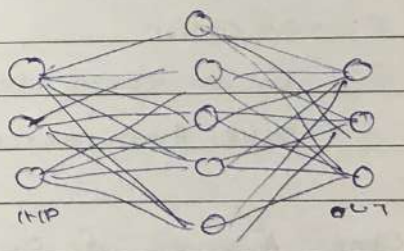
ADVANCED ARTIFICAL INT - U3

Q. Architecture of Artificial Neural Network

ANS. Artificial Neural Network (ANN's) are computer designed to mimic how a human brain processes information. Just like the brain neurons to process data and make decision. ANN's uses artificial neurons to analyse data, identify patterns and make prediction.
These network consists of interconnected nodes known as neurons that work together to solve complex problems. The key idea is that ANN can "learn" from the data they process, just as our brain learns from experience. They are used in various application from recognizing images to making personalized recommendations.

Architecture of ANN consists of three layers. The for.

(i) INPUT LAYER
(ii) OUTPUT LAYER
(iii) HIDDEN LAYER



(i) INPUT LAYER

The input layer is the first layer of an ANN. It recieves the raw data or input features from the external environments and passes them into the network. Each neuron in the layer represents one input feature.

Ex: In a student performance prediction model, inputs might include study hours, attendance and previous scores.

(13) HIDDEN LAYERS

The hidden layers are located between the input and output layers. These layers perform computation on the input using weights, biases and activation function. The hidden layer helps the network learn complex relationship and pattern in the data

Ex: If the house size affects it's price more than the location, the "size" input will have a higher weight

(14) OUTPUT LAYER

The output layer produces the final result or prediction of the network. The number of neurons in the layer depends on the type of problem been solved, for instance one neuron for regression or multiple neuron for classification

Ex: In an spam detection model, the output layer might have two neurons - one for "spam" and one for "not spam"

Other Aspects of Architecture include

(1) Weight & Biases

Weight controls the importance of each unit, while biases help adjust the output independently

(11) Activation Function

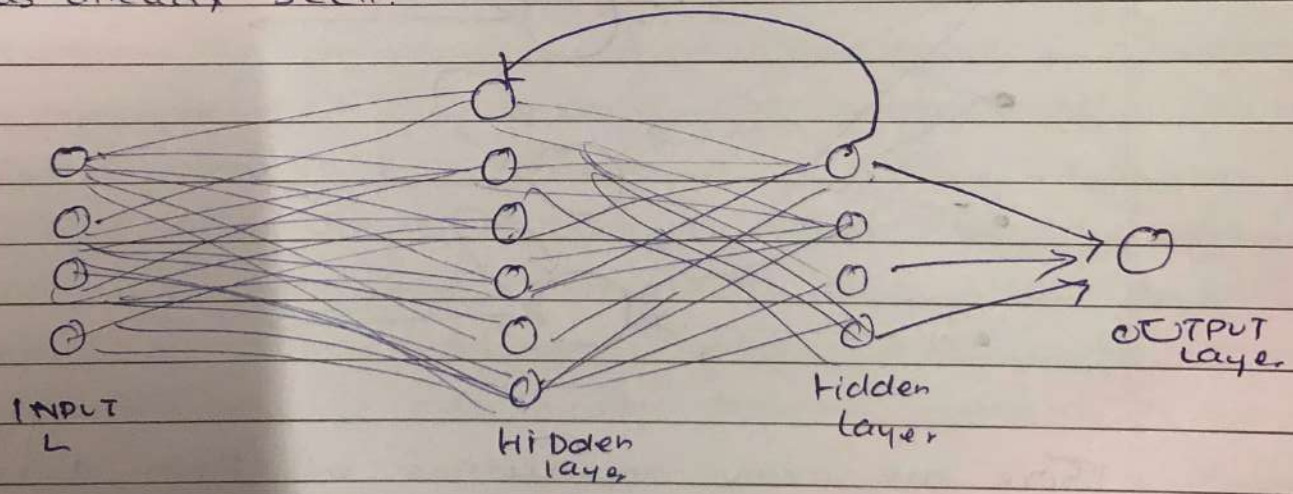
It adds non-linearity to the network, helping it to learn complex patterns instead of simple straight line relationship

(iii) Loss function

It measures the difference between the predicted and actual output, showing how well the model performed

