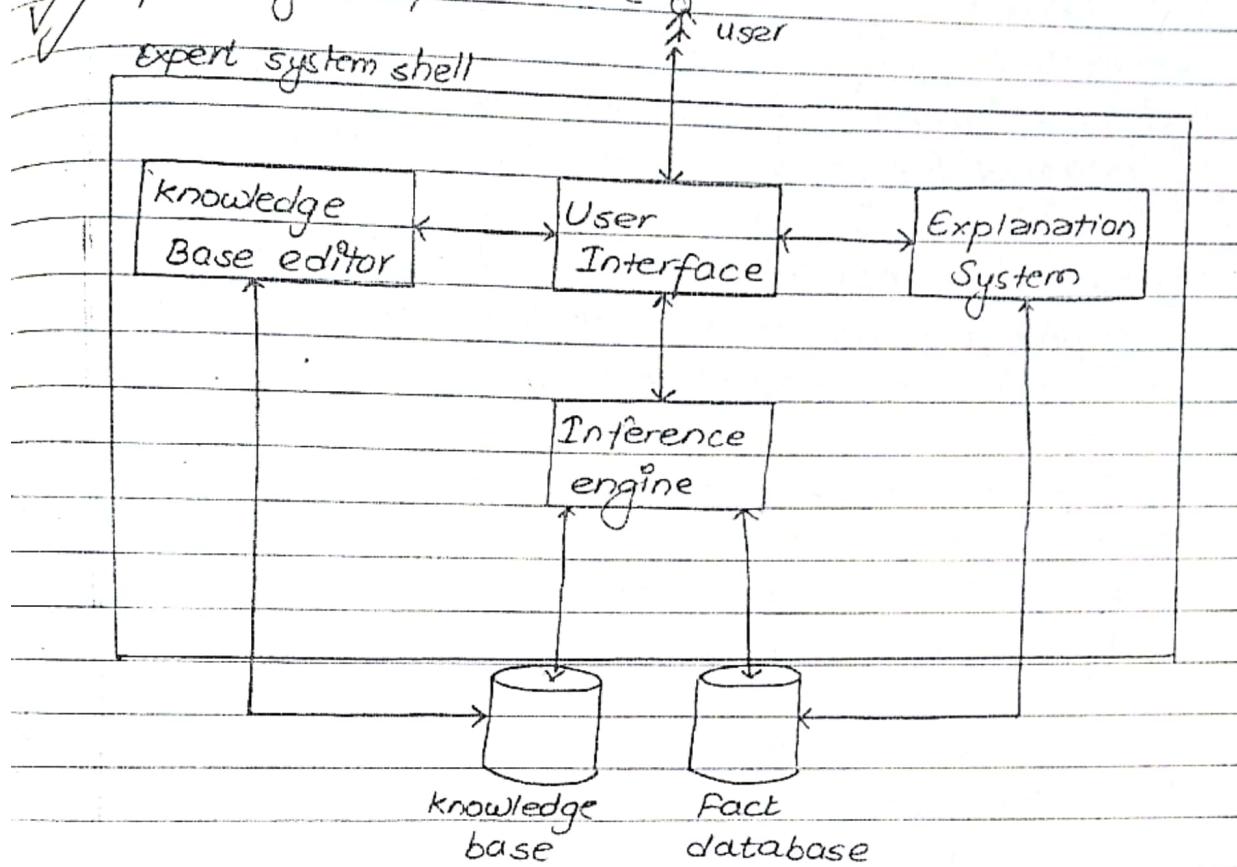
→ They should be able to provide the step of reasoning.

→ It should be able to draw conclusion

5) Difficult to maintain

→ They are very much difficult to maintain expert system.

Expert System Architecture



• Component of FS

1) Knowledge Base:

→ It contains domain specific and high quality knowledge where knowledge is define as the collection of data, information & past experience.

→ Knowledge is required to exhibit intelligence.

→ Success of expert system depends on collection of highly accurate & precise knowledge.

2) Inference engine

→ It is essential in deducting a correct and flawless

solution.

- ⇒ Make inference by deciding which rules are satisfied by facts and fires the rules.
- ⇒ The major task performed by the inference engine are reasoning task, control task, explanation task & uncertainty task.
- ⇒ In case of knowledge base expert system, inference engine acquires & manipulates the knowledge from the knowledge base & to arrive at a particular solution.
- ⇒ In case of rule base ES, it applies rules repeatedly to the fact which are obtained from earlier rule application.
- ⇒ In this case, it adds new knowledge in the knowledge base if required.
- Similarly, it resolves rules conflict when multiple rules are applied to a particular problem.

3) User Interface

- ⇒ It provides interaction between the user of ES and the ES itself.

- ⇒ In other words, the component of an expert system which communicate with user is user interface.

It uses natural language processing & through the user interface, the results are provided to the user.

Q. Explain the rule based expert system architecture along with its application.

Q. What is an expert system? What are different components used in ES.

2.2. Development of Expert System.

Step 1: Identify problem domain

- Problem must be suitable for an expert system to solve it.
- Find the expert in task domain for an ES project.
- Establish cost effectiveness of the system.

Step 2: Design the system

- Identify the ES technology
- Know & establish the degree of integration with other systems & databases.
- Realize how the concept can represent the domain knowledge base.

Step 3: Develop the prototype

- From knowledge base the knowledge engineer works to:
 - i) Acquire domain knowledge from the expert

(ii) Represent it in the form if then else rules.

Step 4:- Test & define the prototype

- The knowledge engineer uses sample cases to test the prototype for any faults in performance.
- End user may also test the prototype of its ES.

Step 5:- Develop & complete the ES

- Test & ensure the interaction with all the elements of ES, its environment, including end user, database and other information system.
- Document the ES project effectively.
- Train the user to use ES.

