INDIVIDUAL TASK - 01

WORKING OF ARTIFICIAL NEURAL NETWORKS (ANNs)

An Intuitive and Technical Study of How Machines Learn

1. Introduction

Artificial Neural Networks (ANNs) are computational models inspired by the human brain. Just like our brain has billions of neurons connected together, ANNs consist of artificial neurons connected in layers to process information.

ANNs are widely used in:

- Image recognition
- Speech recognition
- Medical diagnosis
- Self-driving cars
- Recommendation systems

The goal of ANN is simple:

→ Learn patterns from data and make intelligent decisions.

2. Inspiration from the Human Brain

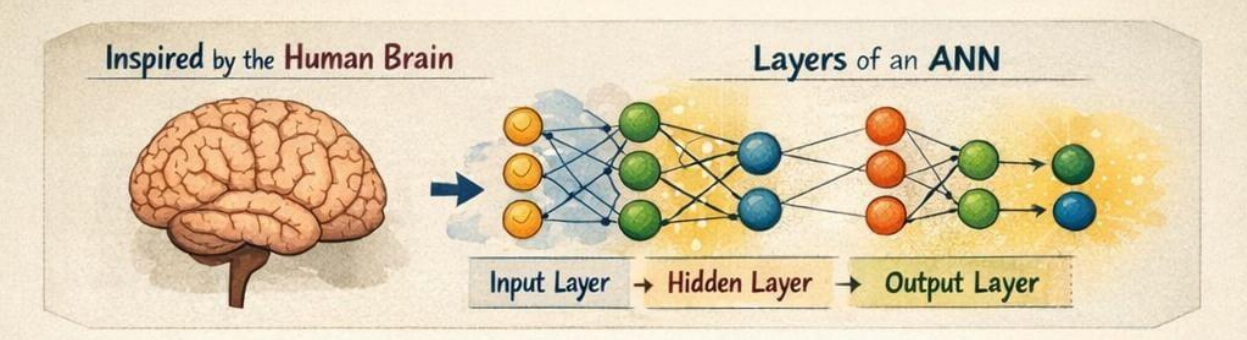
The biological brain contains:

- Neurons
- Dendrites (receive signals)
- Axon (send signals)
- Synapses (connection strength)

Similarly, an ANN has:

- Inputs
- Weights
- Activation function
- Output

The strength of learning depends on weights, just like synapse strength in the brain.



3. Basic Structure of ANN

An Artificial Neural Network has three main layers:

1.Input Layer

- Receives raw data
- Example: pixels of an image

2.Hidden Layer(s)

- Performs calculations
- Extracts patterns
- Can be one or many layers

3.Output Layer

- Produces final result
- Example: Cat or Dog
- More hidden layers = Deep Neural Network (Deep Learning)

4. Working of an Artificial Neuron

Each neuron performs 3 main steps:

Step 1: Weighted Sum

Each input is multiplied by a weight.

Where:

- x = input
- w = weight
- b = bias
- Z = weighted sum

Step 2: Activation Function

The result passes through an activation function to decide whether the neuron should “fire”.

Common activation functions:

- Sigmoid
- ReLU (Rectified Linear Unit)
- Tanh
- Softmax

For example, ReLU:

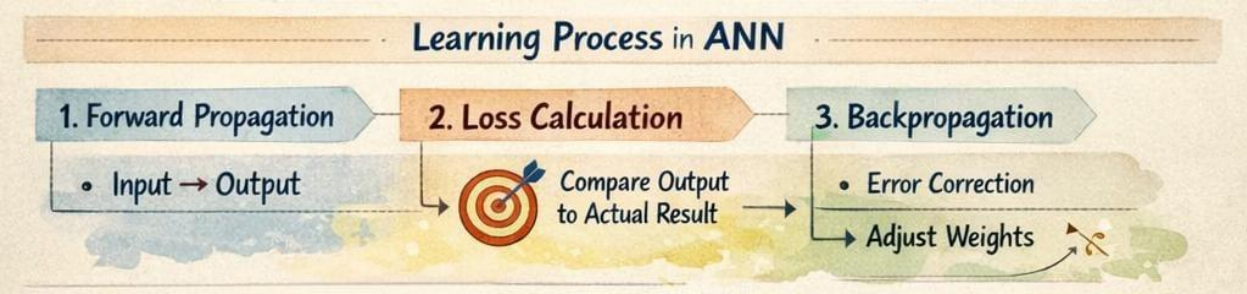
This introduces non-linearity, allowing the network to learn complex patterns.

Step 3: Output Generation

The activated output is passed to the next layer.

5. How ANN Learns (Training Process)

Learning happens in 3 major stages:



→1. Forward Propagation

- Input enters network
- Passes layer by layer
- Produces output
- Compare output with actual answer

→ 2. Loss Calculation

Loss function measures error.