Q. Explain Recurrent Neural Network

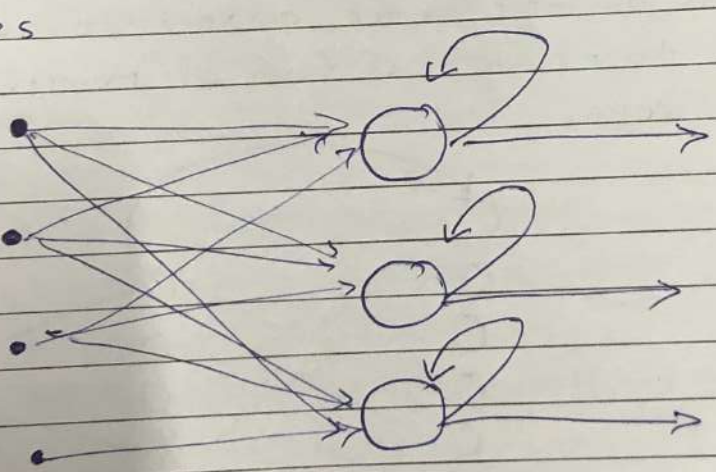
Ans. A Recurrent Neural Network (RNN) is a type of neural network specially designed to process sequential data or data changes over time, such as text, speech and time series. Unlike traditional feedforward neural network which treat each input idependently, RNN's have the ability to remember past information using feedback connections. This means that the output from the previous step is used as input for the current step, allowing the network to maintain a form of "memory" of what it has already seen.



RNN's works by passing the sequential data that they recieve to the hidden layer one step at a time. However, they also have a self-looping or re-current workflow, the hidden layer can remember and use

previous inputs for future predictions in a short-term memory component. It uses the current input and the stored memory to predict the next sequence.

Ex: Consider the sequence, Apple is Red.
You want the RNN to predict red when the input sequence Apple. When the hidden layer processes the word Apple, it stores a copy in its memory. Next, when it sees the word is, it recalls the Apple from its memory and understands the full sequence. Apple is for context. It can predict red for improved accuracy. This makes RNN's useful in speech recognition machine translation, and other language modeling tasks



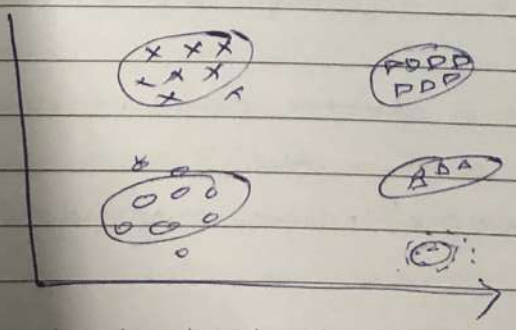
There are many applications of RNN across various sectors, ranging from Natural Language Processing to finance and healthcare. RNN are especially usefull in areas where data is sequential or time-dependent.

One major application is Natural Language Processing, where in RNN helps machines to understand and generate human language. They are used in tasks like machine learning, task summarization and sentiment analysis by remembering the context of word in sentence. Another important use is in Speech Recognition, where RNN's processes audio signals over time to convert spoken words into text. This is the core technology behind voice assistants such as Siri & Alexa.

In summary, RNN are designed to process sequential data by remembering past information, making them usefull for different tasks.

Q. Describe Clustering Techniques with Example

Ans. Clustering is an unsupervised machine learning algorithm or technique that groups similar data points together into clusters based on their characteristics, without using any labelled data. The objective is to ensure that the data points within the same clusters are more similar to each other than those in different clusters, enabling the discovery of natural groupings and hidden complex patterns in data.



- Goal: Discover the natural grouping or structured in unlabelled data without predifined categories
- How: Data Points are assigned to clusters based on similarity or the distance measured
- Similarity: Can include Euclidean distance, cosine similarity Measures or other metrics depending on data type and clustering model
- Output: Each group is assigned a cluster ID, representing shared characteristics within the cluster.

For Ex: If we have a customer purchased data, clustering can group customers with similar shopping habits. These clusters can then be used for marketing, personalized recomm or customer segmentation.

There are different Clustering Techniques as follows

① K-Clustering.

K-means divides data into specific(k) of groups based on how close the points are to each other. It finds the centers of each cluster (called centroids) and groups data around them. The algorithm keeps adjusting these centers until the groups are stable.

