



# **ICTSS00120 - Artificial Intelligence Skill Set**

## **Week 9: Deep Learning Foundations - Introduction to Neural Networks**

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## Learning Objectives

- Understand the basics of neural networks.
- Explore the concept of hidden layers in neural networks.
- Learn about training, test, and validation loops for deep learning.
- Understand the Stochastic Gradient Descent (SGD) and Backpropagation algorithms.
- Introduction to Feed Forward Neural Networks (FNN) and Convolutional Neural Networks (CNN).

# Introduction to Neural Networks

## What is a Neural Network?

- A neural network is a computational model inspired by the way biological neural networks in the human brain process information.
- Composed of interconnected nodes, or neurons, that work together to solve specific problems.
- Typically organized into layers: input layer, hidden layers, and output layer.

# Hidden Layers

## Concept of Hidden Layers

- **Hidden Layers**: These are layers between the input and output layers where computation is performed.
- Each hidden layer applies transformations to the input data to extract features and patterns.

### Key Points :

- More hidden layers can represent more complex functions, but may also require more computational power and data to train effectively.
- Typically use activation functions like ReLU to introduce non-linearity.

# Training, Test, and Validation Loops

## Training, Validation, and Testing in Deep Learning

### 1. Training Loop:

- Model learns from the training data.
- Updates weights using backpropagation and optimization algorithms like Stochastic Gradient Descent (SGD).

### 2. Validation Loop:

- Evaluates the model's performance on validation data not seen during training.
- Helps in tuning hyperparameters and preventing overfitting.

### 3. Test Loop:

- Assess the final model performance on completely unseen data.

# Stochastic Gradient Descent (SGD)

## Introduction to SGD

- **SGD**: An optimization algorithm used to minimize the cost function in neural networks.
- **Process**:
  - i. Start with initial weights.
  - ii. Calculate the gradient of the cost function.
  - iii. Update weights in the opposite direction of the gradient.
  - iv. Repeat until convergence.

## Key Advantages:

- Computationally efficient.
- Capable of handling large datasets effectively.

# Backpropagation

## Backpropagation of Error

- **Backpropagation:** Algorithm used for training neural networks by propagating the error backward through the network.
- **Process:**
  - i. Forward Pass: Compute the output and loss.
  - ii. Backward Pass: Compute the gradients of the loss with respect to each weight using the chain rule.
  - iii. Update Weights: Adjust the weights using the gradient descent algorithm.

### Benefits:

- Helps in minimizing the loss function.
- Efficiently optimizes neural network parameters

# Feed Forward Neural Networks (FNN)

## Introduction to FNN

- **FNN:** Simplest type of artificial neural network where connections between nodes do not form cycles.
- **Structure:**
  - Composed of an input layer, multiple hidden layers, and an output layer.
  - Each neuron in one layer is fully connected to neurons in the next layer.

## Applications:

- Mainly used for tasks requiring pattern recognition, such as image and speech recognition.

# Convolutional Neural Networks (CNN)

## Introduction to CNN

- **CNN**: Specialized neural network designed for processing structured grid data like images.
- **Components**:
  - **Convolutional Layers**: Apply convolution operations to extract features.
  - **Pooling Layers**: Reduce the dimensionality of feature maps.
  - **Fully Connected Layers**: Perform high-level reasoning and classification.

## Advantages:

- Highly effective at capturing spatial hierarchies in data.
- Significantly reduces the number of parameters compared to traditional FNNs.

## Summary and Q&A

### Summary:

- Introduced the basic concepts of neural networks and their components.
- Explained hidden layers, training, validation, and testing loops.
- Covered key algorithms like Stochastic Gradient Descent and Backpropagation.
- Introduced types of neural networks: Feed Forward Neural Networks (FNN) and Convolutional Neural Networks (CNN).

### Q&A:

- Any questions about today's topics?
- How would you apply these concepts in different real-world scenarios?

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# Homework

## Next Week:

- Explore advanced neural network architectures.
- Delve deeper into CNNs and Recurrent Neural Networks (RNNs).

## Tasks:

1. Review the key concepts covered today.
2. Read about the applications of CNNs in image recognition.
3. Watch the linked videos on neural networks and backpropagation.