Example:

- Mean Squared Error (MSE)
- Cross Entropy Loss

If prediction is wrong → Loss is high

If prediction is correct → Loss is low

→3. Backpropagation (Core of Learning)

This is the most important step.

- Calculate error
- Send error backward
- Adjust weights using gradient descent

Formula:

This process repeats thousands of times.

Over time:

- Error decreases
- Accuracy increases

6. Gradient Descent – Optimization Technique

Gradient Descent helps find the minimum loss.

Types:

- Batch Gradient Descent
- Stochastic Gradient Descent (SGD)
- Mini-batch Gradient Descent

Learning rate controls how fast learning happens.

If learning rate is:

- Too high → Model unstable
- Too low → Learning slow

7. Example: ANN for Digit Recognition

Consider handwritten digit recognition using the MNIST dataset.

Input:

- 28 × 28 pixel image
- Converted to 784 input neurons

Hidden layers:

- Extract patterns like curves, lines

Output:

- 10 neurons (digits 0–9)

Network learns by adjusting weights until prediction matches correct digit.

8. Types of Artificial Neural Networks

1. Feedforward Neural Network
2. Convolutional Neural Network (CNN)
3. Recurrent Neural Network (RNN)
4. Long Short-Term Memory (LSTM)
5. Transformer Networks

Each is used for different applications.

9. Advantages of ANN

✓ Can learn complex patterns

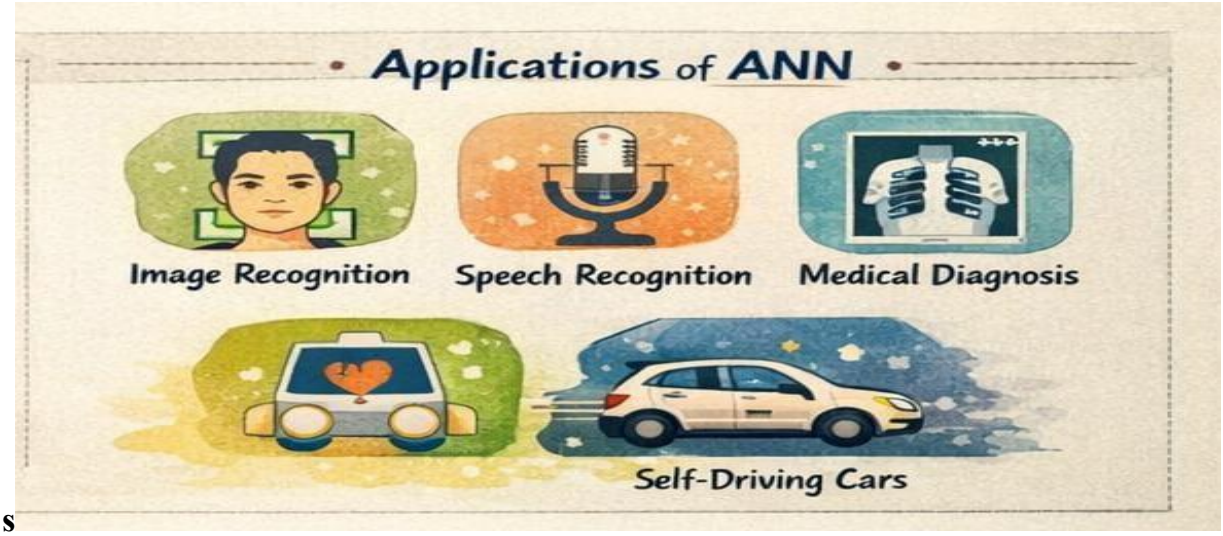
✓ Works well with large data

10. Limitations of ANN

✕ Requires large data

✕ High computational power

11. Real-World Applications



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- Face recognition in smartphones
- Voice assistants
- Medical image analysis
- Fraud detection

12.Why ANN is Powerful?

Traditional programming:--Input → Rules → Output

ANN:--Input → Learn Rules → Output

Instead of giving rules, we give examples.

The network creates its own internal representation.

This is why ANN is called data-driven intelligence.

13. Future of Artificial Neural Networks

With increasing data and computing power:

- Deep learning models are becoming larger
- Self-learning systems are improving
- Integration with robotics and IoT is growing

ANN is a foundation of Artificial Intelligence.

Conclusion: Artificial Neural Networks simulate the working of biological neurons to solve complex problems.

The working of ANN involves:

1. Forward propagation
2. Loss calculation
3. Backpropagation
4. Weight optimization

Through repeated learning cycles, ANN improves accuracy and becomes capable of performing intelligent tasks.

Thus, ANN plays a major role in modern Artificial Intelligence and Deep Learning systems.