Ex: If you have a ~~cluster~~ customer data with age & income, K-means can group them into 3 clusters → young low income middle aged → middle income, and older high-income customer.

(ii) HIERARCHICAL CLUSTERING

Hierarchical clustering builds a tree of clusters, showing how data points are related step-by-step. It either starts with each point as its own cluster and merges them (bottom-up) or starts with one big cluster and splits it (top-down). The results can be shown in a tree diagram called dendrogram.

Ex: A company uses this method to see how similar it's products are group them into categories like

electronics → mobiles → smartphones

(iii) DBSCAN

Density-Based Spatial Clustering of Application with Noise in the DBSCAN groups the data points that are close together and marks isolated ~~groups~~ points as outliers or noise. It's great for finding clusters of different groups shapes and sizes without saying how many clusters to make

(iv) Guassian Mixture Model - GMM.

GMM assumes that data comes from a mix of several bell-shaped (Guassian Distribution). Instead of putting each point into just one cluster, it gives probabilities - meaning a point can belong to multiple clusters with different chances.

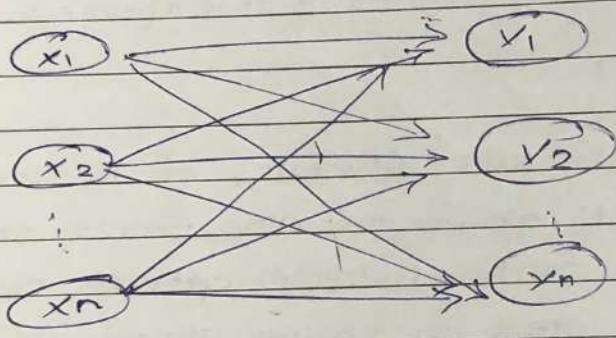
Ex: In voice Recognition, GMM can group different sound patterns where one sound may partly belong to more than one speaker's tone.

Q. Compare Single layer Feed-Forwarder & Multi layer Feed-Forwarder Network

ANS. A Feed Forward Neural Network is an type of artificial neural network where information moves in only one direction - from input to output

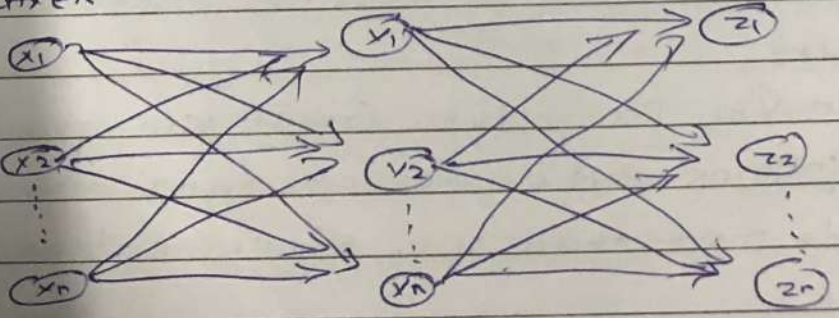
The difference between single layer and multi layer network lies in the number of layers between input and output

(i) SINGLE LAYER



In A SINGLE LAYER FFN, there are two layer input & output, but the input layer doesn't actually do any calculations, it just passes data into next layer. The output layer performs the real work by applying weights to the inputs and combining them to produce final output.

(ii) MULTI LAYER

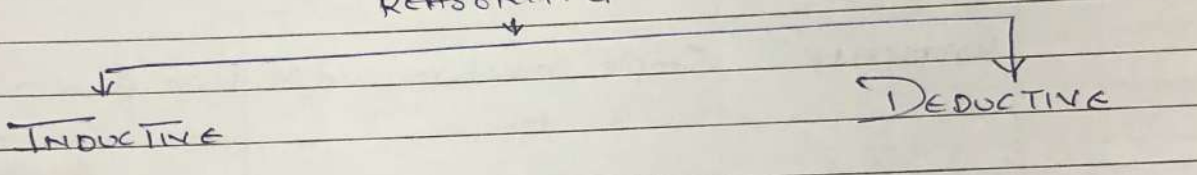


In a multilayer FFN, there are one or more hidden layers between the input and output layers. These hidden layers processes the data and makes the network capable of solving more complex problem.