Step 6:- Maintain the ES

- Keep the knowledge base upto date regular review & update.
- Evolve as per the need in time.

Limitation of ES

- ⇒ Lack of commonsense needed in some decision making.
- ⇒ Cannot make creative response as human expert would in unusual circumstances.
- ⇒ Error may occur in knowledge base and lead to wrong decision.
- ⇒ Cannot adapt changing environment, unless knowledge base is changed.

Application

Application	Description
1) Design domain	Camera lens design, automobile design
2) Medical domain	medical diagnosis system
3) Monitoring Monetary system	Monitoring Monetizing data in long petroleum pipeline of the leakage.
4) knowledge domain	Finding out faults in vehicles & computers
5) Finance & commerce	Detection of possible fraud, suspicious transaction, stock market training, airline scheduling
6) Process control system	Controlling physical process based on monitoring

Natural Language Processing

→ It is the process of understanding & generation of our natural language (English, Russian, etc) to the means of human, computer interfacing through voice.

→ It is mostly used in database system, expert system, automatic text translation system or automatic text summarization.

→ The task of mapping the soundwave to a string of words is called speech recognition system.

→ It has the problem of background noise, inter-speaker variation & intra-speaker variation.

→ NLP is composed of NLU & NLG where,

NLU = Natural Language Understanding
(speech or text to meaning)

NLG = Natural Language Generation
(meaning to text or speech)

Problem in NLP

→ Multiple meaning of words in different places of word

For egs:

Flat = house (mainly in England)

flat = puncher (mainly in America)

→ One sentence may have multiple meaning

Eg:-

- 1) I saw pashupatinath flying over kathmandu.
it has two meaning:-
 - whether pashupatinath is flying
 - or the person is flying.

→ Single word may have multiple meaning.

Eg:- Copy = notebook

Copy = transfer of data in computer system.

→ Language phrases will give separate meaning
in combine way and in segmented way.

For example:-

- Get-rid-off = Release
- Get = obtain.

Steps in NLP

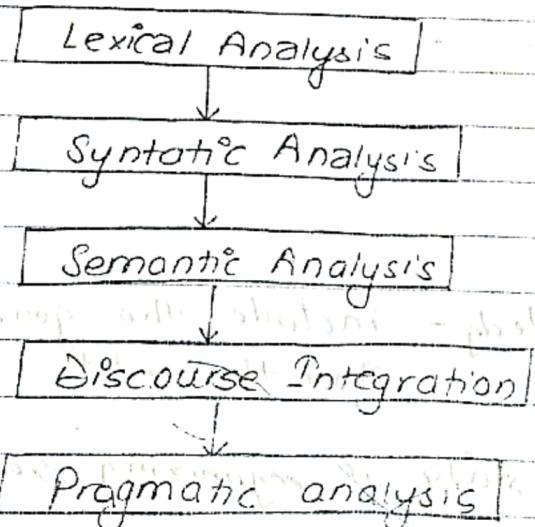


Fig:- Steps in NLP

(NLP processes)

NLP terminology

1) Morphology \Rightarrow It is a study of

\Rightarrow It is the study of construction of word from primitive meaningful units.

2) Syntax

\Rightarrow It refers to arranging of words to make a sentence.

3) Sem-Semantics:

\Rightarrow It is concern with the meaning of words & how to combine words into meaningful phrases & sentences.

4) Pragmatics:

\Rightarrow It deals with using & understanding sentences in different situation & how the interpretation of the sentence is effected.

5) Discourse:

\Rightarrow It deals with how the immediately preceding sentence can effect the interpretation of next sentence.

6) World Knowledge - include the general knowledge about the world

7) Phonology \Rightarrow study of organizing sound systematically

• Explanation.

→ Lexical Analysis

⇒ It involves identifying & analysing the str. of words. Lexicon of a language means. "The collection of words & phrases in a language."

⇒ Lexical analysis is dividing the whole chunk of text into paragraph sentences & words.

2) Syntactic analysis (parsing):

⇒ It involves analysis of word in a sentence for grammar & arranging word in a manner that shows the relationship among the words

⇒ The sentence such as "The school goes to boy" is rejected by english syntactic analyzer.

3) Semantic analysis:

⇒ It draws the exact meaning or the dictionary meaning from the text.

⇒ The text checked for meaningfulness.

⇒ It is done by mapping sente~~s~~ synthetic structure and object in the task domain.

⇒ The semantic analyzer disregard sentence such as hot ice-cream.

4) Discourse Integration:

- ⇒ The meaning of any sentence depends upon the meaning of the sentence just before it.
- ⇒ In addition, it also brings about the meaning of immediately ~~successt~~ succeeding sentences.

5) Pragmatic Analysis:

- ⇒ During this what was said is re-interpreted on what is actually meant.
- ⇒ It involves deriving those aspect of the language which require real world knowledge.

Q. What is NLP? Explain the steps in process of NLP.

Computer Vision / Machine Vision.

⇒ It is the technology concerned with computational understanding & use of information present in visual images.

⇒ Its input image is composed of large number of array of pixel and each contains very little information.

⇒ The individual pixel is meaningless but when we combine similar type of pixel, it will show certain meaningful things.

→ This type of pixel org. for meaningful information is the goal of machine vision.

→ In manufacturing, vision based sensing and interpretation system which helps in automatic inspection such as identification of cracks, holes and surface roughness, counting of object and alignment of parts.

→ The process of machine vision can be pointed as

a) Image acquisition:

• Convert the analog image to digital image

b) Image processing:

• Reduce noise, enhance colour and graylevel adjustment, etc.

c) Image analysis:

• Classify the different object contain in an image.

d) Image Understanding:

• Recognition of different classified object of an image with their description and relation to one another.