

# PART A: NEURAL NETWORKS

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## *1. Introduction to Neural Networks*

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*Neural Networks are computational models inspired by the structure and functioning of the human brain. They consist of interconnected processing units called neurons that work together to solve specific problems such as classification, prediction, and pattern recognition. Neural networks form the foundation of deep learning and modern artificial intelligence systems.*

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## *2. Biological Inspiration*

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*The human brain consists of billions of neurons connected through synapses. Similarly, artificial neural networks use artificial neurons connected by weighted links. Each neuron processes input signals and passes the result to other neurons.*

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### *3. Structure of a Neural Network*

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A neural network is organized into layers:

- Input Layer: Receives raw data
- Hidden Layer(s): Performs computations and feature extraction
- Output Layer: Produces final output

Each connection has a weight, and each neuron includes a bias.

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### *4. Artificial Neuron Model*

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*An artificial neuron performs the following steps:*

- 1. Receives inputs*
- 2. Multiplies inputs by weights*
- 3. Adds bias*
- 4. Applies an activation function*

*Mathematically: Output = Activation( $\Sigma$ (weight  $\times$  input) + bias)*

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## *5. Activation Functions*

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*Activation functions determine the output of a neuron.*

*Common activation functions:*

- *Sigmoid: Used in binary classification*
  - *Tanh: Zero-centered activation*
  - *ReLU: Efficient and widely used*
- *Softmax: Used in multi-class classification*

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## *6. Types of Neural Networks*

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### **6.1 Feedforward Neural Network**

*Data flows in one direction from input to output.*

### **6.2 Recurrent Neural Network (RNN)**

*Designed for sequential data with memory of past inputs.*

### **6.3 Convolutional Neural Network (CNN)**

*Specialized for image and spatial data processing.*

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## *7. Training of Neural Networks*

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*Training involves adjusting weights to minimize error.*

*Key concepts:*

- *Loss function*
- *Gradient descent*
- *Backpropagation*
- *Epochs and batch size*

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## *8. Advantages of Neural Networks*

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- *Can model complex relationships*
  - *Learns from data*
  - *High accuracy*

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## *9. Limitations of Neural Networks*

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- *Requires large data*
- *Computationally expensive*
- *Difficult to interpret*

## PART B: DEEP LEARNING

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### *10. Introduction to Deep Learning*

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*Deep Learning is a subfield of machine learning that uses neural networks with many hidden layers, known as deep neural networks. It enables machines to automatically learn hierarchical features from large datasets.*

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### *11. Difference Between Neural Networks and Deep Learning*

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#### ***Neural Networks***

*May have few layers*

*Limited feature learning*

*Lower computation*

#### ***Deep Learning***

*Uses many layers*

*Automatic feature extraction*

*High computational power*

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## ***12. Deep Learning Architecture***

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*Deep learning models consist of multiple hidden layers that learn features at increasing levels of abstraction.*

### **12.1 Hierarchical Learning**

- *Low-level features (edges)*
- *Mid-level features (shapes)*
- *High-level features (objects)*

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## ***13. Types of Deep Learning Models***

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### **13.1 Deep Neural Network (DNN)**

*A neural network with many hidden layers.*

### **13.2 Convolutional Neural Networks (Deep CNNs)**

*Used for image and video analysis.*

### **13.3 Recurrent Neural Networks (Deep RNNs)**

*Used for language and time-series data.*

### **13.4 Transformers**

*Based on attention mechanisms and used in modern AI systems.*

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## *14. Training Deep Learning Models*

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*Deep learning requires:*

- *Large datasets*
  - *GPUs/TPUs*
  - *Advanced optimizers (Adam, RMSprop)*
  - *Regularization techniques*
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## *15. Applications of Deep Learning*

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- *Computer vision*
  - *Natural language processing*
    - *Speech recognition*
    - *Medical diagnosis*
    - *Autonomous vehicles*
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## *16. Advantages of Deep Learning*

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- *High accuracy*
- *Automatic feature learning*
- *Scales well with data*

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## *17. Limitations of Deep Learning*

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- *Requires huge datasets*
  - *High energy consumption*
  - *Black-box nature*
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## *18. Future Scope of Deep Learning*

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*Future research focuses on explainable AI, efficient deep models, and human-centered AI systems.*