Feature	SINGLE-LAYER	MULTI-LAYER
Structure	Has one I & one O layer	Has one I & one or more H & one O layer
Hidden layer	No hidden layer present	One or more present
Complexity	Simple structure and is easy to design	More complex structure with multiple layers
Computation	Performs only simple computation	Can perform multiple & non-linear computation
Learning Capability	Can handle only linearly seperable data	Can handle both linear & non-linear data
Accuracy	Generally low, due to limited learning capacity	High accuracy, as it captures deeper data patterns
Applications	Basic Classification tasks like AND/OR Gates	Advanced tasks like image recognition Speech processing & predictive system

① Reasoning - Inductive & Deductive

Ans. Reasoning is the process of thinking logically to reach conclusions or make decision on facts, evidence or knowledge. It helps to understand information, connect ideas and solve problems in a rational way.
In both humans and AI, reasoning allows us to understand use what we already know to discover or predict new things. It's an essential part of learning, problem-solving, and intelligent behaviour. Simply put, reasoning is how we make sense of the world and draw conclusions.



① Inductive

Inductive reasoning is an type of logical thinking where we form general conclusion based on specific examples, patterns or observations. It moves from specific to general. We observe a few cases and then assume a general rule applies to all similar cases. However, inductive reasoning does not always guarantee a correct answer because it relies on probability and observations, and not an absolute proof. It's commonly used in scientific research, data analysis and AI, where system learns from example.
Ex: If you notice that the sun rises in the east every morning, you conclude that the sun always rises in east.

Similarly, after meeting several dogs that bark, you might generalize that all dog barks. Inductive reasoning helps in discovering new patterns and forming hypothesis that can be later processed.

(ii) DEDCUTIVE

Deductive reasoning is an logical process that starts from general rules of statements and applies them to specific situations to reach definite conclusions. It moves from general to specific, meaning if the initial statements are true, the conclusion must also be true. This type of reasoning is considered more reliable and precise because it is based on established facts & principles. It is widely used in mathematic, logic and AI systems that ~~allows~~ follows rule-based or expat logic.

Ex: If all humans are mortal and Socrates is a human, then socrates must be mortal.

Another Ex would be - all biras have wings and since a sparrow is a bird, it must also have wings. Deductive reasoning is often used to verify or test the conclusion drawn from Inductive reasoning

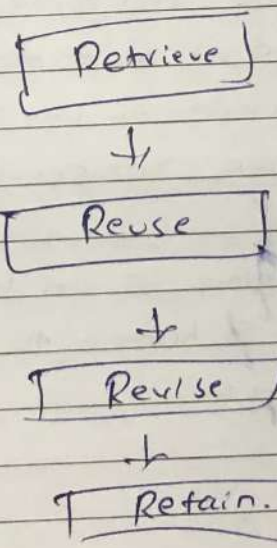
In Conclusion, reasoning is an vital part of logical thinking that enables both AI & human to make sense of information and draw conclusion

Q. Explain Cased-Based Reasoning

ANS: Case-Based Reasoning (CBR) is an approach in AI, where new problems are solved by referring to solutions of similar problem in past, known as cases. Instead of following fixed rules, it relies on experiences and past knowledge stored in databases ~~of~~ of cases.

Case-Based Reasoning works much like human learning & decision-making. When we face a new problem, we recall similar situation from the past and try to adapt solution to the current situation. In AI, a system using CBR stores a collection of cases, where each case contains a problem, its solution and the result. When a new problem arises, the system searches for the similar case, applies or modifies the solution, test if it works, and then stores the new case for future use. This makes the system continously smarter with the experience.

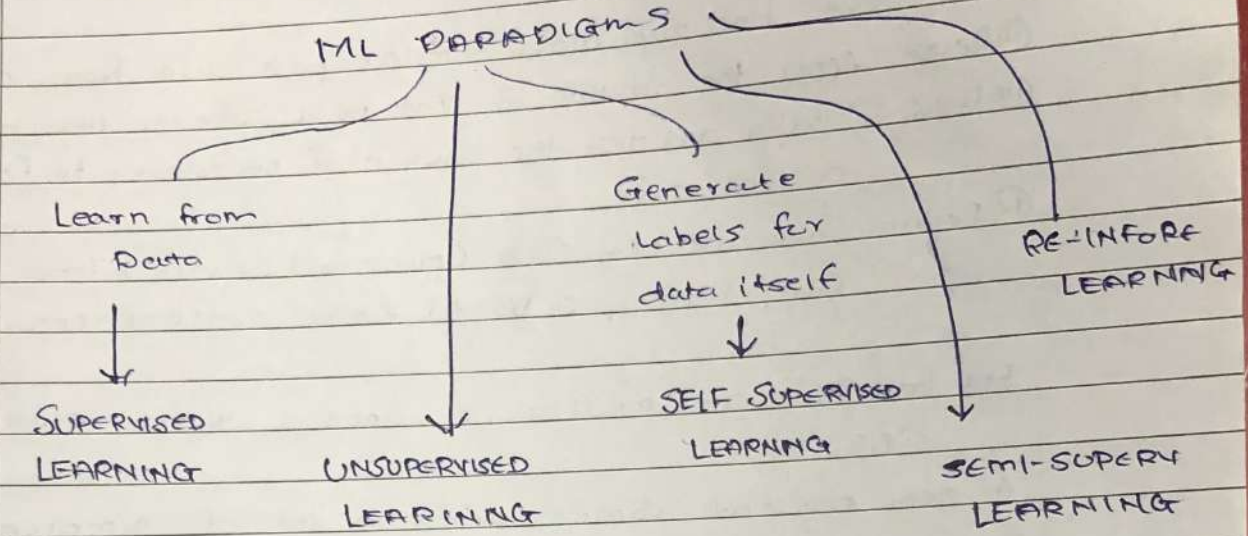
WORKING of CBR



(i) Retrieve : Find the most similar past case from case DB
(ii) Reuse : Apply the solution of that past case to new problem
(iii) Revise : Modify and test the solution if necessary to fit the current case
(iv) Retain : Save the new case (problem + solution) into the case library or DB for future refferences

Ex: Imagine an medical diagnosis system that uses CBR
A new patient comes with a set of symptom - fever, sore throat and fatigue. The system searches it's database for similar previous case and find one was diagnosed as "flu".
It then suggests the same treatement used before, such rest and medication. If the treatement works, this new case (with any updates) is stored in the system's memory for future use.

Q. Machine Learning Paradiagram.
Ans. ML paradigms Refers to fundamental approach or framework that defines how a model learns from a data. Each pardigm has its own way of providing information to the model and its own type of learning objective.
ML Paradigms Include
(i) Supervised learning
(ii) Unsupervised Learning
(iii) Self-Supervised learning
(iv) Semi-Supervised learning
(v) Re-Inforcement Learning.



① SUPERVISED LEARNING

Supervised learning involves training a model on an labelled dataset, where both inputs and corresponding outputs (targets) are known. The goal is to learn a mapping function that can predict outcomes for new, unseen data.

For Ex: A spam Detection System is trained on emails labelled as "spam" or "not spam" to classify future emails automatically. Common algorithms include linear regression, decision trees and neural networks

② UNSUPERVISED LEARNING

Unsupervised learning deals with unlabelled data, where the model tries to uncover hidden patterns or structures without explicit guidance. It is often used for grouping, association or feature extraction.

For Ex: A Retailer might use clustering to group customers

with similar buying habits without knowing any pre-defined categories. Techniques like K-means and principal component analysis (PCA) are common in this paradigm.

(iii) SEMI-SUPERVISED LEARNING

Semi-Supervised learning combines all small amount of labelled data with a large amount of unlabelled data to improve learning accuracy. This approach is useful when obtaining labelled data is costly or time-consuming. For Ex: A medical imaging model might use a few expert labeled scans alongside thousand of unlabeled scans to detect diseases more effectively. This method bridges the gap between supervised and unsupervised learning.

(iv) SELF-SUPERVISED LEARNING

Self Supervised learning automatically Generates labels from the data itself by setting up an pretext task, such as predicting a missing part or next sequence. It allows models to learn useful representation without manually labelled data.

Ex: Language models like GPT are trained to predict the next word in a sentence, effectively learning grammar and meaning. The paradigm has become foundational in modern AI system.

(v) RE-INFORCEMENT LEARNING

Reinforcement learning focuses on training an agent to make a sequence of decisions by interacting with an environment and recieving feedback as reward or penaltres. The goal is to maximize cumulative rewards overtime through trial and error.

Ex: DeepMind's AlphaGo, which learned to play the game Go at a superhuman level by playing millions of matches against itself. RL is widely used game AI, and autonomous systems.